Research and Application of Multi-model-based Comprehensive Evaluation and Scale Prediction Algorithm for Eco-Regional Economy

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Abstract. This paper establishes a mathematical model to analyze the data of Saihanba area, and establishes a prediction and evaluation model to evaluate the ecological zone planning and carbon neutrality. This paper reviewed a large number of literature and screened out 15 factors, then established a factor screening model based on Pearson correlation coefficient, drew a correlation heat map, and then screened out 8 factors to establish a model for evaluating the impact of Sehampa on the ecological environment based on EWM-TOPSIS. Thirty-four major observation points in China are selected for data collection, then the environmental scores of the 34 observation points are calculated based on the 2020 data, and then the scores are visualized as heat maps. Finally, this paper establishes a time-series prediction model to compare and predict China's current carbon stock, with a view to providing some reference for other fields.

Keywords: EWM, TOPSIS, Evaluation Model, Eco-Regional Economy.

1. Introduction

Green water and green mountains are golden mountains and silver mountains. Historically, the Saihanba was a natural park with abundant water and grass, dense forests, and a large population of animals and birds. Thanks to the efforts of our government, the Saihanba forest has recovered from the desert, and has now become an ecologically friendly green farm with a stable function of preventing sand. The forest coverage of the Saihanba area has reached 80%, providing 137 million cubic meters of clean water to Beijing and Tianjin every year [1]. The ecological environment has been a hot topic in the academic world, and our scholars have made remarkable achievements in their research to carry out work related to environmental performance assessment [2]. The ecological environment consists of various substances of different natures and different states of movement in the living system and environmental system, which is the space for human survival and development, and the core and foundation of regional sustainable development. However, the selection of ecological environment indicators has not resulted in a more complete system. This study is derived from Question C of the 11th Asia-Pacific Regional University Student Mathematical Modeling Competition 2021, which is modeled by various methods and used to evaluate the establishment of the Saihanba Ecological Conservation on the goodness of the local ecology and the impact on the sand and dust storms in Beijing.

2. Construction of EWM-TOPSIS evaluation model

2.1 Factor screening based on Pearson's correlation coefficient

After reviewing a large amount of literature to conduct a factor search and initial screening, this paper identifies the focus and direction of research in the industry as shown in the Figure 1 below.

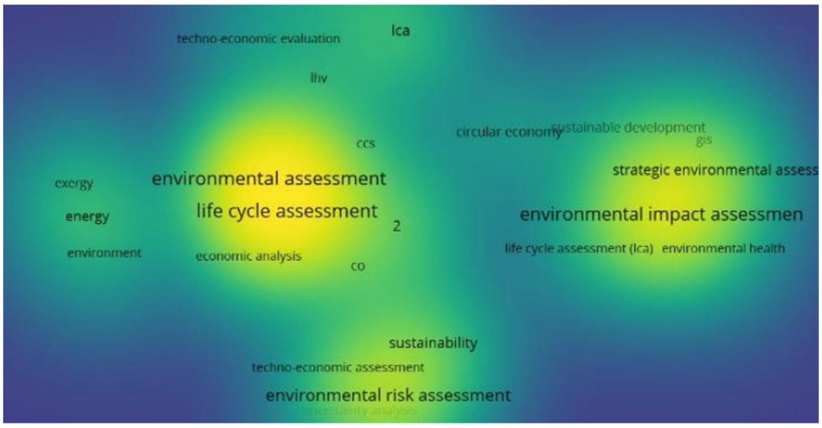

Figure 1. Industry research hotspot map

Pearson Correlation Coefficient (Pearson Correlation Coefficient) is used to measure whether two data sets are on a line, and it is used to measure the linear relationship between distanced variables. The calculation formula is [3]:

$$\mathrm{r} = \frac{N\sum x_i y_i - \sum x_i y_i}{\sqrt{N\sum x^2 - (\sum x_i)^2}\sqrt{N\sum y^2 - (\sum y_i)^2} \qquad (1)$$

The greater the absolute value of the correlation coefficient, the stronger the correlation: the closer the correlation coefficient is to 1 or -1, the stronger the correlation degree, and the closer the correlation coefficient is to 0, the weaker the correlation degree [4]. Under normal circumstances, the correlation strength of variables is judged by the following value ranges as shown in the Table 1 below [5]:

Table 1. Correlation coefficient

Correlation Coefficient	Strength
0.8 – 1.0	Extremely strong
0.6 – 0.8	Powerful
0.4 – 0.6	Medium
0.2 – 0.4	Weak correlation
0.0 – 0.2	Not relevant

In this paper, we have collected data through the official website and analyzed the relationship between the factors and their relationship with the factors and their relative relationship with the environment.

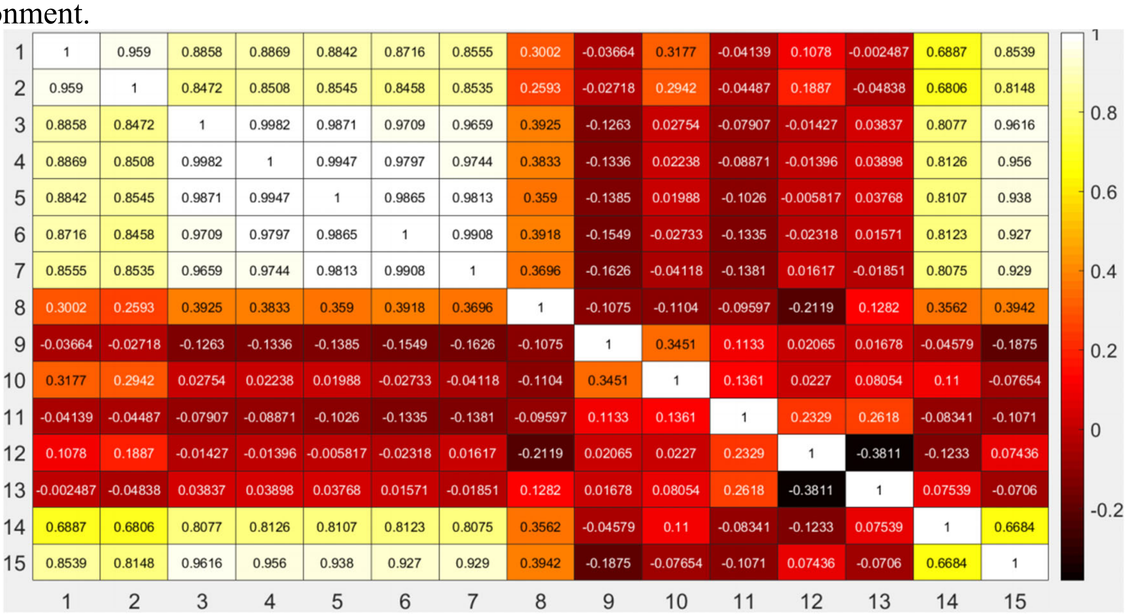

Figure 2. Factor correlation analysis

Table 2. Evaluation system of Saihanba's impact on the ecological environment

First-level index	Secondary indicators	Three-level indicators
Evaluation system of Saihanba's impact on the ecological environment	Water resources	Sewage treatment rate
		Precipitation
		Water demand gap per capita
		Water quality compliance rate
	Air	PM10
		City Air Quality API
	Greening	Urban greening rate
		Green area per capita

2.2 Evaluation model based on EWM-TOPSIS method

After obtaining the data of each indicator, in order to describe the quantitative trend of the target, this paper adopts the method of TOPSIS and entropy weight to calculate the comprehensive indicator parameters [6]. First, we need to use the entropy weight method to weight the indicators in the evaluation system to obtain the proportion of each indicator parameter in the evaluation system (100% overall). The entropy weight method is less subjective and can make full use of the characteristics of the data.

Step 1: Normalize.

$$p_{ij} = \frac{M_{ij}}{\sum_{j=1}^{n} M_{ij}} \tag{2}$$

Step 2: Calculate the information entropy weight of each factor.

$$E_i = -\ln(n)^{-1} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{3}$$

The information entropy weight is a measure of the degree of disorder. The larger the information entropy weight, the stronger the disorder of the corresponding parameters, which means that the index has a greater impact on the evaluation system [7].

Step 3: Calculate the weight of each indicator r.

$$Q_i = \frac{1-E}{\sum_{i=1}^{N} (1-E_i)} (i = 1,2,3 \dots \dots) \tag{4}$$

Step 4: Calculate the weight of each indicator in the index.

$$w = \sum_{i=1}^{k} Q_i M'_{ij} \tag{5}$$

Step 5: Construct a decision matrix.

Step 6: Standardize the decision matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{6}$$

Step 7: Establish a weighted decision matrix.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & \vdots & & \vdots & & \vdots \\ v_{i1} & v_{i2} & \cdots & v_{ij} & \cdots & v_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mj} & \cdots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_j r_{1j} & \cdots & w_n r_{1n} \\ \vdots & \vdots & & \vdots & & \vdots \\ w_1 r_{i1} & w_2 r_{i2} & \cdots & w_j r_{ij} & \cdots & w_n r_{in} \\ \vdots & \vdots & & \vdots & & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_j r_{mj} & \cdots & w_n r_{mn} \end{bmatrix} \tag{7}$$

Step 8: Calculate the positive and negative ideal value.

$$A^{+}=\left\{\left(\max_{i} v_{ij} \mid j\in J\right),\left(\min v_{ij} \mid j\in J'\right) \mid i\in M\right\}=\left\{v_1^{+},v_2^{+},\cdots,v_j^{+},\cdots,v_n^{+}\right\}$$
$$A^{-}=\left\{\left(\min_{i} v_{ij} \mid j\in J\right),\left(\max_{i} v_{ij} \mid j\in J'\right) \mid i\in M\right\}=\left\{v_1^{-},v_2^{-},\cdots,v_j^{-},\cdots,v_n^{-}\right\} \quad (8)$$

Step 9: Calculate the distance between each value and the positive and negative ideal value.

$$S_{i^+}=\sqrt{\sum_{j=1}^{n}\left(v_{ij}-v_j^{+}\right)^2}, i\in M$$
$$S_{i^-}=\sqrt{\sum_{j=1}^{n}\left(v_{ij}-v_j^{-}\right)^2}, i\in M \quad (9)$$

Step 10: Calculate the relative closeness of each plan.

$$C_{i^+}=\frac{S_{i^-}}{S_{i^-}+S_{i^+}}, 0<C_{i^+}<1, i\in M \quad (10)$$

First, the entropy weight algorithm is used to calculate the weight of the indicator, and then the team analyzes the attributes of the indicator system [8].

Table 3. Evaluation system of Saihanba's impact on the ecological environment

First-level index	Secondary indicators	Three-level indicators	E-weight (%)
Evaluation system of Saihanba's impact on the ecological environment	Water resources	Sewage treatment rate	11.15
		Precipitation	13.26
		Water demand gap per capita	-11.07
		Water quality compliance rate	8.71
	Air	PM10	-14.30
		City Air Quality API	15.62
	Greening	Urban greening rate	14.68
		Green area per capita	11.21

Then we calculate the entropy weights from 1975 to 2020 according to the weight calculation table, and visualizes the data as shown in the figure below. It can be found that the overall environmental weight of my country has increased almost linearly after 1980, and the entropy weight in 2020 has increased by compared with the low point weight in 1980.

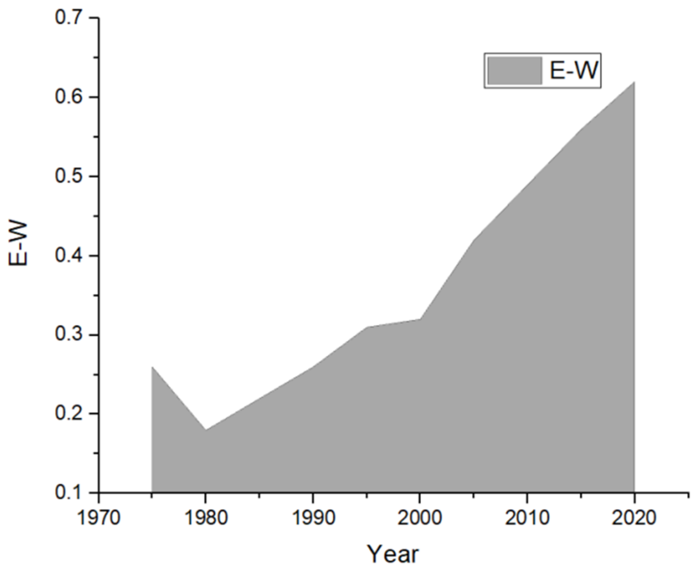

Figure 3. Entropy weight of my country's environmental assessment from 1975 to 2020

3. Evaluation of Beijing's Dust Control Capability

3.1 Sand and dust index definition

We need to select appropriate indicators, collect relevant data, establish a mathematical model to evaluate the impact of Saihan Dam on Beijing's anti-dust ability, and quantitatively evaluate Saihan Dam's anti-dust effect in Beijing. First, we defined the sand and dust index in Beijing. The selected reference indicators include the annual average concentration of inhalable particulate matter and fine particles (μ g/m3), the annual average concentration of sulfur dioxide (μg/m^3), and the annual average of nitrogen dioxide. The concentration value (micrograms/cubic meter), precipitation (mm), average wind speed (m/s) and the number of rainy days, the team normalized each parameter and gave the following definition of sand and dust index.

$$S = \frac{x_1+x_2+x_3}{J*N+V} \tag{11}$$

Then we calculated the Beijing sand and dust index from 1980 to 2020 according to the calculation formula, and analyzed the correlation with the parameters selected. The visualization is as follows.

Figure 4. Factor correlation analysis

Table 4. Evaluation system of Saihanba's impact on the ecological environment

First index	Secondary indicators	Third level indicators
Saihanba's anti-dust effect in Beijing	Water resources parameters	Precipitation
	Air parameter	PM10
		City Air Quality API
	Greening parameters	Urban greening rate

3.2 Evaluation model based on EWM-TOPSIS method

First, the entropy weight algorithm is used to calculate the weight of the indicator, and then we analyze the attributes of the indicator system.

Table 5. E-W of Saihanba's impact on the ecological environment

First index	Secondary indicators	Third level indicators	E-W
Saihanba's anti-dust effect in Beijing	Water resources parameters	Precipitation	28.97%
	Air parameter	PM10	-26.89%
		City Air Quality API	22.46%
	Greening parameters	Urban greening rate	21.68%

Then we calculates the entropy weights from 1975 to 2020 according to the weight calculation table, and visualizes the data as shown in the figure below. It can be found that the wind and sand control index in Beijing area has an entropy weight in 2020 that is 268.84% higher than the low point weight in 1975.

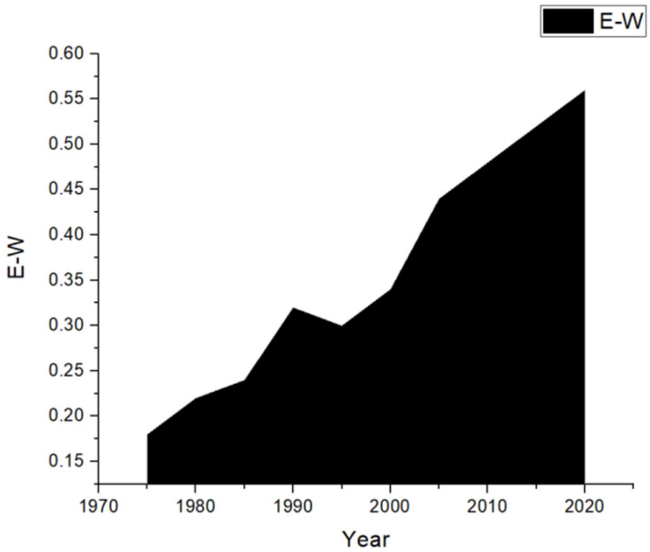

Figure 5. Entropy weight of Beijing's ability to prevent wind and sand assessment

4. Nationally based environmental assessment model

4.1 Collection and processing of data in major cities

We need to establish a mathematical model and collect relevant data to determine which geographical locations in China need to establish ecological zones, determine the number or scale of the proposed ecological zones, and assess its impact on China's carbon neutrality goals.

This article selects 34 major observation points across the country for data collection. The specific observation points are visualized as shown in the figure below.

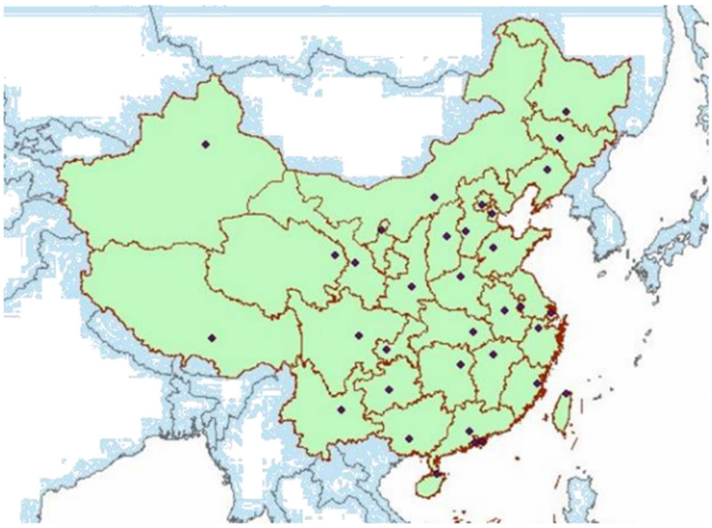

Figure 6. 34 Visualization of observation points

Then we calculated the environmental scores of 34 observation points based on the 2020 data, and visualized the scores in a heat map as follows. The closer the color is to the warm color, the lower the environmental score, and the need to build an ecological park.

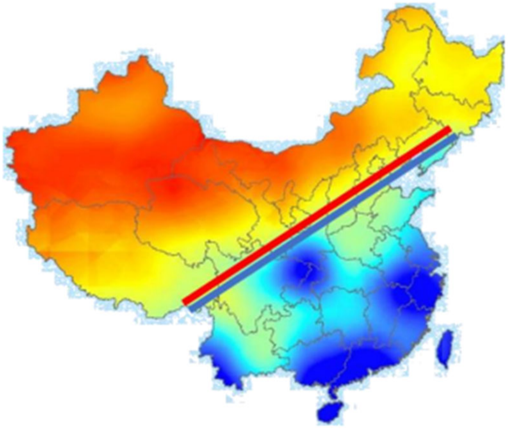

Figure 7. Visualization of the national environmental rating heat map

Hainan Province's score is 1, which can be used as a reference value to predict the area of other provinces. Then we went to the official website of the Hainan Provincial Bureau of Statistics and Statistics http://stats.hainan.gov.cn/tjj/tjsu/ for the area of nature reserves (ten thousand Hectares) is about 6,660,600 hectares.

Xinjiang scores 16.86, and it is recommended to establish a nature reserve of 666.06*16.86 = 11.2297716 hectares.

Qinghai scored 8.64. It is recommended to establish a nature reserve of 666.06*8.64 = 57,547,584 hectares.

Gansu scored 6.32, and it is recommended to establish a nature reserve of 666.06*6.32 = 4,204,992 hectares.

Inner Mongolia scored 11.48, and it is recommended to establish a nature reserve of $666.06 * 11.48 = 76{,}463{,}688$ hectares.

With a score of 5.34 in Tibet, it is recommended to establish a nature reserve of $666.06 * 5.34 = 35{,}567{,}604$ hectares.

4.2 Comparison and prediction of carbon neutrality

This paper establishes a time prediction model to compare and predict my country's current carbon storage capacity.

If the time series consists of the preceding numerical values and random items, that is: c

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + u_t \tag{12}$$

$$y_t = \varphi_1 B y_{t-1} + \varphi_2 B^2 y_{t-2} + \cdots + \varphi_p B^p y_{t-p} + u_t \tag{13}$$

$$\varphi B = 1 - \varphi_1 B - \varphi_2 B^2 - \cdots - \varphi_p B^p \tag{14}$$

The model is transformed into:

$$\varphi(B)\mathrm{y}_1 = u_1 \tag{15}$$

The stationary condition of the model is that all the solutions of $\Phi(\mathrm{B})$ are outside the unit circle, that is, its value is greater than 1. If the value of the time series is a linear function of its current value and the random term, then:

$$y_t = \mu_t - k_1 u_{t-1} - k_2 u_{t-2} - \cdots - k_q u_{t-q} \tag{16}$$

If the above formula is satisfied, the sequence can be called a moving average sequence, where q is the order of autoregressive. By introducing a lag operator, the function can be transformed into:

$$y_t = k(B) u_t \tag{17}$$

If a time series value is a linear function of the previous data, the current random item, and the previous random item, that is:

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + u_t - u_t + k_1 u_{t-1} + k_2 u_{t-2} + \cdots + k_q u_{t-q} \tag{18}$$

The sequence is called the autoregressive moving average sequence, and the p and q in the formula are called the autoregressive moving average order. The parameters Φ and K are called autoregressive moving average coefficients. Then introduce the lag operator, the function can be converted to:

$$\varphi(B)y_t = k(B)u_t \tag{19}$$

The model's stationarity judgment condition is that the roots of autoregressive and moving average polynomials are all outside the unit circle. The following article briefly describes the time series forecasting steps of ARIMA:

Step 1: Variance test

According to the time series data provided in the attachment of this article, calculate the autocorrelation and partial correlation and perform the variance test to judge the stability of the data;

Step 2: Judgment of the stability of the time series

When the time series signal is unstable, the model needs to differentiate the time series, and then calculate the autocorrelation and partial correlation, until the value tends to zero;

Step 3: Model identification

According to the distribution of the calculated function in the time series, select the corresponding function model and determine the order of the model;

Step 4: Parameter estimation

After determining the sequence, determine the parameters of the model;

Step 5: Model verification and prediction

After determining the parameters, the model is used to analyze the residuals of the model, and the obtained model is used for predictive analysis. Obtain a comparison chart of carbon stocks for maintaining the status quo and adding ecological zones. By 2025 , China's carbon stocks will be reduced by .

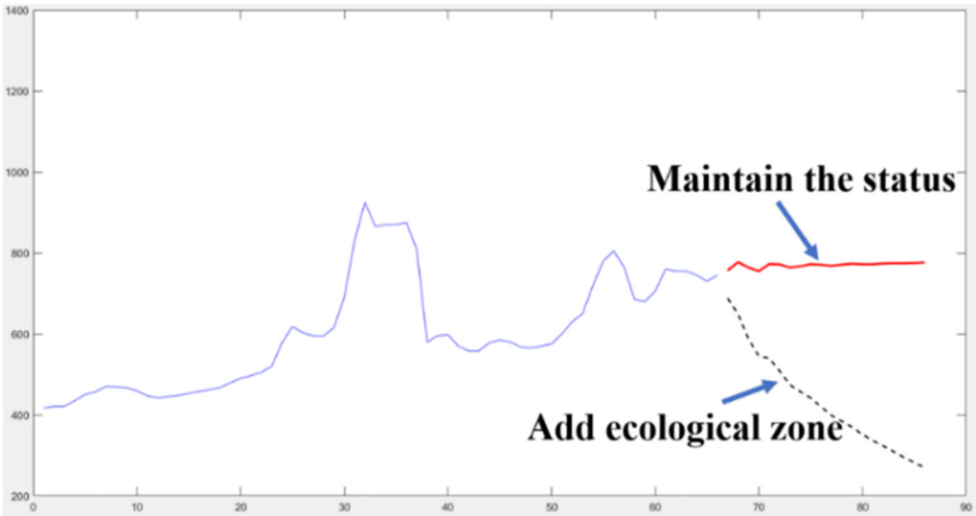

Figure 8. Comparison of total carbon

5. Conclusions

This paper establishes a mathematical model to analyze the data of Saihanba area, and establishes a prediction and evaluation model to evaluate the ecological zone planning and carbon neutrality. This paper reviewed a large number of literature and screened out 15 factors, then established a factor screening model based on Pearson correlation coefficient, drew a correlation heat map, and then screened out 8 factors to establish a model for evaluating the impacts of Sehampa on the ecological environment based on entropy weights-TOPSIS. The entropy weights for the year 2020 increased by

268.84% compared with the low-point weights for the year 1975. Thirty-four major observation points in China were selected for data collection, then the environmental scores of the 34 observation points were calculated based on the 2020 data, and then the scores were visualized as heat maps. Finally, this paper established a time-series prediction model to compare and predict China's current carbon stock, and the environmental scores of the four observation points were calculated based on the 2020 data. It is expected that China's current carbon stock will decrease by 28.6% by 2025.

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