Evaluation model and promotion based on the ecological characteristics of Saihanba

Bingqi Wang

College of Science, Beijing Forestry University, Beijing, China.

Abstract. Saihanba Mechanical Forest Farm is an important sand source control project area in China.In order to promote the excellent case of Saihanba to other regions of the country and even the Asia-Pacific region, we have established a Saihanba ecological environmental impact model and ecological engineering construction assessment model, to provide suggestions for the establishment of ecological protection areas in China and even countries in the Asia-Pacific region. This paper determined the index of Saihanba ecological influence evaluation system using frequency analysis method and theoretical research method, determined the TOPSIS weight based on entropy weight method, to establish a complete ecological and environmental influence evaluation system. Subsequently, the paper introduced the data of relevant indicators around 1962 into the evaluation system, which got good scores, indicating that Saihanba has a great positive impact on the ecological environment. On the basis of problem 1, this paper had redefined the index and weight, established the index system based on the sandstorm background in Beijing, and brought the relevant data of Beijing in recent years into the model, and the establishment of Saihanba had played a relatively significant optimization effect on all the indicators of the sandstorm in Beijing. In view of problem 3, this article was first divided into 9 different ecological system service functional zones according to the National ecological function zoning (revised version) proposed by the Ministry of Environmental Protection and the Chinese Academy of Sciences. Meanwhile, based on the TOPSIS model, proposed a modified model based on DPSIR. The model fully omitted the impact of ecological, economic, policy and other factors on the construction of ecological protection areas .Meanwhile, multi-objective planning method based on genetic algorithm was used to solve the above problems to determine the best number and scale of ecological reserves in the region.

Key words: Entropy power method TOPSIS principal component analysis genetic algorithm multi-objective planning BP neural network DPSIR.

1. Restatement of the problem

China has always maintained that clear waters and green mountains are the ecological development force of gold and silver mountains.In China's state-owned forest farm, Saihanba Forest Farm, as an environmental model, has an extremely high ecological civilization value.According to the relevant situation of Saihanba, a mathematical model analysis was established to study the following problems:
1. According to the natural environmental conditions of Saihanba and relevant data and information, establish the Saihanba ecological environmental impact assessment model, analyze the impact of Saihanba on the local ecological environment, and quantify and compare the results before and after the recovery of Saihanba.
2. According to the model established in Question 1, study the wind and sand fixation in Beijing.According to the existing data and established indicators, the impact of Saihanba on Beijing against sandstorm capacity is evaluated, and the role of Saihanba in Beijing against sandstorms is evaluated.
3. Promote the ecological model of Saihanba, and multiple social and economic factors should be considered.By establishing which geographical locations are in China, ecological areas, ecological reserves are needed to be established, and the quantity and scale that need to be established.

2. Model establishment and solution

2.1 Problem 1: The Ecological Environment Impact Assessment model of Saihanba

2.1.1 Study Area Overview

Saihanba Forest Farm is located in the northernmost part of Weichang Manchu and Mongolian Autonomous County, Hebei Province. It is located in the semi-arid and

* Corresponding author: 798460040@qq.com

semi-humid zone. It belongs to the transition zone of the Inner Mongolia Plateau and the Greater Hinggan Mountains, and the terrain is relatively complex.Saihanba machinery forest farm in the national Beijing-Tianjin sand source management engineering area, after more than 50 years of continuous cultivation and protection, part of the forest has been included in the national and provincial scope of forest ecological benefits compensation (Saihanba machinery forest farm forest resources quality analysis and evaluation), it has high ecological benefits, in wind resistance, environmental protection, maintaining ecological balance and stability have played an important role.

2.1.2 Construction of an ecological function evaluation system in Saihanba

3.1.2.1 Design and analysis of Saihanba ecological function evaluation system

In order to evaluate the impact of Saihanba on the local environment before and after its construction is a relatively complex process, which involves many kinds of influencing factors. Therefore, we especially combine the function of the ecosystem and mainly consider the following aspects in the process of designing the Saihanba ecological function evaluation system:

Tab 1. Selected indicators

Target layer	Code layer
Forest natural ecological space	vegetation coverage
	Total proportion of wetland area
	Forest land area (forest accumulation) accounted for the total ratio
water conservation	Forest area
	annual precipitation
	The annual steam dispersion of forest
	Annual water conservation
Conservation of soil	Woodland soil organic matter content
	Forest maintain organic matter content every year
	Forest fixed soil quantity in different years
carbon fixation and oxygen release	Net productivity
	Annual carbon fixation of soil per unit area
	Annual oxygen release per unit area
wind prevention and sand fixation	wind speed
	Solid sand quantity
bio diversity protection	Shannon-Wiener Diversity index

1. Forest natural ecological space.Forest natural ecological space is the most basic condition for forestry ecosystem consideration, mainly including plant coverage rate, wetland area, nature reserve area and woodland area (accumulation area).

2. water conservation.Water conservation is particularly important for the treatment of Saihanba wasteland, which refers to the ecosystem interception, penetration and accumulation of precipitation through its unique structure and water interaction, and realizes the regulation of water flow and water cycle through evaporation.

3. Soil conservation.The benefits of conservation soil in the recovery of Saihanba are obvious.

4. carbon fixation and oxygen release.Absorbing carbon dioxide and releasing oxygen is the most basic biological function of plants and an important ecological function of forest plants.

5. wind prevention and sand fixation.Wind protection and sand fixation is a kind of ecological construction activity carried out in arid and semi-arid in areas to maintain soil and water and prevent dust-arid storms.

6. Biodiversity maintenance.Biodiversity is the sum of the ecological complexes formed by organisms and the environment and the various ecological processes associated with this, including three levels: ecosystem, species, and genes.

3.1.2.2 Selection method of indicators

The establishment of the function index of the forest ecosystem system is the key to affect the ecological environment evaluation system. The relevant literature and data foundation of Saihanba in the forest evaluation system are relatively weak, so the determination of the evaluation index is particularly important.In this paper, theoretical analysis and frequency statistics are used to determine the ecological function evaluation indicators.

2.1.3 Saihanba ecological function evaluation indicators are determined

For the selection of evaluation indicators, we fully consider the impact of the system on the system, taking into account the data that we can find, and the indicators that we choose are as follows:

2.1.4 Determine the weight of Saihanba ecological function evaluation index

3.1.4.1 Computational steps of the TOPSIS model based on the entropy weights method

The TOPSIS method is a common comprehensive evaluation method that can make full use of the raw data information, and its results can accurately reflect the gap between the evaluation schemes.The entropy method is an objective empowerment method, which determines the weight of the index by calculating the index according to the influence of the relative degree of change on the system overall. The index with a large degree of relative change has a large weight.Organic combination of the two contributes to the more scientific determination of the weight.

2.1.5 Assessment level and classification of Saihanba ecological function level

According to the range of ecosystem functional level numerical scores derived from the TOPSIS model, the functional level evaluation level can be divided into 6 levels (A is the best, F is the worst), and the classification is divided in the table:

Tab 2. Evaluation level and classification of ecological function level

grade	A	B	C	D	E	F
score	>80	60-80	45-60	30-45	20-30	<20
classify	Supreme function	Good function	Intermediate function	Primary function	Low-level function	Lack of function

2.1.6 Environmental impact and its evaluation before and after Saihanba recovery

3.1.6.1 Environmental evaluation before and after Saihanba recovery

Tab 3. Level of ecological function after and before the recovery of Saihanba

metric	2021year		1962year	
	Comprehensive weight	fraction	Comprehensive weight	fraction
Forest natural ecological space	10.76%	9.46	16.51%	1.37
water conservation	11.19%	9.84	16.57%	1.38
Conservation of soil	13.74%	16.26	15.7%	1.31
carbon fixation and oxygen release	2.11%	7.4360	16.8%	1.39
wind prevention and sand fixation	36.35%	31.99	12.4%	1.03
bio diversity protection	9.79%	8.61	15.6%	1.30
total points		88		8

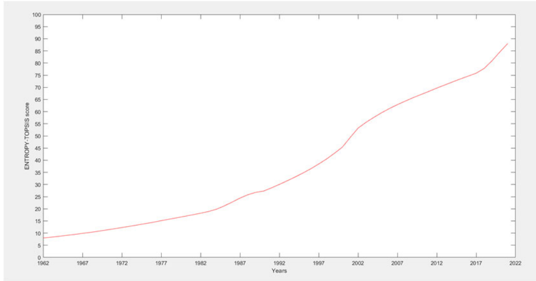

Figure 1 Distribution map of ecological function scores from 1962 to 2021 based on topsis calculation

2.2 Question 2: Instance study of windproof and sand fixation in Beijing by Saihanba Forest Farm

2.2.1 Construction of Saihanba to Beijing

3.2.1.1 The index of Saihanba to Beijing

Problem 2 is an example analysis of problem 1, and in combining the indicators in the problem 1 windproof and sand fixation function, we expand the index of problem 1 through the theoretical analysis method and the frequency statistical method. The specific analysis is as follows: First of all, according to the sandstorm cause, we choose temperature, wind speed, annual sandstorm frequency and vegetation coverage, in order to improve the representative of sandstorm, meteorological and vegetation elements, we according to the seasonal distribution of sandstorm (Beijing and Tianjin sandstorm source management engineering area sandstorm spatial and temporal change and its vegetation recovery relationship), the occurrence of Beijing sandstorm has obvious seasonal, namely spring sandstorm frequency.In spring, the surface is bare and the vegetation is sparse, which provides sand source material for the sandstorm. At the same time, the air is dry and windy in spring, which provides conditions for the occurrence of dust storms, so we have narrowed the scope of meteorological indicators to spring.

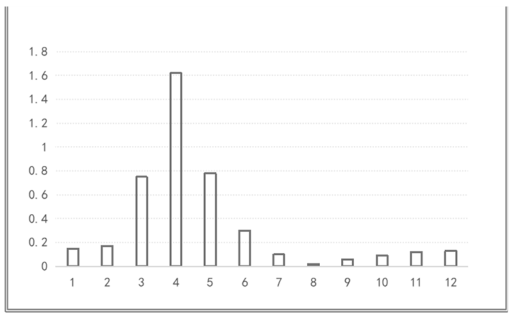

Figure 2 Distribution of Beijing sandstorm season in 1962-2021

3.2.1.2 Dust storm resistance to Beijing based on correlation analysis and nonlinear fitting

Correlation analysis is the analysis of two or more variable elements with correlation to measure the closeness of the two variable factors.The influence icon was quantified by establishing the cause of sandstorm in

Beijing and the vegetation coverage data of Saihanba forest farm.

Nonlinear fitting mathematically fits the vegetation coverage rate of Saihanba with the Beijing meteorological indicators, determines the correlation by fitting the slope of the fitted curve, and then quantitatively analyzes the impact effect

2.2.2 Longitudinal impact assessment of Saihanba on sandstorm resistance in Beijing

3.2.2.1 Data

The meteorological data came from the Climate Data Center of the National Meteorological Administration, including the monthly average temperature, precipitation, average wind speed and frequency of dust storm of multiple weather stations.Vegetation coverage data were obtained from the Saihanba Mechanical Forest Farm.Data sources are accurate and reliable.

3.2.2.2 Relevant judgment of annual dust storm frequency and vegetation coverage rate in Saihanba

According to the established fitting equation, the annual dust frequency is negatively associated with the Saihanba vegetation coverage rate, that is, the increased vegetation coverage rate in Saihanba contributes to the decrease of the annual dust frequency.

3.2.2.3 Relevant judgment of spring average temperature and vegetation coverage rate in Saihanba

According to the established fitting equation, the annual temperature is positively associated with the Saihanba vegetation coverage rate, that is, the increased vegetation coverage rate in Saihanba contributes to the annual temperature increase.

3.2.2.4 Relevant judgment of spring monthly wind speed and Saihanba vegetation coverage rate

According to the established fitting equation, the monthly wind speed in spring is negatively associated with Saihanba vegetation coverage, that is, the increased vegetation coverage in Saihanba contributes to the decrease of wind speed.

According to the comprehensive evaluation of the above data, Saihanba is of great help to the wind and sand resistance capacity in Beijing.

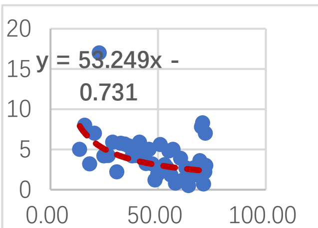

Figure 3. Plot of data fitting between sandstorm frequency in 2-2 years and vegetation coverage in Saihanba

y = 53.249x-0.731

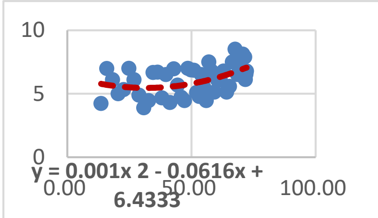

Figure 4 Plot of data fitting between mean air temperature in spring and vegetation coverage in Saihanba

y = 0.001x2 - 0.0616x + 6.4333

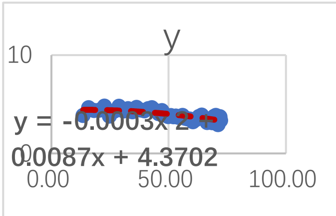

Figure 5 Plot of data fit for spring monthly wind speed and Saihanba vegetation coverage

y = -0.0003x2 + 0.0087x + 4.3702

2.2.3 Horizontal impact assessment of Saihanba on the sandstorm resistance capacity in Beijing

Subsequently, we plan to evaluate the evaluation of the dam on the sandstorm resistance ability of Beijing in the form of a pie chart. The predicted data results are as follows：

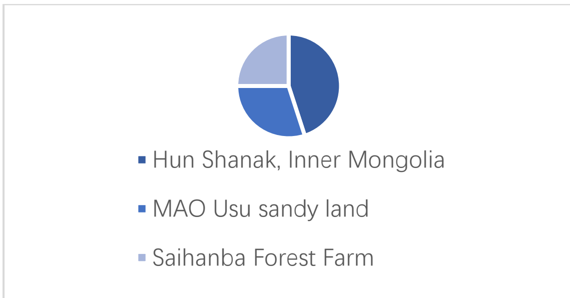

Figure 6 Preast of sand resistance of three lines of defense

Although Saihanba is of great help to Beijing against wind and sand, it is still relatively weaker than other lines of defense.

2.3 Problem 3: Saihanba mode expansion model and carbon neutralization evaluation analysis

2.3.1 National ecological function division

The content studied in this section, to explore which areas of the country need to establish nature reserves, in order to simplify the model and let the model has wider applicability, we according to the national ecological function division (modified), the national divided into nine kinds of ecological service system, and select each functional area representative 9 regions, analysis and evaluation.

Table 4 The National Ecological Function Division System

Ecological function category (Category 3 categories)	Ecological function type (Category 9)	Example of function zones
Ecological adjustment	Water conservation	Daba Mountain Water conservation functional area
	bio diversity protection	Biodiversity protection functional area of the Lesser Hinggan Mountains
	soil conservation	Soil protection functional area of loess hills and ravines in northern Shaanxi
	wind prevention and sand fixation	Horqin Sandy Land windproof and sand fixation functional area
	Flood regulation and storage	Wanjiang Wetland flood regulation and storage functional area
Product delivery	Supply of agricultural products	Sanjiang Plain agricultural products to provide functional areas
	Forest products are provided	Lesser Xingan Mountains mountain forest products provide functional areas
Living security	Metropolis group	The Yangtze River Delta metropolitan group functional area
	Key town groups	Wuhan urban group functional area

2.3.2 *TOPSIS ecological environment evaluation system with carbon neutralization index*

Table 5 A TOPSIS model introducing carbon neutralization metrics

Target layer	Code layer
Forest natural ecological space	vegetation coverage
	wetland area
water conservation	precipitation
	surface runoff
	Lake area
Conservation of soil	Soil contains nitrogen
	Soil contains phosphorus
carbon fixation and oxygen release	Vegetation solid carbon
	Soil solid carbon
wind prevention and sand fixation	wind speed
	Flow sand index
bio diversity protection	Total biomass
Carbon neutralization	carbon emission
	Carbon absorption

2.3.3 *Gray forecast for correlated data forecast for the next 20 years*

3.3.3.1 Implementation steps for gray prediction

1. Data inspection

Modeling using GM (1,1) requires testing of the data, first calculating the ratio of columns

$$\lambda(k) = \frac{x^0(k-1)}{x^0(k)}, 其中k = 2, 3, ..., n$$

$$X = (e^{\frac{-2}{n+1}}, e^{\frac{2}{n+1}})$$

If all level ratios fall within the allowable coverage interval, the columns x (0) can build a GM (1,1) model for gray prediction.Otherwise, you need to transform the data appropriately, such as translation.

2. Build a gray model

$$u = \begin{bmatrix} a \\ b \end{bmatrix}, Y = \begin{bmatrix} x^0(2) \\ x^0(3) \\ ... \\ x^0(n) \end{bmatrix}, B = \begin{bmatrix} -z^1(2) & 1 \\ -z^1(3) & 1 \\ ...... & \\ -z^1(n) & 1 \end{bmatrix}$$

Define the gray derivative, define the gray differential equation, define the bleaching background, gray action quantity, development coefficient; listed according to the matrix, GM (1,1) can be expressed as, Y=Bu, the next is to seek the value of a aa and b bb, can use linear regression or formal equation to find the value according to the least squares principle.

3, calculate

$$\frac{dx^1(t)}{dt} + ax^1(t) = b$$

$$x^1(t) = (x^0(1) - \frac{b}{a})e^{-a(t-1)} + \frac{b}{a}$$

The corresponding whitening model gives the solution of x 1 (t) to make t + 1 = t have

$$x^1(t+1) = (x^0(1) - \frac{b}{a})e^{-a} + \frac{b}{a},$$

That is the value that we predicted.

4, checkout

Table 6 Data predictions for the next two 0 years

Ecological function category (3)	Ecological function type (9)	Example of function zones	2020	2030	2040	2050
Ecological adjustment	Water conservation	Daba Mountain Water conservation functional area	11.52909446	10.54505972	9.645014611	8.821790421
	bio diversity protection	Biodiversity protection functional area of the Lesser Hinggan Mountains	7.906167409	5.92852619	4.44557027	3.333559538
	soil conservation	Soil protection functional area of loess hills and ravines in northern Shaanxi	52.55053724	50.63856949	48.79616565	47.02079474
	wind prevention and sand fixation	Horqin Sandy Land windproof and sand fixation functional area	19.12840272	18.6780674	18.23833422	17.80895357
	Flood regulation and storage	Wanjiang Wetland flood regulation and storage functional area	17.2614061	13.91840389	11.22283814	9.049320383
Product delivery	Supply of agricultural products	Sanjiang Plain agricultural products to provide functional areas	17.1578097	12.97170143	9.806906638	7.414248498
	Forest products are provided	Lesser Xingan Mountains mountain forest products provide functional areas	7.906167409	5.92852619	4.44557027	3.333559538
Living security	Metropolis group	The Yangtze River Delta metropolitan group functional area	187.1247155	162.4923874	141.1025576	122.5283971
	Key town groups	Wuhan urban group functional area	84.2788419	80.18846679	76.29661326	72.59364629

https://doi.org/10.1051/e3sconf/202337503013

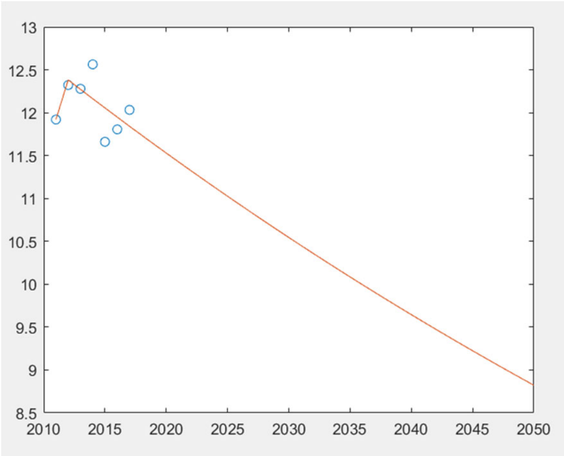

Figure 7 Grey prediction renderings

The data before the construction of the ecological reserve were brought into the model to get the corresponding scores.

From the above data, we obtain that the region should establish nature reserves, and that the establishment of ecological reserves has had a good impact on carbon neutrality.

3.3.3.2 A multi-objective planning model based on the genetic algorithm solves the number and model of ecological reserves

Taking into account the economic, political and ecological elements, we use the multi-objective planning method based on genetic algorithms to achieve the solution.We propose to establish [3], an evaluation system based on the DPSIR model.DPSIR, that is, driving force (D), pressure (P), state (S), impact index (I), response (R), which covers social, economic, environmental, human beings and many other factors, and more fully reflects the interaction relationship between human activities and the natural ecological environment.

The construction of the ecological protection area has its particularity relative to the construction of other projects. We obtain authoritative and specific calculation formulas by consulting the relevant information, [4], and supplement the calculation formulas of several other dimensions:

net present value (NPV)

$$NPV=\sum_{i=1}^{m}A_i\left[\sum_{t=0}^{n}\left(P_tQ_t+\sum E_j+\sum S_k-IP-IC\right)_t(1+i_0)^{-t}\right]$$

Internal rate of return (IRR)

$$NPV(IRR)=\sum_{i=1}^{m}A_i\left[\sum_{t=0}^{n}\left(P_tQ_t+\sum E_j+\sum S_k-IP-IC\right)_t(1+i_0)^{-t}\right]=0$$

Dynamic investment payback period

$$\sum_{i=1}^{m}A_i\left[\sum_{t=0}^{T_p}\frac{P_tQ_t+\sum E_j+\sum S_k}{(1+i_0)^t}\right]=\sum_{i=1}^{m}A_i\left[\sum_{t=0}^{T_p}\frac{IP+IC}{(1+i_0)^t}\right]$$

Profit cost ratio

$$R=\frac{\sum_{i=1}^{m}A_i\left[\sum_{t=0}^{T_p}\frac{P_tQ_t+\sum E_j+\sum S_k}{(1+i_0)^t}\right]}{\sum_{i=1}^{m}A_i\left[\sum_{t=0}^{T_p}\frac{IP+IC}{(1+i_0)^t}\right]}$$

This model comprehensively considers the three ecological, economic and social benefits of ecological protection area construction, reflects the unique attributes of ecological engineering construction, and is of good help to the solution of this problem.Based on this, we solve the multi-objective planning problem described above using a genetic algorithm.

References

1. Code for Functional Assessment of Forest Ecosystem Services, State Forestry Administration of China, 2008.
2. The National Ecological Function Division (Revised Edition), the Ministry of Environmental Protection and the Chinese Academy of Sciences, 2015.
3. Research on ecological and environmental carrying capacity evaluation and obstacle factors of Hebei urban agglomeration based on DPSIR-TOPSIS model *, Kong Jiangwei, Zeng Jian and Gao Mengxi.
4. Forestry Bureau of 18 Station of Daxing'anling Forestry Bureau, Li Bo, Northeast Forestry University, Zhao Zhengyong.
5. Saihanba Forest Farm Research (1962-2017) —— and and ecological environment perspective
6. Trade-offs and synergies of ecosystem services in forest barrier belt of Northeast China.QI Lin1,2, ZHANG Yue2,3, XU Dong4, ZHU Qi2,3, ZHOU Wang-ming2, ZHOU Li2, WANG Qing-wei2, YU Da-pao2* ,2021
7. Ecological Environment Carrying Capacity Evaluation and Obstacle Factors ofHebei Province Urban Group Based on DPSI Ｒ -TOPSIS ModelKONG Jiang-wei，ZENG Jian，GAO Meng-xi ,2019