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Study on Ecological Environment Impact and Site Selection of Saihanba Machinery Forest Farm Based on Multiple Regression Analysis

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Abstract. Based on the index data of the direct beneficiary area of Saihanba Machinery Forest Farm, this paper establishes the ecological environment assessment model for the period from 1990 to 2020; in addition, RSEI is established and applied to determine the site that can take in the Saihanba model in the country. Obvious impact of Saihanba Machinery Forest Farm on the ecological environment has been found since 2005 from the ecological environment score of the study object. According to the eco-index, the site area of the ecological zone to be built is 983,500 square kilometers, which is roughly 1:105 to the area of Saihanba Machinery Forest Farm.

Keyword. Saihanba ecological environment; model site selection; multiple regression analysis; grey comprehensive evaluation

1. Introduction

Three generations of workers of Saihanba Machinery Forest Farm have planted 1.15 million mu on the wasteland, which has laid a solid foundation for protecting water source and green ecology in China and even in Northern China in the history of global ecological civilization. It is of great significance to establish a proper ecological environment impact system of Saihanba Machinery Forest Farm and make targeted policy recommendations. In combination with facts, a mathematical model was established in this paper to evaluate the impact of Saihanba Machinery Forest Farm on the surrounding ecological environment. The areas that benefited most directly from the Farm were selected as the research objects for analysis. The regression model was applied to the areas with high desertification in China to calculate the eco-index.

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Saihanba mode may be applied to build the location of ecological zone using the above model analysis, and the zone scale could be doped out according to the analysis results.

2. Literature Review

Forests are able to absorb carbon dioxide, conserve water, regulate climate, prevent wind and fix sand [1], maintain biodiversity, etc. They play a great role in the terrestrial ecosystem. The rise and fall of forests have an immediate impact on the global economic and social development and ecological environment [2]. The relationship between the forest coverage rate, stock volume per unit area and per capita forest area, however, is not optimistic, far behind the global average level [3].

China attaches more and more importance to ecological environment in the 21st century. Going through theory presentation, scientific appraisal and nowadays national law making, and being in planned construction from 1980s, Saihanba Machinery Forest Farm, guided by national policies and guidelines, has made its goal of sustainable development, that is, clear goals, standard systems, effective practice and outcomes. "Lucid Waters and Lush Mountains Are Invaluable Assets" is a signal of the strategic goal of ecological protection [4].

In 2017, President Xi Jinping made important instructions on the moving deeds of the builders of Saihanba Machinery Forest Farm [5], stating the need to persist in the construction of ecological civilization and strive to build a new pattern of human and nature development [6]. Saihanba Machinery Forest Farm is the largest artificial forest farm in the Beijing-Tianjin-Hebei region, which can prevent sandstorm pollution [7], purify water quality, alleviate pollution and effectively solve environmental problems that damage people's health. Saihanba model, which is of great significance for promotion, can be popularized to the whole country, benefiting to the mass construction of ecological forests [8].

3. Data source and Description

3.1 Data source

Due to the availability and accuracy of data, the sample period was selected from 1990 to 2020. The data involved in this paper come from *China Forestry Statistical Yearbook*, *China Statistical Yearbook on Environment* and statistical yearbooks of provinces and cities. The missing year data here were supplemented by interpolation method.

3.2 Ecological environment evaluation index system model

Based on the characteristics of Saihanba on the evolution of the surrounding ecological environment, the variables with high use frequency that can show the direct impact of Saihanba Machinery Forest Farm from the natural environment, including three primary indexes: soil environment, atmospheric environment and water environment, covering water, land and air levels, were selected in this paper, to comprehensively present the impact of the Farm on the ecological environment. In view of soil

environment, two representative indexes, forest and species, were taken. The atmospheric environment is considered mainly from air quality, dust fall and humidity. Water environment is typically represented by available water resources. Finally, a two-level comprehensive evaluation model, including three primary indexes and six secondary indexes, was established to construct the Saihanba surrounding ecological environment evaluation index system, as shown in Table 1.

Table 1. Evaluation index system

First-level indicators	Secondary indicators	Variable interpretation	Weight	Attribute
Soil environment（0.55）	Forest coverage	Ratio of forest area to total land area	0.28	+
	Species diversity	Ratio of species to individual number in biological community	0.17	+
Atmospheric environment（0.2）	Air quality index	Non-dimensional relative value that comprehensively represents the degree of air pollution or air quality level	0.063	+
	Dustfall	Monitoring of natural precipitation of atmospheric dust	0.048	-
	Relative humidity	Percentage of water vapor pressure in air and saturated water vapor pressure at the same temperature	0.089	+
Water environment（0.25）	Available water resources	Available surface water and groundwater	0.25	+

4. Saihanba Surrounding Ecological Environment Evaluation

4.1 Sample selection

Saihanba is located in Weichang Manchurian Mongolian Autonomous County, the northernmost end of Hebei Province, at E 116°51' - 117°39' and N 42°02' - 42°36'. It is adjacent to Keshiketeng Banner and Duolunduo County in Inner Mongolia to the North and to the West; Yudaokou Farm, Jiangjiadian, Baoyuanjian, Disanxiang and Dahuanqi townships in Hebei Province to the east. It borders upon Yudaokou Farm, Jiangjiadian, Disanxiang, Dazhao Town in Weichang County of Hebei Province [9]. Plateaus and mountains staggered here from sand dunes. To the west is a semi-fixed dune with severe desertification, low vegetation coverage, and high erosion [10]. The areas that were most affected by aeolian sand before the establishment of Saihanba Machinery Forest Farm can roughly be doped out according to the geographical location, wind direction, etc. [11]

To sum up, according to the wind direction and sand source, the most affected regions after the establishment of Saihanba Machinery Forest Farm: 11 cities in Hebei, Beijing, Tianjin and Chifeng City in Inner Mongolia, were selected as the study areas in this paper [12].

4.2 The result of surrounding ecological environment evaluation model of Saihanba machinery forest farm

The evaluation index system of Saihanba surrounding ecological environment as shown in Table 1 was constructed in this paper, and the secondary index data of 14 regions in 3.2 were used to build the evaluation model of the Forest Farm surrounding

ecological environment. Using the General Steps of Grey Evaluation Model to Obtain Evaluation Results, as shown in Table 2 [13].

Table 2. Result of ecological environment evaluation

	1990	2002	2005	2008	2017	2020
Baoding	0.0469	0.0886	0.09764	0.10207	0.11721	0.11949
Beijing	0.05869	0.09548	0.11197	0.0892	0.12116	0.12465
Cangzhou	0.05175	0.08696	0.10297	0.0971	0.11027	0.11552
Chengde	0.05189	0.08316	0.09041	0.10154	0.12151	0.12409
Chifeng	0.05034	0.09206	0.09566	0.10452	0.11981	0.12152
Handan	0.06924	0.08068	0.08594	0.10237	0.13364	0.13499
Hengshui	0.05388	0.07993	0.08929	0.1019	0.12305	0.12646
Langfang	0.05503	0.08807	0.09649	0.09656	0.11457	0.11879
Qinhuangdao	0.0676	0.08392	0.08621	0.09788	0.12069	0.12442
Shijiazhuang	0.05005	0.08557	0.09403	0.09277	0.1253	0.1251
Tangshan	0.04797	0.08169	0.09326	0.10947	0.12735	0.13003
Tianjin	0.04407	0.08214	0.08333	0.09405	0.12846	0.13748
Xingtai	0.06254	0.07997	0.08672	0.09591	0.11896	0.12244
Zhangjiakou	0.04889	0.08786	0.09018	0.1033	0.12244	0.12515

As shown in the chart, the ecological environment score of Beijing in 2005 has far exceeded other regions, reaching 0.11197. Moreover, that of the study area increased rapidly after 2005, and basically went up to 0.1 in 2008, 0.13 in 2020, at the leading level. Therefore, we assume that the restoration of Saihanba was basically completed around 2005, and the ecological environment here has been greatly improved compared with that before and after the restoration.

5. Location Model of Saihanba Ecological Zone

5.1 Primary geographic location of the ecological zone

To popularize Saihanba model around the country, the first is to find the places in sore need of establishing ecological zones according to the degree of desertification and the size of forest coverage rate in China [14], The degree of Desertification and Forest cover are shown in Figure 1.

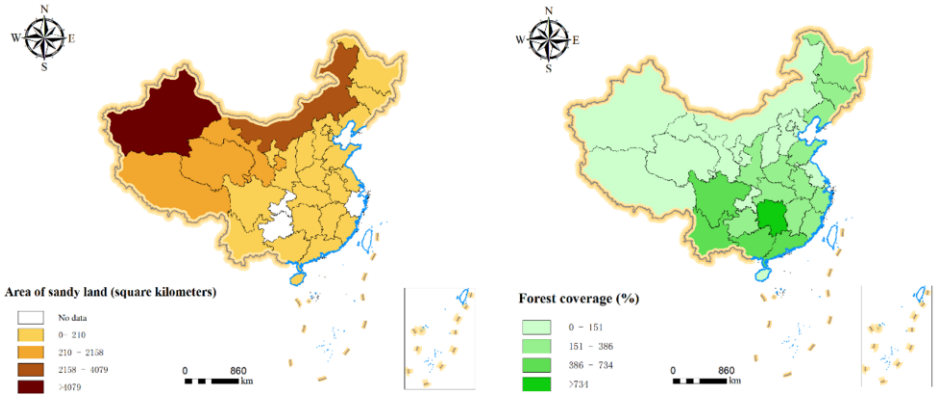

Figure 1. Comparative analysis of desertification

Based on the influence range of desertification in the figure 1 [15], Xinjiang, Inner Mongolia, Qinghai, Tibet, Gansu, Shaanxi, etc., are selected as the preliminary alternative ecological zones. These regions are sorted according to the calculated eco-index, and assessed by the average value of the regions with high ecological environment level.

5.2 Rsei based on multiple linear regression

14 areas with high desertification shown in 5.1 were taken as the study subjects based on the ecological environment evaluation index system in 3.2. A multiple linear regression model was established with the ecological environment scores of 14 areas as explained variables according to the analysis steps in 4.2, and the secondary indexes in table 1 as explanatory variables.

After the joint significance test of six explanatory variables, P=0.009 $<$ 0.05, so the original hypothesis is rejected at 95% confidence level, that is, the joint significance test is passed, and the linearity in this paper is significant.

Moreover, SSR=196, SSE=719, SST=915. We can obtain: $R^2 = 0.7857, \overline{R^2} = 0.7770$

a White test is conducted on the data. Wherein, the original hypothesis of this test: no heteroscedasticity. Using Stata, p=0.0002 $<$ 0.05, so the original hypothesis is rejected at 95% confidence level. Heteroscedasticity is found, which is necessary to be solved.

VIF is used to test multicollinearity. The larger the VIF_m, the greater the correlation between the m_{th} variable and other variables. If VIF $>$ 10, severe multicollinearity is considered in this regression equation. MeanVIF=1.66 $<$ 10, so no multicollinearity is found.

6. Conclusion

6.1 Result of surrounding ecological environment evaluation of Saihanba

In this paper, the scores of each region in the analyzed years were visualized to accurately describe the change trend of ecological environment. The scores of each region in the analysis year are shown in Figure 2.

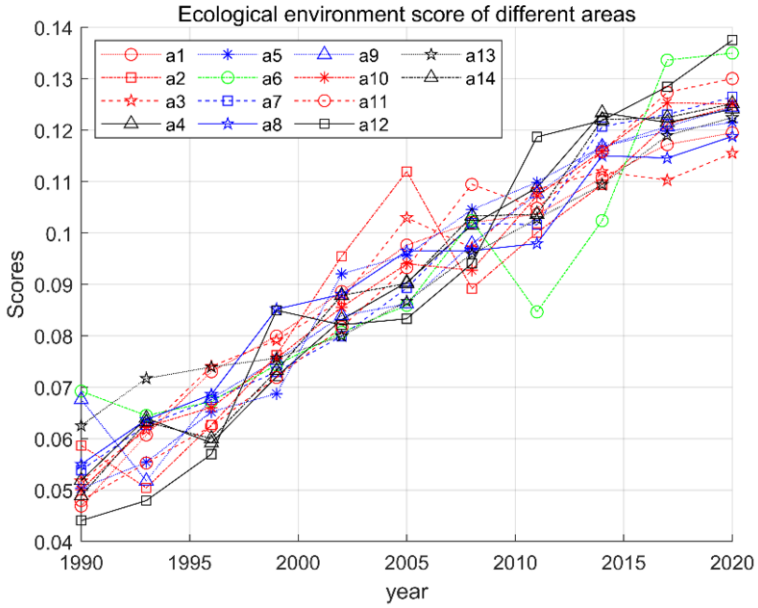

Figure 2. Schematic diagram of ecological environment scores in different regions

As can be seen from this figure 2 The ecological environment was getting better, and obvious improvement was found from 1990 to 2005; the improvement trend was relatively stable in the later stage. It was predicted that the restoration of Saihanba would be basically completed around 2005, and the ecological environment had been greatly improved compared with that before and after restoration. This shows that the establishment of Saihanba Machinery Forest Farm has a significant impact on the surrounding ecological environment without considering other factors.

6.2 Results of ecological location

According to the analysis results in 5.2, the overall regression function of eco-index on whether to establish an ecological zone is finally obtained:

$$y = 0.0372x_1 + 0.1226x_2 + 0.4522x_3 - 0.8654x_4 + 7.982x_5 + 0.2500x_6 + 6.3306$$

The index data of the preliminarily selected ecological zones were substituted into the overall regression equation of the eco-index, and the ecological environment index of 14 regions was obtained, The specific values are visible in Table 3. According to the third category obtained by the clustering, the mean value of the ecological environment index of the areas with high ecological environment level (10.45906) was used as the

standard to judge whether the ecological zone was established. Finally, Xinjiang, Tibet and Gansu were selected to establish ecological zones.

Table 3. Table of eco-indexes

Area	EI	Area	EI	Area	EI
Chengde	19.08361482	Baoding	19.19454922	Handan	18.27936268
Neimenggu	16.5666962	Xizang	9.31863308	Qinghai	16.2023456
Beijing	24.76576088	Cangzhou	16.33053288	Shanxi	15.2089676
Hengshui	15.94753324	Xinjiang	14.029064	Sichuan	18.644014
Gansu	14.7978686	Chifeng	22.98231538	AVE	10.45906

Therefore, the ecological zone is finalized to span three provinces in this paper, covering an area of 1,664,900 square kilometers in Xinjiang, 425,800 square kilometers in Gansu, 1,228,400 square kilometers in Tibet, a total of 3,319,100 square kilometers according to national statistics. In addition to the area suitable for human habitation, the final area of the ecological zone is 983,500 square kilometers. As Saihanba Machinery Forest Farm covers an area of 9,300 square kilometers, the approximate ratio is 1:105, which shows the huge scale.

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