ISSN: 2414-1895 DOI: 10.6919/ICJE.202207_8(7).0087

Influence of Saihanba Forest Farm on Regional Ecological Environment

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Abstract

In this paper, we have studied the impact of Saihanba forest farm on the regional ecological environment over the years. By establishing the mathematical model of the influence of Saihanba area over the years, it is analyzed by using the ARCGIS spatial analysis method and the TOPSIS method. Specifically, an index evaluation system was established, and the impact on the surrounding environment before and after the Saihan Dam was visually analyzed by using the methods of ARCGIS and Kriging. Using the TOPSIS model based on information entropy, the correlation between the Saihanba forest farm and the ability to resist sand and dust was analyzed. Finally, the TOPSIS method is used to establish the weights of the relevant indicators. And use polynomial regression analysis to predict the impact of carbon neutrality in China.

Keywords

ARCGIS; TOPSIS; Entropy Weight Method (EWM); SPSS; Kriging Method; Polynomial Regression Analysis.

1. Introduction

China is committed to implementing the strategy of sustainable development, improving the mechanism for coordinating ecological progress, and building an ecological progress system. China is committed to transforming its economic and social development into all-round green growth, and building a beautiful country. With the help of the Chinese government, Saihanba forest farm has been brought back to life from the desert. Great changes have taken place in the ecological environment since 1962. The forest area of Saihanba mechanical forest farm increased from 240,000 mu to 1.155 million mu, the forest coverage rate increased from 11.4 percent to 82 percent, and the forest stock increased from 330,000 cubic meters to 10.368 million cubic meters. Each year, it contains 284 million cubic meters of water, absorbs 863,300 tons of carbon dioxide and releases 598,400 tons of oxygen. It has built the world's largest artificial forest, creating a solid green ecological barrier for the Beijing-Tianjin-Hebei region.

In this paper, based on the “national environmental protection standard of the people's republic of china” HJ 192-2015 [1], an index and evaluation system is established, and the ARCGIS and Kriging methods are used to visualize the impact of the surrounding environment before and after the Saihan Dam [2]. In addition, using SPSS software to carry out regression analysis on Saihanba's ecological environment state index and sand-dust index, the influence of Saihanba forest farm on sand-dust resistance in Beijing is obtained from the macro level. Using ARCGIS to obtain the data distribution of relevant weather stations in Beijing, and using ARCGIS to establish a geographic model of the impact of Saihanba on the sand and dust resistance in Beijing. Finally, the weighted overlay analysis was carried out using ARCGIS software to visualize the overall distribution of china's ecological environment, and the polynomial regression prediction model was used to analyze the impact of the establishment of ecological reserves on china's carbon neutrality.

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2. Ecological Environment Status Evaluation Index System

The model building process is shown in the Fig.1, which includes biological richness index, vegetation coverage index, water network density index, land stress index, pollution load index and an environmental limitation index.

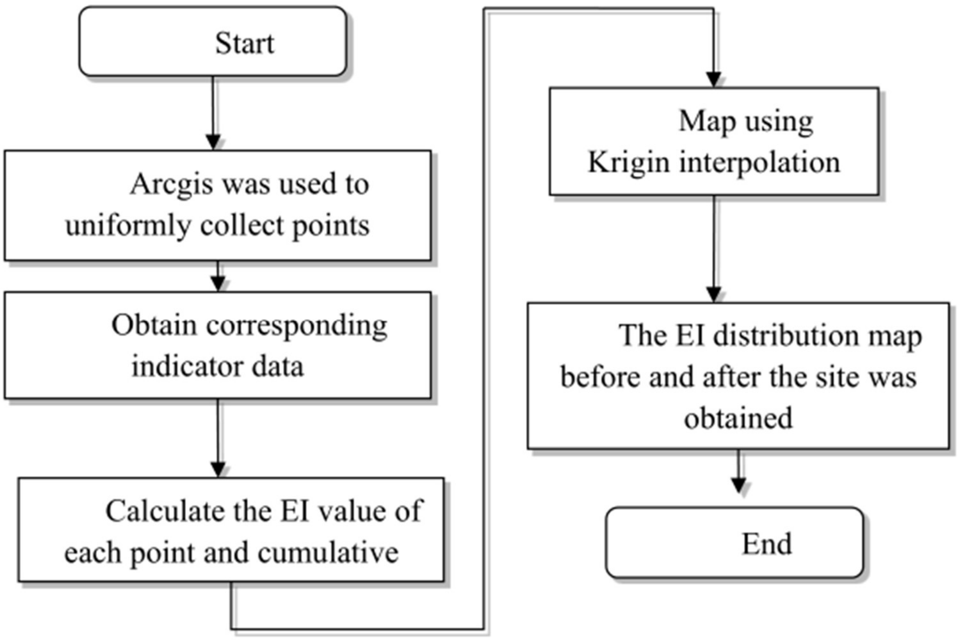

Fig. 1 Schematic diagram of the model building and solving process

We use ARCGIS to uniformly collect chengde city to obtain the ecological environment impact indicators of each point, which is shown in Fig.2.

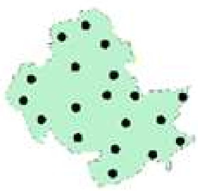

Fig. 2 Use ARCGIS to collect evenly geographically in chengde city

The Kriging method is an advanced geostatistical processing method that generates an estimated surface from a set of discrete points with z-values. Unlike other interpolation methods in the Interpolation toolset, the kreggin tool can efficiently study the interaction between z-value representations of the spatial behavior of a phenomenon, and then select the best estimation method to generate an output surface, which can be expressed as:

$$\hat{Z}(so) = \sum_{i=1}^{N} \lambda_i Z(s_i) \quad (1)$$

Volume 8 Issue 7, 2022
DOI: 10.6919/ICJE.202207_8(7).0087

The process for bringing the index we set up into ARCGIS is shown in Fig.3.

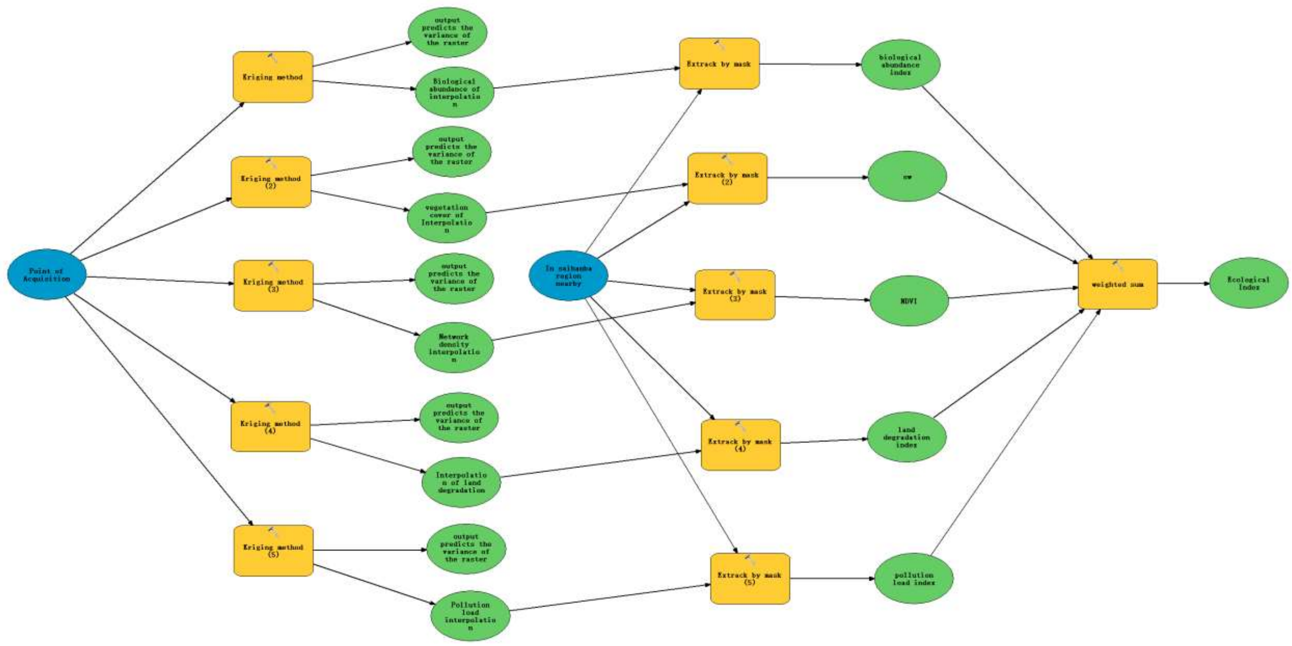

Fig. 3 Chriskin interpolation process

According to the evaluation criteria in the “national environmental protection standard of the people's republic of china HJ 192-2015”, we draw the EI distribution of chengde city into a graph, as shown in Fig.4 and Fig.5.

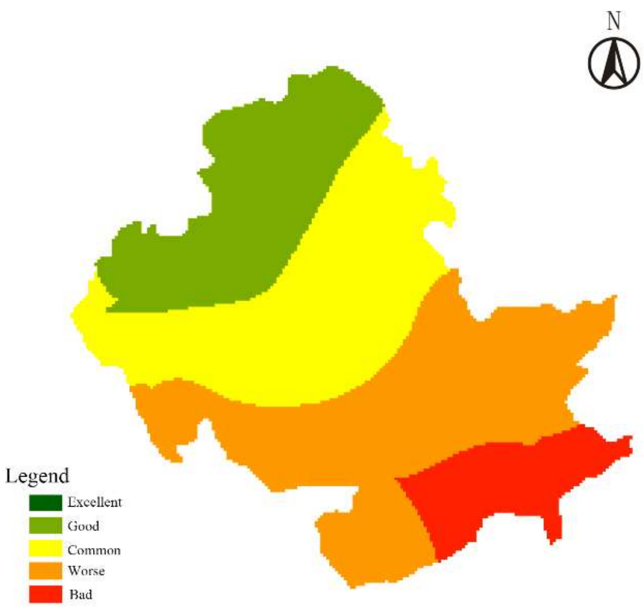

Fig. 4 Distribution of EI in chengde city in 1962

From Fig.4 and Fig.5, it can be seen that from 1962 to the present, with the gradual expansion of Saihanba forest farm, the EI status of Saihanba forest farm itself has gradually increased, and the EI value of chengde city, where Saihanba is located, has also risen.

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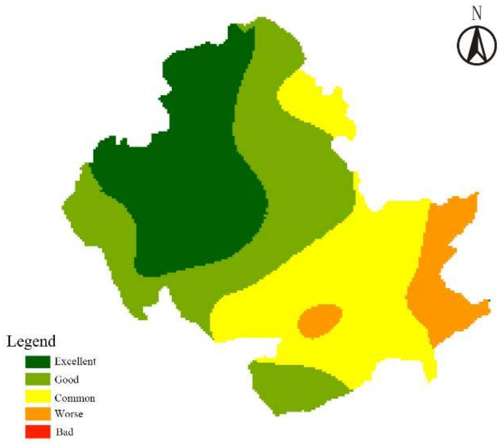

Fig. 5 Distribution of EI in chengde city in 2020

3. Establish Evaluation System with EWM

Entropy weight method is an objective weighting method, which uses entropy weight method to express the relative importance of evaluation indicators. This method is to determine the weight of the index according to the size of the information load of each index, which is completely based on the characteristics of the data itself. It is believed that the greater the degree of difference in evaluation indicators, the greater the amount of effective information provided by the indicator, and the correspondingly greater the weight of the indicator. On the contrary, the weight of the indicator is smaller. It has the advantages of small amount of calculation, can comprehensively consider the connection between multiple evaluation objects of the same index, weaken the influence of outliers, etc., and reduce the interference of human subjectivity on the evaluation process. In the establishment of the evaluation question, we believe that the greater the degree of change in the index, the more it can reflect the changes in the impact of sandstorms in Beijing from 1965 to 2021. Quoting Beijing's annual dust, floating dust, sandstorm days, and annual average PM10 particle data from 1965 to 2021.

In order to eliminate the influence of the dimensional difference of various indicators on the evaluation results, the data needs to be standardized first, and all the indicators need to be normalized. The formula for standardization can be expressed as:

$$x_{ij} = (\max[a_{ij}] \,|j \in J - a_{ij}) / (\max[a_{ij}] \,|j \in J - [\min a]_{ij} \,|j \in J) \tag{2}$$

where $\max[a_{ij}] \,|j \in J - a_{ij}$ represents the maximum value of j index, and $[\min a]_{ij} \,|j \in J$ represents the minimum value of j index.

Then calculate the specific gravity y_{ij} of i data under j index:

$$y_{ij} = (x_{ij}') / (\sum_{i=1}^{m} x_{ij}') \quad (0 \le y_{ij} \le 1) \tag{3}$$

Thus, the specific gravity matrix of the data is:

$$Y = \{y_{ij}\}_{(m \times n)} \tag{4}$$

The information entropy of each index can be expressed as:

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$$e_j = K\sum_{i=1}^{m} y_{ij} \ln y_{ij} \tag{5}$$

The weight of j can be calculated as:

$$w_j = (1 - e_j)/\sum_{i=1}^{m}[(1 - e_j)] \tag{6}$$

TOPSIS method is to draw up the optimal scheme A* and the negative ideal scheme A- on the basis of weighted normalized matrix, and determine the relative distance of each scheme A*and A-, so as to determine the priority of decision-making schemes by relative distance. The ideal solution is the virtual best solution, and the negative ideal solution is the virtual worst solution. By comparing the distance between each calculation scheme and the ideal scheme and the negative ideal scheme, the scheme that is both close to the ideal solution and far away from the negative ideal solution is the best scheme.

Vector normalization can be expressed as:

$$r_{ij} = x_{ij}/\sqrt{\sum_{i=1}^{m} x_{ij}^2} \tag{7}$$

By using EWM and TOPSIS methods, an evaluation model of dust change in Beijing was established. We found that the influence of dust in Beijing gradually decreased from 1965 to 2020.

We used SPSS to conduct regression analysis between the ecological environment index of Saihanba and the dust index of Beijing, and quantified the relationship between the ecology of Saihanba forest farm and the dust in Beijing. We standardized the ecological index of Saihanba from 1965 to 2021 with the dust index of Beijing, which can be expressed as:

$$EI' = (EI - \overline{EI})/S_{EI} \tag{8}$$

where $\overline{EI}$ represents the average value of EI from 1965 to 2021, and S_j represents the standard deviation of EI from 1965 to 2021.

Taking the standardized Saihanba ecological environment index EI' as the independent variable and the standardized Beijing dust index as the dependent variable, SPSS software was used for regression analysis, and the results obtained are shown in Fig. 6 and Fig. 7.

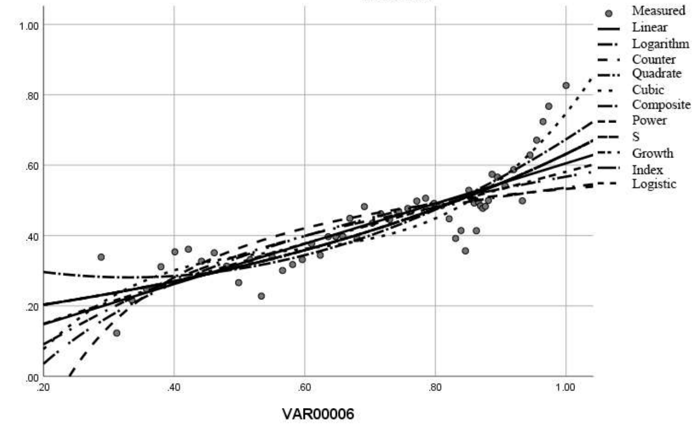

Fig. 6 Fitting graph for regression analysis

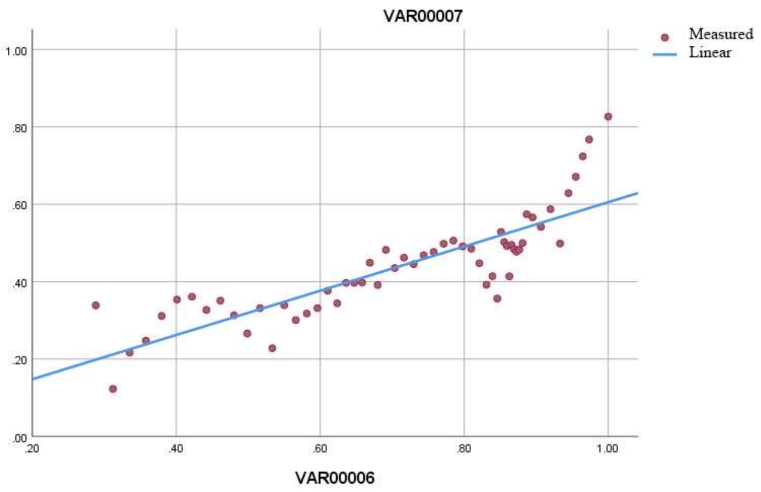

Fig. 7 Fitting graph of linear regression equation

The regression analysis equation is:

$$Q = 0.5718123980088752 * [EI]^{\wedge\prime} + 0.03339854941092468 \tag{9}$$

According to SPSS regression analysis, we found that from 1965 to 2021, the cubic equation fitted Saihanba ecological environment status index and Beijing dust index best $S2$ =0.810. Linear fitting $S2$ =0.715, the linear fitting is within the acceptable range. In the Fig.6 and Fig.7, we found that the ecological environment status index of Saihanba was positively correlated with the dust index of Beijing. The better the ecological environment management of Saihanba is, the less the influence of dust on the ecological environment of Beijing.

4. Influencing Factors

We use remote sensing satellites for data acquisition indicators, which is shown in Fig.8.

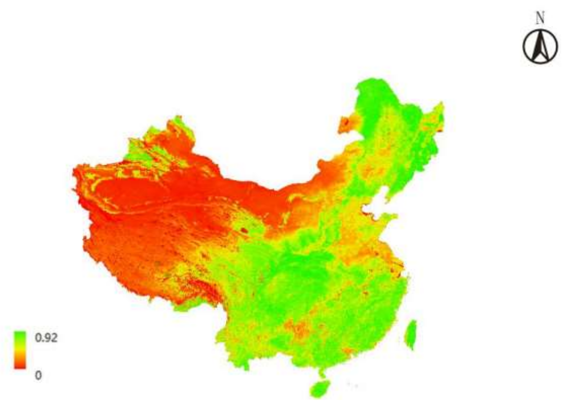

Fig. 8 Distribution map of vegetation coverage in china

Then we use ARCGIS software for weighted overlay analysis of the data, and calculate the value of ERI for each region and finally get the overall distribution of the national ecological environment, which is shown in Fig.9.

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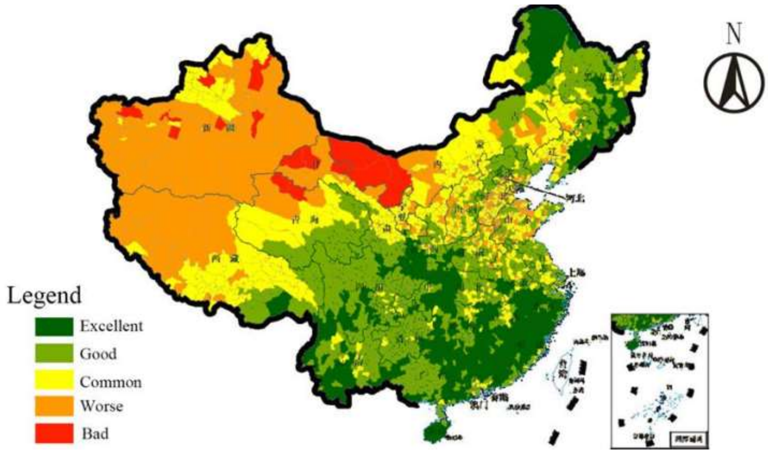

Fig. 9 Schematic diagram of establishing the scope of ecological protection zone

In Fig.9, the red area is the establishment area of the ecological reserve. According to the estimated area based on satellite images, the area of the protected area that needs to be established is about 40,000 square kilometers.

Collecting data on the absorption of CO2 in Saihanba. According to the relationship between ERI and the reduction of CO2 emissions, perform polynomial regression to predict the amount of co2 absorption when ERI is less than 20.

We can get the cubic equation is:

$$E\_co2 = (0.0009 * ERI^3 - 0.0317 * ERI^2 + 0.4875 * \mathrm{ERI} + 0.0318) \times 10.6 \quad (10)$$

According to the satellite image data, we further subdivide the red area into three different areas, with EI values of 0-7, 7-14, 14-20. Cambodia is rich in tropical forest resources, and its forest resource status has a certain influence on the Indochina Peninsula and even Asian forests. However, they are still facing related problems such as land desertification, declining forest coverage, and carbon emissions. Studying the mathematical model established by Cambodia's ecological zone is not only of great significance to the sustainable development of Cambodia, but also of great significance to the improvement of the environmental status of the surrounding areas [3].

Using ARCGIS to obtain relevant indicator data of Cambodia, and draw the ERI map of Cambodia, which is shown in Fig.10.

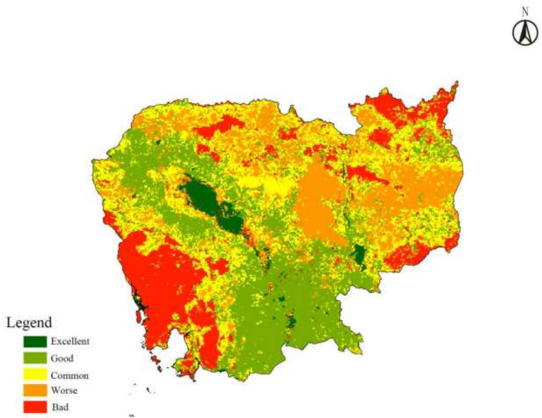

Fig. 10 ERI distribution map of Cambodia

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From Fig.10, the red area is the area where Cambodia needs to establish an ecological protection zone. According to the estimated area based on satellite images, the area that needs to be established is about 18,000 square kilometers. Cambodia has an area of 18,000 square kilometers of red areas, in which protected areas have been established, Take the average value of 11 for the ERI in the red zone to calculate the E_{co2} = 505710 of the red zone in Cambodia.

After the establishment of protected areas in these areas, the ecological environment of the red area developed to the orange area is E_{co2} =1340425.5. CO2 absorption and emissions increase every year is ΔE_{co2} = 834715.5.

5. Conclusion

In this paper, we use satellite remote sensing technology and ARCGIS software to combine a series of classical mathematical models to develop process, ecological environment indicators and other methods and key technologies for system construction, to provide a reference for the real-time dynamic evaluation and scientific response of the ecological environment in the future. At the same time, the data is visually reflected in the spatial position. Based on the influence of Saihanba on surrounding environmental factors, the model is gradually extended to the whole country, and eventually to other countries in East Asia. It provides a reference for my country and other countries to establish ecological reserves and achieve future carbon neutrality goals.

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