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

DOI: 10.23977/erej.2022.060310
ISSN 2616-3756 Vol. 6 Num. 3

Research on the Impact of Saihanba Towards Ecological Environment -Building Multi-factor Weighted Evaluation Model Based on Data Normalization

Hangyu Zeng

College of Statistics and Mathematics, Central University of Finance and Economics, Beijing, 102206, China

Keywords: Saihanba, linear interpolation, principal component analysis, data normalization, mathematics model

Abstract: In order to evaluate Saihanba's positive role in protecting the environment and maintaining ecological balance and stability, we use linear interpolation, principal component analysis and data normalization to build the mathematics model, which is able to be applied in different situation. The innovation of this paper is that the fitting method suitable for the change of data is selected according to the environmental indicators, and the significance and fitting effect is good. At the same time, the combination of principal component analysis and multiple linear regression avoids subjective judgment, and the quantitative analysis results have high scientific validity and confidence.

1. Introduction

Strengthening environmental protection is conducive to promoting economic restructuring and changes in growth patterns, achieving steady and healthy development and better meeting the needs of human work and life; it is also a way of using the theoretical methods of environmental science to make moderate use of natural resources, minimize pollution and damage caused to the natural environment and achieve harmonious and sustainable development between human beings and nature.[1] For more than 40 years, with the great support and care of leaders at all levels, the Saihanba, with the youth and sweat of two generations of young people, has created a sea of 10,000 hectares of forest, which is a great creation and a human miracle of human transformation of nature;[2] together with the deep historical and cultural heritage and the rich ethnic flavor of Manchuria and Mongolia, the Saihanba has been approved as a national nature reserve and has become a good example of successful environmental management.[3] Aiming at quantifying the ecological impact of the establishment of the Saihanba, we establish an mathematical model to evaluate.[4]

2. Assumptions and Establishment of Model

2.1 Modelling and analysis of the ecological environment

We mainly start from the natural environment and socio-economic aspects, and categorize the forest resources evaluation into two dimensions of natural value and social value.

On the basis of the two dimensions of natural and social values, we further refined the assessment perspectives, selected several evaluation indicators and collected relevant data respectively to achieve a multi-faceted and comprehensive analysis as far as possible.The natural values of forests are mainly in the areas of soil and fertilizer fixation, water conservation and carbon and oxygen sequestration. The external expression of the social value of Saihanba is the tourism income of Saihanba Scenic Area. The model introduces the consumer index as a measure of inflation. We present the real economic value of tourism area income in Year i as follows: $E'_i = E_i \times \frac{\delta_i}{\delta_{2020}}$.

Combining the above analysis, for the data of Year i, we have S_{1i} and S_{2i} to represent the natural value score and social value score for current year, respectively, we can obtain that:

$$S_{1i} = \left(15 \times \frac{A_i^{\frac{3}{2}}}{A_{max}^{\frac{3}{2}}} + 15 \times \frac{V_{Fi}}{V_{Fmax}}\right) + 30 \times \frac{V_{wi}}{V_{wmax}} + 30 \times \frac{\frac{m_{CO_2 i}}{44} + \frac{m_{O_2 i}}{32}}{\frac{m_{CO_2 max}}{44} + \frac{m_{O_2 max}}{32}} \quad (1)$$

$$S_{2i} = 10 \times \frac{E'_i}{E'_{imax}} \quad (2)$$

Therefore in Year i, The total environmental value evaluation index for the year is.$S_i = S_{1i} + S_{2i}$.

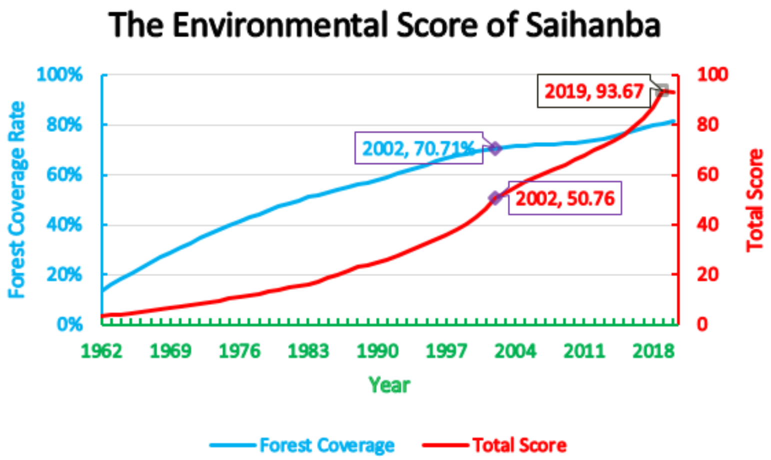

Figure 1 The Environmental Score of Saihanba

After the restoration was completed, the forest cover maintained a steady growth, reaching 81.46% in 2020. And the evaluation index of environmental indicators improved from 50.76 in 2002 to 93.67 in 2019, after a short-term decline in growth rate, the indicators reaccelerated, and the growth in this phase was driven by the economic benefits gained from the Saihanba tourism area. As the ecological environment is restored, more and more tourists come to visit the area, which reflects the social value of the Saihanba. The Saihanba governance system as well as the spirit of Saihanba has become a benchmark for environmental governance all over the world.

Regression analysis was performed with forest cover as the independent variable and the model-derived environmental assessment index as the dependent variable. Because the function has a clear inflection point at 2002 and the influences that dominate the model before and after the inflection point are different, the data for 1962-2001 and 2002-2019 were subjected to correlation analysis and significance tests, respectively.

Correlation analysis and significance testing of the data for 1962-2001 yielded.

Table 1 Correlation analysis and significance testing of the data

Category	Data
Multiple R	0.932
Standard Deviation	4.48
Significance F	2.66E-18
P-value(Intercept)	1.97E-07
P-value(X)	2.66E-18

From the correlation analysis, it is evident that the forest cover for 1962-2001 is strongly positively correlated with the environmental assessment index; and the standard error values are small and the fit is good.

Table 2 Correlation analysis and significance test for the data

Category	Data
Multiple R	0.979
Standard Deviation	2.54
Significance F	1.87E-12
P-value(Intercept)	1.36E-10
P-value(X)	1.87E-12

From the correlation analysis, it is evident that the forest cover for 1962-2001 is strongly positively correlated with the environmental assessment index; and the standard error values are small and the fit is good.

In summary, the environmental value index derived from the model has a strong positive correlation and high significance with the forest cover of Saihanba in the time period before and after 2002, so the results derived from this model are reliable.

Some suggestions are as follows, including enhancing the natural and social values of the Saihanba scenic area in the post-epidemic era, and how to balancing environmental protection and economic development.

1) The importance of Saihanba in maintaining ecological balance cannot be overstated.

2) The ecosystem of Saihanba is still dominated by planted forests, with weaker self-regulation ability, less abundant species, and weaker negative feedback regulation resistance to external disturbances compared to natural forest ecosystems.

3) Attract investment in ecological construction so as to increase forest cover and to improve its environmental rating index.

2.2 Study on the impact of the Saihanba on Beijing's resistance to dust storms and sandstorms

In order to quantify the role played by the Saihanba in counteracting dust storms, we used principal component analysis to score meteorological and environmental data for the past two decades, and quantified the magnitude of the impact made by changes in each indicator of the environment around the Saihanba on the meteorological conditions in Beijing, respectively, using multiple linear regression.

All possible influencing factors are included in the evaluation of the model, and the coefficients of the independent variables and the variables that can be excluded are judged by multiple linear regression.

In the assessment of sandstorm resistance, the improvement of sand resistance is manifested in several aspects. It is particularly important to use the data of different dimensions effectively and to select the appropriate weighting for the overall evaluation. Here we choose the principal component analysis method, using the idea of dimensionality reduction to reduce the correlation between variables and transform multiple indicators into a few comprehensive indicators, so as to achieve data compression.

Comprehensive assessment of Beijing's sand resistance in the last two decades

1) The indicators were standardized by z-score using SPSS software to eliminate the effect between different indicator measures.

2) Performing principal component analysis applicability tests

Correlation between indicators is determined by KMO and Bartlett's sphericity test, and if multiple variables are independent of each other or have little correlation, they are not suitable for principal component analysis. In general, when the KMO statistic is greater than 0.5 and the significance is less than 0.05, it is reasonable to select principal component analysis.

Table 3 KMO and Barolit Test

KMO and Barolit Test	Data
KMO Measure of Sampling Adequacy	0. 744
Significance of Barolit Sphericity Test	0. 000

From the test results, it can be seen that the KMO statistic is greater than 0.5 and significant less than 0.05, which satisfies the conditions for the applicability of the principal component analysis method, so the model is reasonably valid for selection.

3) Extraction of principal component factors

From the explanatory variables analysis table, it can be seen that the percentage of variance of the first principal component is 65.213% and the eigenvalue is 4.565, and the percentage of variance of the second principal component is 16.383% and the eigenvalue is 1.147. According to the criteria of cumulative variance contribution of 80% and eigenvalue greater than 1 to select the principal components, the first 2 were identified from the table as principal components to replace the previous 7 indicators, which can explain both the vast majority of the original information and uncorrelated with each other, but also to achieve data dimensionality reduction and condensation of information.

Table 4 Explanatory variables analysis table

Variable	Characteristic Value	Variance Percent	Total Percent
1	4. 565	65. 213	65. 213
2	1. 147	16. 383	81. 596
3	0. 627	8. 955	90. 551
4	0. 351	5. 008	95. 559
5	0. 257	3. 672	99. 232
6	0. 037	0. 534	99. 765
7	0. 016	0. 235	100. 000

The standardized variables are denoted as ZX_i (i=1,2,3,4,5,6,7), F_1 and F_2 the coefficients of the computational equation can be derived from the component matrix, and F the coefficients of the computational equation are the opposite of the percent variance of the two principal components (since each indicator measures the level of pollution or severe weather conditions, we take the opposite of each value for each year in order to obtain a comprehensive evaluation of the better the environment, the higher the score F).

Of these, the component matrix data are as follows.

Table 5 The component matrix data

Z-score Name	Variable 1	Variable 2
Windy Day	0. 545	−0. 683
Average Wind Speed	0. 858	−0. 010
PM10	0. 946	0. 106
Sulfur Dioxide	0. 964	0. 075
Nitrogen Dioxide	0. 961	0. 156
COD	0. 417	0. 735
Water Resource	−0. 780	0. 316

$$F1 = 0.26ZX_1 + 0.40ZX_2 + 0.44ZX_3 + 0.45ZX_4 + 0.45ZX_5 + 0.20ZX_6 - 0.37ZX_7 \quad (3)$$

$$F2 = -0.64ZX_1 - 0.01ZX_2 + 0.10ZX_3 + 0.07ZX_4 + 0.15ZX_5 + 0.69ZX_6 + 0.30ZX_7 \quad (4)$$

$$F = -0.65F1 - 0.16F2 \quad (5)$$

F The value is the quantitative score of the resistance to dust storms. Combining F variation of values with year, we obtain the following results(Figure 2).

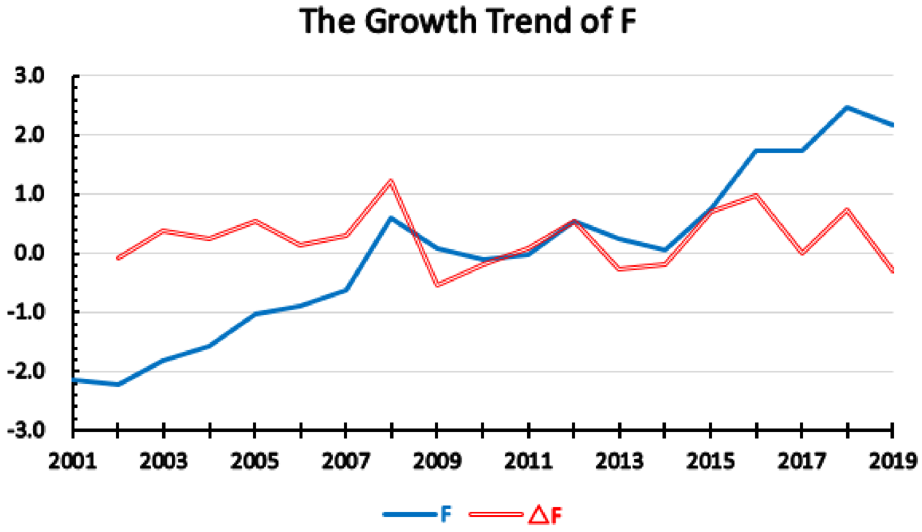

Figure 2 The Growth Trend of F

The line graph provides us with a clear picture of the F changes in values over time and the annual growth rate of the F values. It can be seen that the resistance to dust storms in Beijing is on the rise, with an annual growth rate generally between 0 and 1, with a steady to positive trend.

Six factors that may affect the resistance to dust storms in Beijing, such as forest cover, area covered, forest stock, water content, carbon dioxide absorption and oxygen release, were taken as independent variables to analyze the correlation between different factors and the composite score.

1) Multiple linear regression using SPSS software

2) Variable exclusion

Since the initial selection of independent variables is somewhat subjective, depending on the regression results, appropriate exclusions can be made to streamline the formula and improve the accuracy of the model.

Table 6 Variable exclusion

Variable Name	T Stat	Significance	Partial Correlation
Forest Coverage	1.220	0.243	0.310
Forest Stock	−0.580	0.571	−0.153
Carbon Dioxide Absorption	0.241	0.813	0.064

3) Determining the linear regression equation

Denote the forest cover, water content and oxygen release by A, V_w and m_{O_2} determine the constant and variable coefficients from the following table.

Table 7 Variable exclusion

Variable Name	Unstandardized Coefficient	Standardized Coefficient
Intercept	−20.34	
Area	0.144	0.459
Water Reservation	0.077	0.059
Oxygen Release	0.106	0.516

We obtain the following linear regression equation and the degree of influence of each factor on F

$$F = -20.340 + 0.144A + 0.077V_w + 0.106m_{O_2} \tag{6}$$

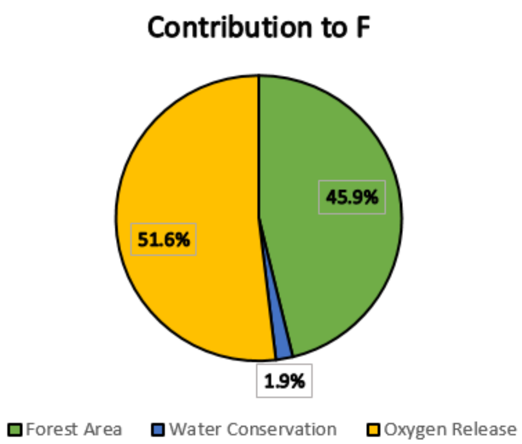

Figure 3 Contribution to F

The model summary shows that the goodness-of-fit data is very close to 1 and therefore the fit is good.

Table 8 ANOVA table

Category	Data
Multiple R	0.960
Adjusted R Square	0.907
Standard Deviation	0.429
F	59.406
Significance F	0.000

From the ANOVA table, the sig value is less than 0.05 and the model is significant overall. Combining the above tests, it is appropriate to use multiple linear regression for multivariate analysis.

The following are some suggestions for further reducing the frequency of dust storms in Beijing and further demonstrating the positive role of the Saihanba in reducing dust storm weather in Beijing.

1) The area north of Beijing has a small proportion of wetlands and forests, and the terrain is mainly plains and hills.Therefore, the reduction of the frequency of sand and dust storms in Beijing cannot rely solely on the Saihanba, but requires the creation of additional barriers.

2) Control the production of plants north of Beijing in the winter to reduce the generation of pollutants.

3) Taking the example of the sandstorm in Beijing in spring 2021, the source of dust and sand is mainly from the Mongolian plateau.

3. Model Evaluation and Rationalization Recommendations

● In the process of data collection and model building, we visited the websites of National Bureau of Statistics, Beijing Bureau of Statistics, Chengde Bureau of Statistics, and China Meteorological Data Sharing Network to find and collect a few missing data, part of which was supplemented by linear interpolation, and the remaining part was done to eliminate the process. As a result, most of the data we obtained had less deviation from the actual situation, and the impact of data deviation on the modeling process was minimized as much as possible.

● For question 1, the selection of two-dimensional multiple indicators can more comprehensively evaluate the impact of Saihanba on the ecological environment.

● In question 2, to quantify the ability of Beijing to resist sandstorms, we used principal component analysis to perform data downscaling and principal component weighting work on the basis of collecting multiple relevant indicators to obtain quantitative scores for each year.

4. Conclusion

● The model in the first question is an evaluation model and the indicators chosen are not sufficiently representative in the data collection. The role of forests in purifying the air was considered in the modeling to a limited extent; CO_2 absorption and oxygen emissions do not fully represent the contribution of forests to improving air quality, and indicators such as PM2.5, AQI, etc. should be considered.

● The model for the second question is a model for a multivariate correlation study and through the results obtained it was found that among the variables selected, the contribution of the cultured water source to the control of dust storms is significantly smaller than the other two variables and the variable cultured water source should be removed for further correlation analysis.

References

[1] Liu Xueming. Red faith casts green miracle[N]. China Organization and Personnel News, 2021-11-16(001). DOI:10.28127/n.cnki.ncrsb.2021.003622.

[2] Yu Shengliang. Perseverance needed to combat sandstorms [N]. Securities Times, 2021-03-18(A03). DOI:10.38329/n.cnki.nzjsb.2021.001163.

[3] Pei Yan. Carrying forward the spirit of Saihanba and starting a new journey [N]. Yongzhou Daily,2021-10-22(004). DOI:10.38286/n.cnki.nyzrb.2021.002588.

[4] Wang Zhichun, Chen Suhua, Wang Bibo, Wu Yajuan. Research on climate suitability evaluation model of cereals in Chifeng region[J/OL]. Northeast Agricultural Science:1-7 [2021-11-28]. http://kns.cnki.net/kcms/detail/22.1376.S.20211027.2029.029.html.

[5] Yan Jinyi. Carbon Neutral Action of Carbon Dafeng "Steady Walk" to "Add Up" for Development[N]. China Economic Herald, 2021-11-25(003).