Environment, Resource and Ecology Journal (2022)
Clausius Scientific Press, Canada

DOI: 10.23977/erej.2022.060106
ISSN 2616-3756 Vol. 6 Num. 1

Evaluation the Impact of Ecological Reserve Construction on the Environment Based on HSB Model

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Keywords: HSB model, Principal component analysis, Ecological evaluation model

Abstract: This paper establishes a HSB model based on principal component analysis and liner fitting method to evaluate Saihanba. Finally, it is concluded that the three factors that affect the ecological environment from high to low are climate resources, forest resources and water resources.

1. Introduction

Saihanba Forest Farm has a vast territory and various geomorphological types, forming complex and diverse natural ecosystems such as forests, grasslands, wetlands, rivers and lakes, and giving birth to rich biodiversity. At present, the ecological environment quality of Saihanba Forest Farm shows a trend of steady improvement, the deterioration trend of all kinds of natural ecosystems has been basically curbed, the stability has been gradually enhanced, and the ecological quality of key ecological engineering areas has been continuously improved.

This paper selects 11 influencing factors from three aspects of climate resources, land energy and water resources as the input of FEE model. Taking Saihanba as an example, the influencing factors of ecological environment are stratified by principal component analysis and Lin linear regression, and then fitted by liner model. And combined with the Chinese Academy of Environmental Sciences and the China Environmental Monitoring Station to solve the ranking of the main factors affecting the ecological environment, so as to establish a model of the influencing factors of the ecological environment.

2. Model Establishment and Solution

In this paper, 11 influencing factors are selected from three aspects: climate resources factors, forest resources factors and water resources factors, as the input of HSB model, and the eco-environmental index as the output of the model.

2.1 Data pre-processing

This paper collects a large number of model input variable data, first carries on the interpolation fitting to the missing value, then carries on the singular value processing and data cleaning, and normalize it with the following formula.

$$X_{norm} = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

2.2 Applicability test

Test the applicability of principal component analysis. Assuming that the correlation coefficient between Xi and Xj is Rij, we can determine the correlation coefficient between variables based on the following calculation.

$$r_{ij} = \frac{Cov\left(X_i, X_j\right)}{\sqrt{Var\left[X_i\right] Var\left[X_j\right]}}$$

Where Cov (Xi,Xj) is the covariance of Xi and Xj, Var [Xi] and Var [Xj] are the variances of Xi and Xj, respectively. If most of the correlation coefficients are greater than or equal to 0.3, the preliminary applicability of principal component analysis can be judged.

After calculation, most of the data obtained meet the above conditions, and it is preliminarily determined that the principal component analysis method can be used. Next, we conduct further tests.

2.3 Principal component analysis

Principal component analysis (PCA) is a commonly used method in dealing with multivariables. The main information contained in the original variables can be integrated and the main influencing factors can be identified.

(1) The correlation coefficient matrix is calculated.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \vdots & \vdots & & \vdots \\ r_{p1} & r_{p2} & \cdots & r_{pp} \end{bmatrix}$$

r_{ij} (i, j = 1, 2, …, p) is the correlation coefficient between X_i and X_j, its formula is

$$r_{ij} = \frac{\sum_{k-1}^{n}\left(x_{ki} - \bar{x}_i\right)\left(x_{kj} - \bar{x}_j\right)}{\sqrt{\sum_{k-1}^{n}\left(x_{ki} - \bar{x}_i\right)^2 \sum\left(x_{kj} - \bar{x}_j\right)^2}}$$

Considering that R is a real symmetric matrix, it is sufficient to calculate only the upper triangular elements or the lower triangular elements.

(2) Calculation of eigenvalues and principal component loads.

First solve the eigenequation to find the eigenvalues li (i = 1, 2, … , n) and put them in order of magnitude. Then the eigenvectors ei (i = 1, 2, …, n) corresponding to the eigenvalues are found separately. The eigenvalues are calculated from the correlation coefficient matrix, as well as the contribution rate and cumulative contribution rate of each principal component.

The Contribution Rate (CR) is

$$CR = \frac{\lambda_i}{\sum_{k=1}^{p} \lambda_k} (i = 1, 2, \cdots, p)$$

The Cumulative Contribution Rate (CCR) is

$$CCR = \frac{\sum_{k=1}^{i} \lambda_k}{\sum_{k=1}^{p} \lambda_k} (i = 1, 2, \cdots, p)$$

The calculated results are as follows:

Table 1: Results of component matrix

Component factor	Component 1	Component 2	Component 3
AQI	0.1409	-0.3346	0.3294
TSP	0.2018	0.1437	-0.1344
PM2.5	0.2467	-0.2851	-0.3104
PM10	-0.0042	0.0227	-0.5829
farea	0.1441	0.2170	0.4038
l use	-0.2273	0.4944	0.2896
f Coverage	-0.4376	0.0321	-0.2994
Tnumber	-0.3953	0.1207	0.1680
w	-0.0623	0.2381	-0.3933
Srich	-0.1894	-0.7482	0.1770
CO2	0.6529	-0.1404	-0.1802
CR	0.6814	0.2460	0.0606
ACR	68.14%	92.74%	98.80%

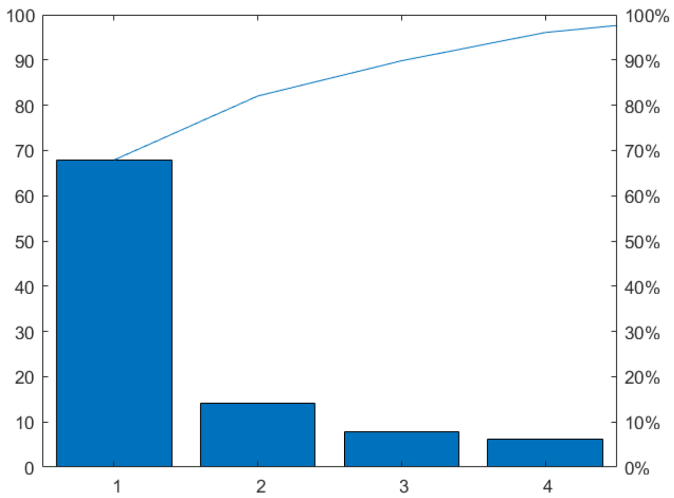

Figure 1: Contribution rate of principal components

$$\begin{aligned} \mathrm{Y1} = {} & 0.1409\,\mathrm{AQI} + 0.2018\,\mathrm{TSP} + 0.2467\,\mathrm{PM2.5} - 0.0042\,\mathrm{PM10} + 0.1441\,\mathrm{farea} - 0.2273\,\mathrm{l\ use} \\ & - 0.4376\,\mathrm{f\ Coverage} - 0.3953\,\mathrm{Tnumber} - 0.0623\,\mathrm{w} - 0.1894\,\mathrm{Srich} + 0.6529\,\mathrm{CO2} \end{aligned}$$

$$\begin{aligned} \mathrm{Y2} = {} & -0.3346\,\mathrm{AQI} + 0.1437\,\mathrm{TSP} + 0.2851\,\mathrm{PM2.5} + 0.0227\,\mathrm{PM10} + 0.2170\,\mathrm{farea} + 0.4944\,\mathrm{l\ use} \\ & + 0.0321\,\mathrm{f\ Coverage} + 0.1207\,\mathrm{Tnumber} + 0.2381\,\mathrm{w} - 0.7482\,\mathrm{Srich} - 0.1404\,\mathrm{CO2} \end{aligned}$$

$$\begin{aligned} \mathrm{Y3} = {} & 0.3294\,\mathrm{AQI} - 0.1344\,\mathrm{TSP} + 0.3104\,\mathrm{PM2.5} - 0.5829\,\mathrm{PM10} + 0.4038\,\mathrm{farea} + 0.2896\,\mathrm{l\ use} \\ & - 0.2994\,\mathrm{f\ Coverage} + 0.1680\,\mathrm{Tnumber} - 0.3933\,\mathrm{w} - 0.1770\,\mathrm{Srich} - 0.1802\,\mathrm{CO2} \end{aligned}$$

In the expression of the first principal component, it can be seen that CO2, AQI and TSP occupy a higher load and have a strong correlation, so this principal component is defined as the influence component of climate resources. In the expression of the second principal component, it can be seen that luse et al occupy a higher load, so this principal component is defined as the influence component of forest resources. In the expression of the third principal component, it can be seen that water resources w has a great influence on this principal component, so this principal component is defined as the influence component of water resources.

Through the analysis of the total variance interpretation result map of principal components, it is known that the cumulative contribution percentage of the three selected principal components to the initial 11 variables is 96.80%, far more than 85%, which is very representative. therefore, in this paper, the leading influencing factors of ecological environment are divided into three categories: climate resources, forest resources and water resources.

$$Y = \frac{5}{12}Y_1 + \frac{1}{3}Y_2 + \frac{1}{4}Y_3$$

The relationship between Y (ecological environment index) and climatic resources influence components, forest resources influence components and water resources influence components is obtained.

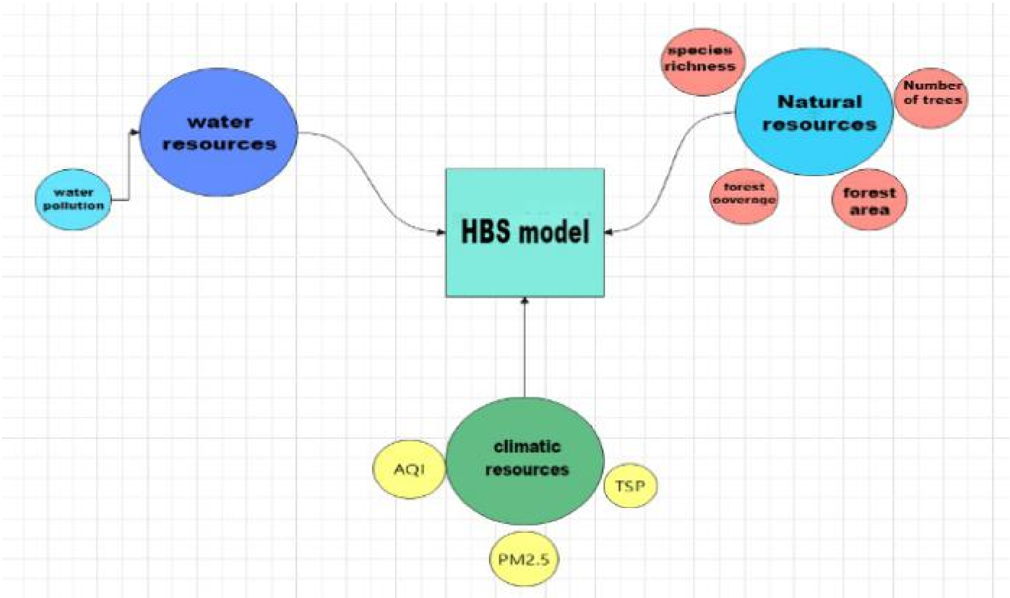

Figure 2: Dominant factor diagram

3. Conclusion

This paper studies the quantitative evaluation of the environmental impact after the restoration of Saihan dam and the value of forest ecosystem service function in the nature reserve, it provides a good basis for future ecological functional regionalization and ecological environment planning and help planners to carry out rational distribution and management of real resources from the perspective of time and space, and lay a good foundation for sustainable development inside and outside the Saihanba Nature Reserve.

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