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Research on the Eco-environmental Capability Assessment Model on Statistical Method

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Abstract: The forest coverage rate increased up to 230% in Saihanba Forestry during 40 years. This paper aims to find the reasons for forest success and generalize its experience in management. Firstly, four factors are selected after contacting Saihanba Forestry to obtain data support. After screening out a large number of indicators, weights were established and models were established by statistical methods. Then, the model was applied and analyzed related to the application. Meanwhile, the model is extended to expand the scope of use. The Eco-environmental Capability Assessment Model makes partial predictions for the future, analyzes the impact of common factors on a region, and guides countries to achieve carbon neutrality. Finally, specific and feasible solutions and related suggestions for long-term ecological protection are given based on the model.

1. Introduction

Saihanba Forestry plays an important role in ecological stability. In this paper, the data from this area are used to build models through statistical methods to quantitatively evaluate the impact of the Eco-environmental Capability Assessment Model. On this basis, the benefits of Peking sandstorm are quantitatively evaluated. This study extended the model to the whole country to determine the number and scale of ecological reserves to be built in China. Meanwhile, relevant data from Singapore were collected to determine the geographical location of ecological reserves and assess their impact on greenhouse gas absorption and reduce carbon emissions.

At the same time, possible solutions and suggestions for the construction of ecological protection areas.

2. Model Establishment and Solution

2.1 Saihanba Mechanical Forest

Saihanba Forestry is a very typical national forest park with great social impact, and it was selected as a paradigm for the Global Forest Goals 2021 report. Its management experience is also a good guide to the improvement and management of the ecological environment in the Asia-Pacific region.

2.1.1 Preparation and Factor Selection

Since the determination of data and indicators is more subjective, and we need to ensure the applicability and stability of the data, we set forest coverage, change of precipitation, change of temperature, and change of social or human attention as evaluation indicators based on the consideration of environment, ecology and humanities. The data came from the authoritative official website, and finally the population flow and social concern indexes were not directly measurable, so pytho was utilized to crawl through the web to collect the ecological and leisure data related to the Saihanba National Forest Park and nearby attractions, which required preliminary normalization to transform these data into data with consistent structure for easy storage, ensuring the robustness of the data as much as possible.

2.1.2 Internal Relation

Between the four factors studied, it reflects a common trend in the continuous improvement of the ecological environment of Saihanba Forestry over time since its establishment.

Table 1: Forest coverage

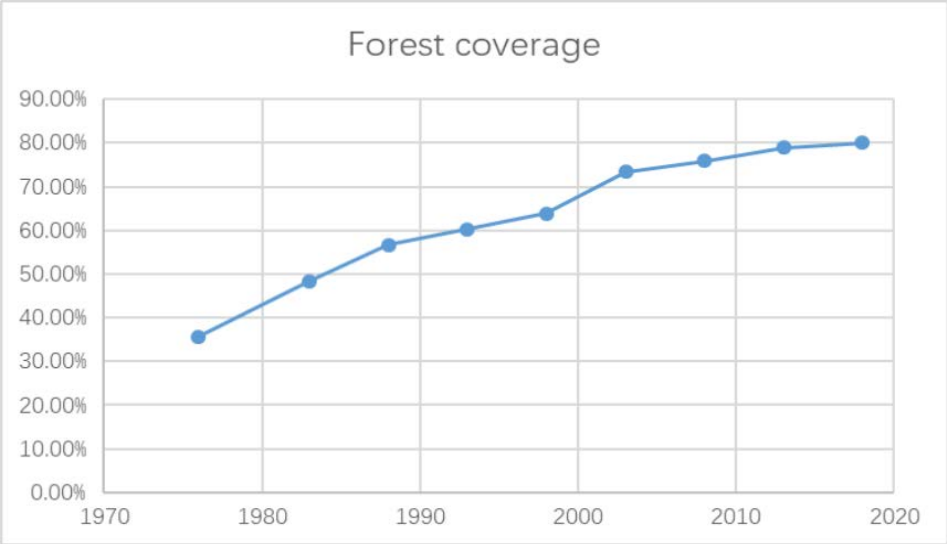
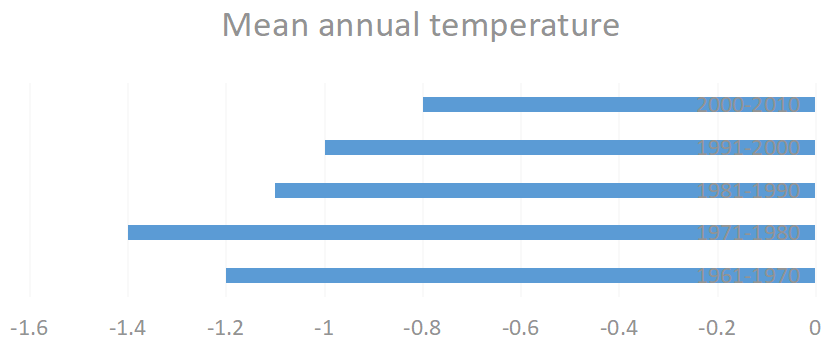


Table 1 shows forest coverage, the R^2 calculated by MATLAB is 0.9721, and the fitted regression equation is.:

$$y_1=0.6306e^{0.03x}-0.4186\dot{e}^{-0.376}$$

In the above equation, x represents the year data, and y1 represents the forest cover.

Table 2: Shows temperature data.



$$y_2 = 0.08571x^2 - 0.4143x - 0.82$$

In the above equation, x represents the year, y_2 represents the average temperature.

Table 3: Statistical Table of Precipitation Growth and Decline

Time/Year	Mean annual precipitation
1961-1970	433.4
1971-1980	413.4
1981-1990	440.8
1991-2000	513.0
2000-2010	463.2

Table 3 shows rainfall. Its goodness-of-fit is 0.9324, and its fitted regression equation is given:

$$y_3 = -14.2x^3 + 126x^2 - 310.9x + 634.8$$

Table 4: Social attention

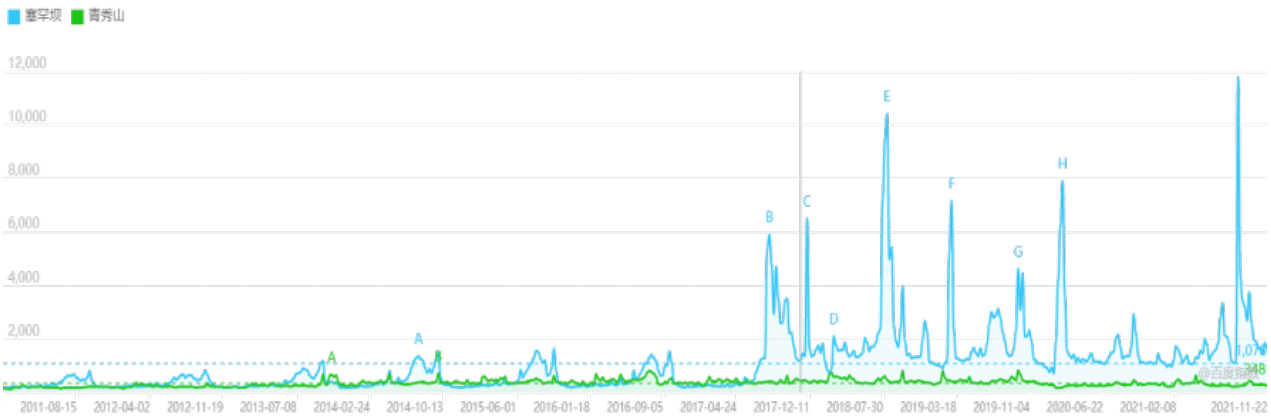


Table 4 shows social attention, we take the trend of the change after Baidu included the Saihamba search keywords, and to reflect the difference, we choose Qingxiu Mountain (a national 5A scenic area) for comparison (Table 4), and use python crawl the number of people's comments and trips on the tourism website as a specific measure for the change of its social attention people flow.

We draw the above conclusions from this study.

2.2 Establishment of Evaluated Model

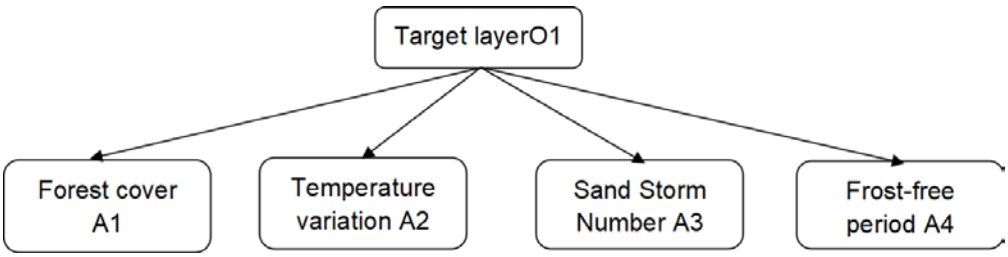


Figure 1: Hierarchy model.

Its research and analysis of environmental improvement in Beijing for changes in $A_1, A_2, A_3, A_4$is conducted using hierarchical analysis to determine the weights below.

$$W_A = \begin{bmatrix} O1 & A_1 & A_2 & A_3 & A_4 \\ A_1 & 1 & 2 & 3 & 4 \\ A_2 & 1/2 & 1 & 2 & 3 \\ A_3 & 1/3 & 1/2 & 1 & 2 \\ A_4 & 1/4 & 1/3 & 1/2 & 1 \end{bmatrix}$$

From the characteristic equation, $W_A - \lambda I = 0$, Using Matlab software to solve the matrix W_A Maximum Eigenvalue: $\lambda_{max} = 4.1541$, The corresponding eigenvectors:

$$W_0 = (0.5383 \quad 0.2227 \quad 0.1492 \quad 0.0898)$$

Since the order of the matrix A is 4th order, the empirical value simulated by the Monte Carlo algorithm shows that the test consistency index is R.I = 0.89, calculating:

$$CI = (\lambda_{max} - 4)/(4 - 1) \approx 0.01$$

Therefore, the consistency ratio index is CR=CI/RI=0.0112, which is much less than 0.1, and it is known that the criterion layer is satisfying consistency for the matrix of the target layer, the construction of the judgment matrix W_A is consistent with the consistency test rules.

Normally, these characteristic values can be used directly as weights to evaluate the influence factors, but the hierarchical analysis used in this method is very subjective, but it is obvious that if the evaluation model can be built as objectively as possible, it will be beneficial to the promotion of the model afterwards, so the fuzzy comprehensive evaluation and hierarchical analysis are used here.

2.3 Model Solving

Calculation of individual factors from the set of factors C, c_n The affiliation degree of the evaluated object's rank, to create a fuzzy relationship matrix R

The W just obtained by analytic hierarchy process is substituted for modeling

A weighted average calculation is used to multiply the weight vector with this fuzzy relationship matrix to obtain the fuzzy comprehensive evaluation result vector of the object under study S=W*R.

A first-order fuzzy integrated evaluation model is used to establish a hierarchy to determine the importance of each indicator, defining a weight of 90 points between 0.8 and 1 (i.e. an eigenvalue of 0.8 scoring 90), 70 points between 0.6 and 0.8, 50 points between 0.4 and 0.6, and 30 points between 0 and 0.4. The combined weight of the scheme layer for the target layer is defined as $W_A = [0.54,0.22,0.15,0.09]$ as a basis, it is known that their scores are about 58, 24, 10, 8.

Construct the score matrix $R_{B1A1}^T = [58,24,10,8]^T$, Then the total score of comprehensive

evaluation can be calculated:

$$S_{\mathrm{A}} = W_A \times \mathrm{R}_{\mathrm{A}}^{T} = 38.82$$

The results of the calculation of individual scores for each indicator are shown in Table 5.

Table 5: Fuzzy comprehensive evaluation score

Evaluation Indicators	Comprehensive score
Forest cover A_1	31.32
Temperature change A_2	5.28
Sandstorm number change A_3	1.5
Frost-free period variation A_4	0.72
Total score S_{A}	38.82

Therefore, the weight size of the fuzzy comprehensive evaluation model established by the four index factors of forest cover, temperature change, sandstorm number change, and seasonal snow and ice cover change in this question is calculated as:

$$\omega_1 = \frac{31.32}{38.82} = 0.81; \omega_2 = \frac{5.28}{38.82} = 0.14; \omega_3 = \frac{1.5}{38.82} = 0.04; \omega_4 = \frac{0.72}{38.82} = 0.02$$

$$U = 0.81 * A_1 + 0.14 * A_2 + 0.04 * A_3 + 0.02 * A_4$$

$$\begin{cases} \mathrm{y}_1 = 0.6306\mathrm{e}^{0.03\mathrm{x}} - 0.4186\dot{\mathrm{e}}^{-0.376} \\ \mathrm{y}_2 = 0.08571\mathrm{x}^2 - 0.4143x - 0.82 \\ \mathrm{y}_3 = -14.2\mathrm{x}^3 + 126\mathrm{x}^2 - 310.9\mathrm{x} + 634.8 \\ y_4 = 2.714x^2 - 1.086x + 15 \end{cases}$$

In the above equation: U denotes the utility function of environmental improvement.; $A_1 = y_1, A_2 = y_2, A_3 = y_3, A_4 = y_4$.

3. Model Evaluation

3.1 Forecast Results

The scope of the research will be further expanded. This study Conduct research and prediction on Nanjingis analyzed by time series ARIMA model for specific air quality index.

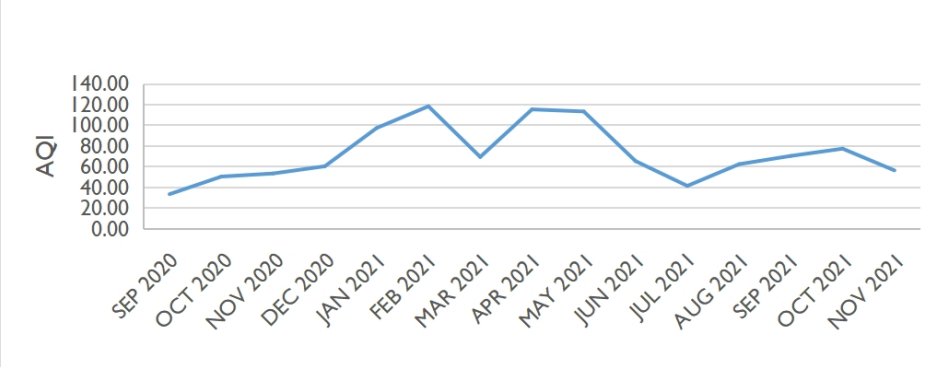


Figure 2: Air quality Index of Nanjing in 2020-2021

The formula is as follows:

$$y'_z = \alpha_0 + \sum_{i=1}^{p} \alpha_i y'_{t-i} + \varepsilon_t + \sum_{i=1}^{P} \beta_i \varepsilon_{t-i}$$

Its autocorrelation coefficient and partial autocorrelation coefficient were made as shown in Figure 3:

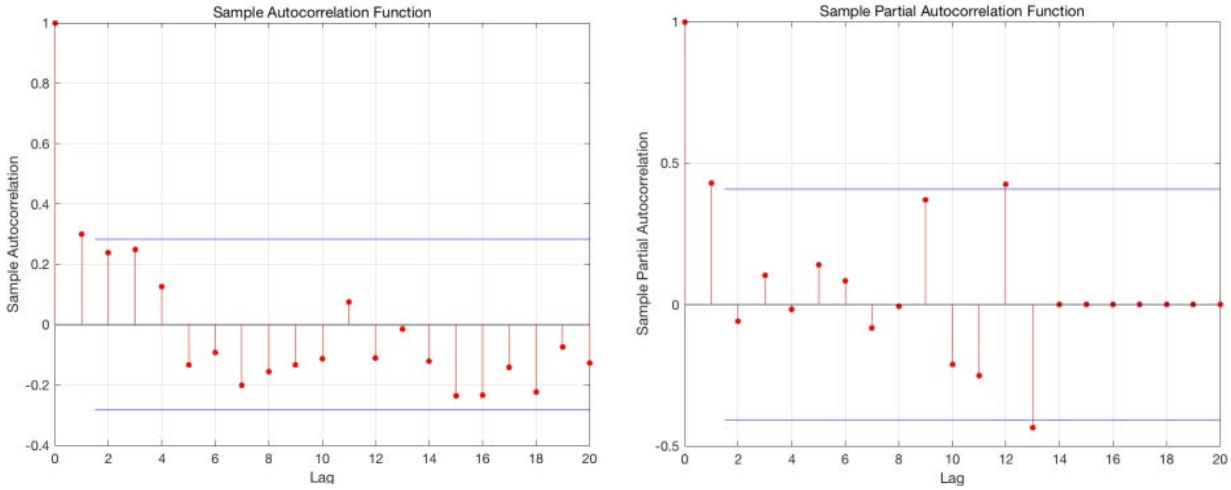


Figure 3: Autocorrelation function graph and partial autocorrelation function graph

The final stable R_2 value obtained was 0.76 and the p-value was greater than 0.05.

Table 6: The AQI index of the next five periods was predicted

Time	AQI
2021/12	81
2022/1	118
2022/2	139
2022/3	90
2022/4	136

It can be seen that the average value of AQI has improved to a certain extent under the specific prediction of ARIMA model, especially at the beginning of next year.

This study also makes predictions for Singapore.

the grey prediction model equation is obtained:

$$x^1(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ai} + \frac{b}{a}, i = 0,1,\cdots,n$$

Table 7: The AQI index of the next ten periods was predicted of Singapore

TIME	AQI	TIME	AQI
2022/1	87.13	2022/7	58.22
2022/2	98.56	2022/8	40.93
2022/3	118.83	2022/9	47.32
2022/4	73.55	2022/10	27.86
2022/5	61.24	2022/11	40.79
2022/6	52.41	2022/12	53.67

Based on Singapore's existing policy assessment, Singapore is expected to experience a reduction in GHG emissions, a small increase in temperature, a longer frost-free period, and a better response

to the global climate change trend in the coming years, and is expected to achieve its goal of zero GHG emissions under the *Global Climate Change Convention* relatively soon.

3.2 Deficiencies

Firstly, the assumptions of the model are relatively strict, and in real life, if there are national policy changes or large natural disasters, the accuracy of the model will be drastically reduced, so the model lacks good robustness. Secondly, in the second question, hierarchical analysis is used to determine the weights of corresponding indicators, which is somewhat subjective and may make the model's results partially biased. The ARIMA model is used in the third question to predict the AQI for the future periods. Due to the systematic error of the ARIMA model, only the beginning periods are guaranteed to be more accurate, and the number of periods predicted is limited.

4. Model Promotion

For the determination of the weights, at the same time can be combined with the entropy weighting method for objective evaluation of the data, if the subjective and objective results are more consistent, the model can be considered robust.We can use the exponential smoothing method or moving average to predict the air quality index at the same time and make a hypothesis test. If the prediction results are basically the same at 95% confidence level, the accuracy of the model can be enhanced, which is beneficial to its further promotion.

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