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Research on Smart Forest with Less Carbon Using Multiple Linear Regression Models and TOPSIS Entropy

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Abstract: In the era of rapid development of the Internet, climate change is an increasingly serious threat to carbon dioxide emissions and fixed amounts and human health, and its governance problems need to be solved urgently. Based on forest data from 193 countries by the World Bank, we first developed carbon sequestration models that determine the amount of carbon dioxide sequestration in forests. Then with K-Means++ and system clustering models, we combined the comprehensive scores of the three major indicators of nature, economy and society under the TOPSIS entropy rights law, SPSS software and the decision-making evaluation model of integrated forest management to evaluate the use value of forests. Finally, combining the positive impact of harvesting on forest management and the macro and micro impacts under the comprehensive forest management plan, we present the research results of selective logging to promote carbon sequestration at reasonable intervals, which makes the study of forests and carbon sequestration more meaningful.

1. Introduction

In recent years, with the development and popularization of the Internet, the increasingly serious climate change has brought about sea level rise, weather anomalies and other problems that have been ignored for a long time, and have had a huge impact on human production and life. In this context, how to take effective measures to control greenhouse gas emissions has become a key issue affecting the community of human destiny, and the role of forests in the process of controlling greenhouse gases is particularly important. Elements such as vegetation, soil and water are present in most forest ecosystems, so forests can affect the atmospheric carbon cycle and balance by fixing and storing carbon to form forest products. Therefore, the establishment of carbon sequestration assessment models and forest management strategies is necessary.

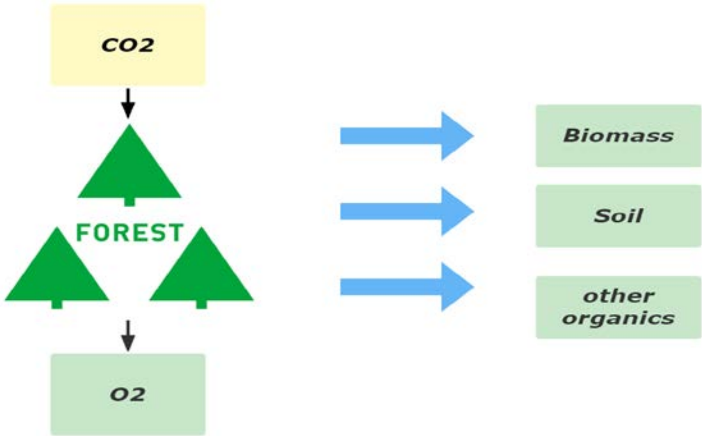

Figure 1: A road map of forests to carbon sequestration

2. Data and methods

2.1 Data description

This paper mainly uses carbon sequestration data from 193 countries of the World Bank and forests.

2.2 Research methods

First of all, from the perspective of carbon storage and NPP (with the help of CASA model and ENVI software), we comprehensively calculated the carbon sequestration and extracted eight impact factors of carbon sequestration by querying relevant literature. Then, a multivariate linear regression model was established to quantitatively analyze the data of vegetation type, forest source type and climate type, and the comprehensive index of each index was obtained, and finally the organic relationship between the eight impact factors and the amount of carbon sequestration was established, and a carbon sequestration model was developed to determine the amount of carbon dioxide sequestration in the forest. Then, we pre-processed the forest data and used K-Means++ and systematic clustering model to extract three first-level indicators affecting the value of forest use, and then used the TOPSIS entropy weight method at Euclidean distance to weight eight secondary indicators, and obtained overall scores. Based on this, eight different forest management plans have been developed, each of which can be used to assess the use value of forests.

3. Establishment of a forest carbon sequestration assessment model

3.1 Calculation of carbon sealed stock based on adjacent carbon storage

Forest carbon storage refers to the amount of carbon retained in forest ecosystems. In this paper, the increase of forest carbon sinks is calculated by using the changes in adjacent carbon storage, which is similar to the forest sequestration stock:

$$CS' \approx C_{n+1} - C_n \tag{1.}$$

Forest carbon storage is calculated using the forest stock conversion factor method:

$$C_F = \sum_{i=n}^{j=n} (S_{ij} \times C_{ij}) + \alpha \sum_{i=n}^{j=n} (S_{ij} \times C_{ij}) + \beta \sum_{i=n}^{j=n} (S_{ij} \times C_{ij}) \tag{2.}$$

We calculate forest carbon density using:

$$C_{ij} = V_{ij} \times \delta \times \rho \times \gamma \tag{3.}$$

3.2 Calculation of carbon seal stock based on NPP

We learned from our review that net primary productivity (NPP) can also be used to measure forest carbon sequestration:

$$NPP = GPP - Ra \tag{4.}$$

Where GPP represents the total energy fixed per unit area of time for green plants, Ra represents the part of the green plants that are consumed.

NPP is estimated using the CASA model. The specific process is shown in the following figure.

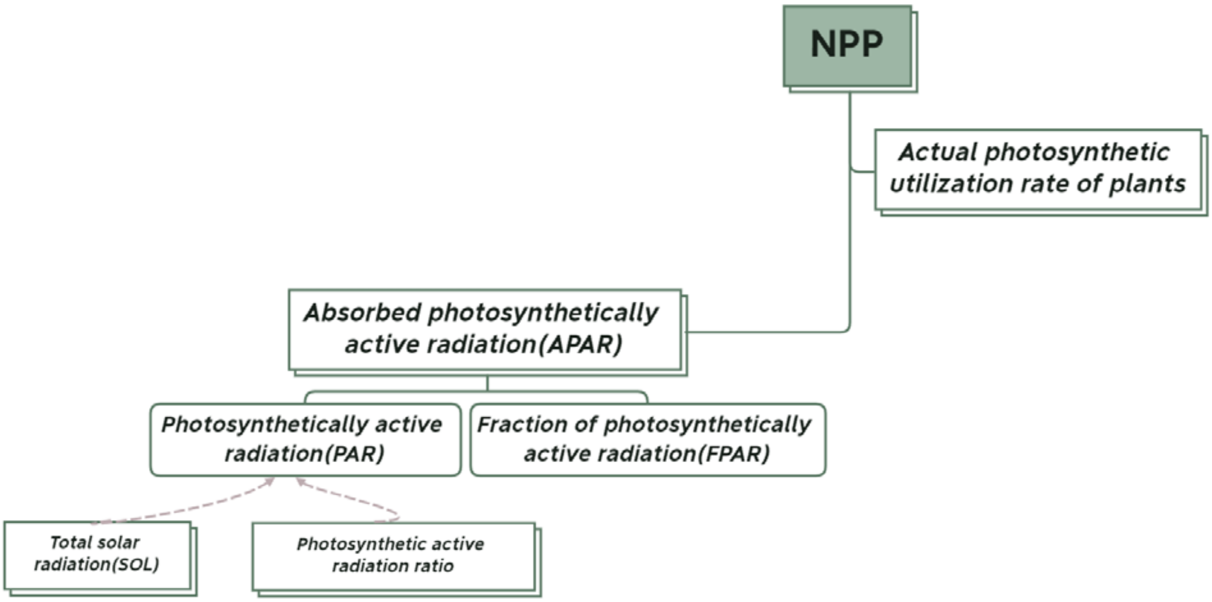

Figure 2: CASA model estimation process

This process is used through ENVI software to measure the net primary productivity of all regions of the world.

3.3 Comprehensive calculation of Carbon Sequestration (CS)

In view of the shortcomings of the carbon sealed stock obtained by the above two estimation methods, in order to reduce the error and make the model in this paper more convincing, the comprehensive calculation method is used to obtain the final carbon sequestration value:

$$CS = \alpha CS' + \beta NPP + \gamma - \xi \tag{5.}$$

The calculation results are as follows: (The higher the amount of carbon sequestration, the stronger the carbon sequestration capacity in the region.)

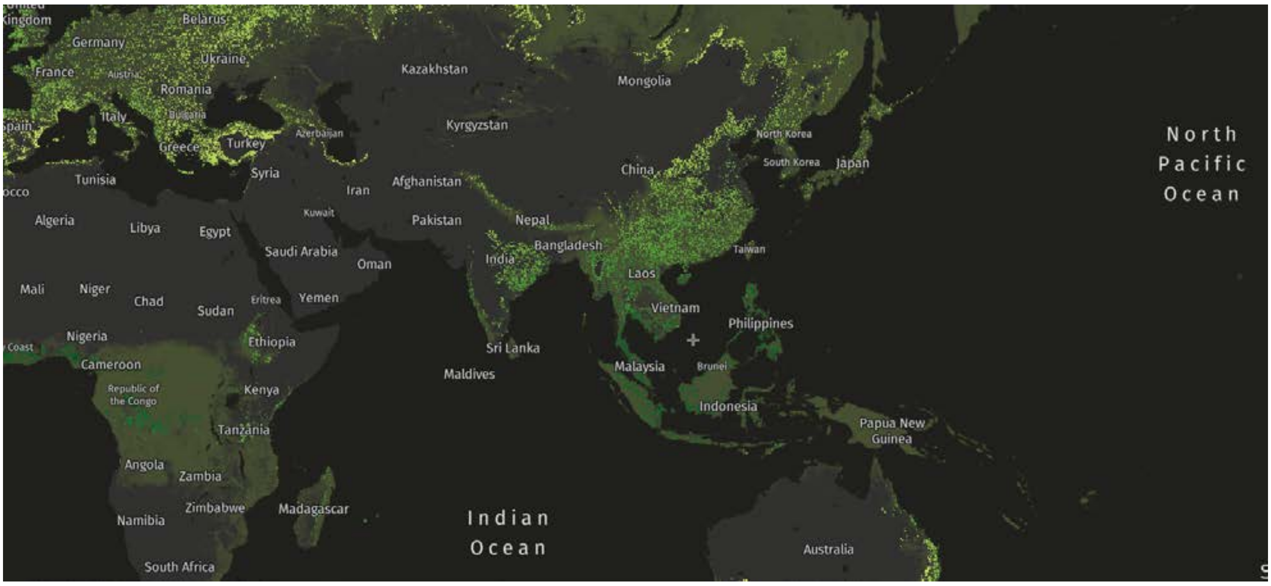

Figure 3: Carbon sequestration results in selected areas

3.4 Establishment of a carbon sequestration assessment model for forest systems

Through the review of relevant literature, the following eight indicators are selected to initially measure the carbon sequestration capacity of forests.

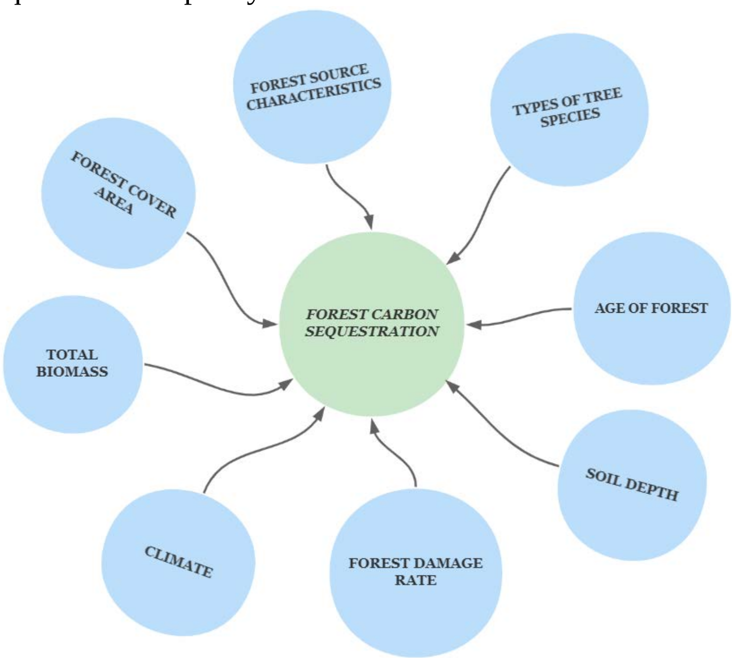

Figure 4: Eight impact factor analysis of carbon sequestration

Using the collected forest data to build a multivariate linear regression model, and using the above eight impact factors, we get the expression of carbon sequestration:

$$CS = -42.57 + 25.61 * TSII + 8.07 * FSC + 24.33 * FA + 10.08 * CI + 29.719 * FCA + 5.9 * TB + 8.453 * SD - 17.618 * FDR \quad (6.)$$

Based on this, we optimize carbon sequestration by increasing forest cover, total biomass, soil depth, tree species type index, climate index, vegetation index, and reducing forest disaster rates.

4. Assessment model for decision-making in forest management

First of all, the K-Means++ cluster analysis of various indicator data that have an impact on forest management was carried out, and we decided to evaluate the forest management decision-making from three levels: natural, economic and social.

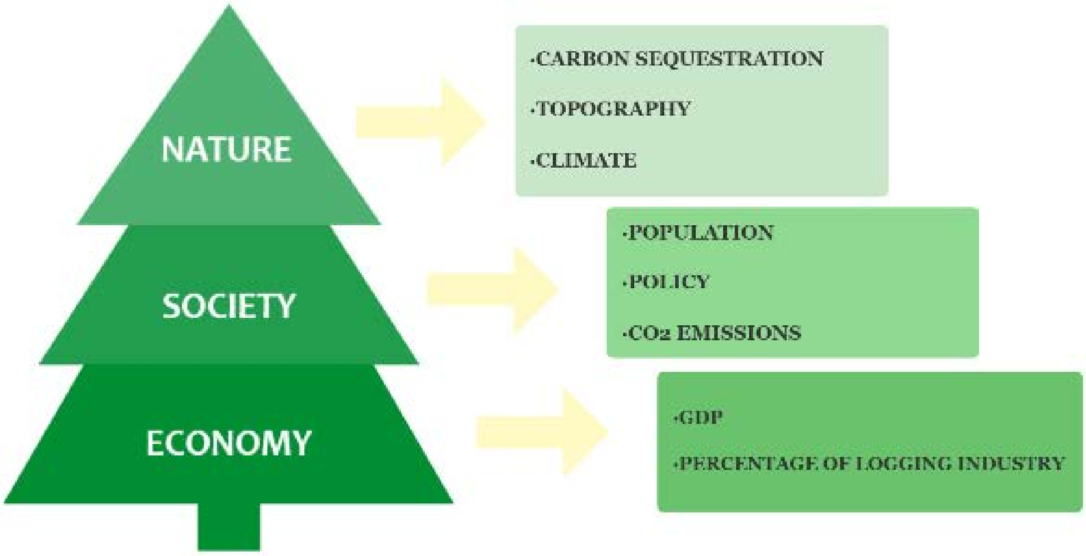

Figure 5: Structure chart of the three major indicators

In order to avoid the subjective analytic hierarchy method, we use the weighted TOPSIS entropy method and SPSS to give a forest value maximization scoring system. Remember the overall score as:

$$C_i = \frac{D_j^-}{D_j^+ D_j^-}, (j = 1,2,\cdots,n), C_i \in [0,1] \quad (7.)$$

Table 1: The result of the entropy weight of each indicator

First-level indicators	Secondary indicators	Overall score
NATURE	CS	0.262
	Topography	0.029
	Climate	0.047
ECONOMY	Logging industry's share of the economy	0.039
	GDP	0.385
SOCIETY	Carbon dioxide emissions	0.107
	Related Policy	0.12
	Population	0.011

Table 2: Eight types of forest management plans

Condition	Plan
High nature High economy High society	The harvesting period and the cutting-off period are rotated every 2 years. 1/12 of the trees are harvested each year during the harvest period
High Nature High Economy Low Society	The harvesting period and the cutting-off period are rotated every 2 years. 1/11 of the trees are harvested each year during the harvest period
High Nature Low Economy High Society	The harvesting period and the cutting-off period are rotated every other year. During the harvesting period, 1/8 of the trees are cut every year, and the trees are mainly broad-leaved forests.
High Nature Low Economy Low Society	The harvesting period and the cutting-off period are rotated every other year. During the harvesting period, 1/7 of the trees are harvested every year. The trees to be harvested are mainly broad-leaved forests and rainforests.
Low Nature High Economy High Society	Every 1 year of harvesting, the cutting is stopped for 3 years. During the harvest period, 1/12 of the trees are harvested each year.
Low Nature High Economy Low Society	Every 1 year of harvesting, the cutting is stopped for 3 years. During the harvest period, 1/10 of the trees are harvested each year.
Low Nature Low Economy High Society	2 years of deforestation for every 1 year of logging. During the harvesting period, 1/6 of the trees are harvested each year.
Low Nature Low Economy Low Society	2 years of deforestation for every 1 year of logging. During the harvesting period, 1/5 of the trees are harvested each year.

5. Analysis of the need for selective forest harvesting

With the help of computer calculations, we know that sometimes moderate deforestation is beneficial to forests in many ways.

Carbon sequestration

Cutting down trees does not always weaken the carbon sequestration capacity of forests, on the contrary, proper felling can promote better growth and carbon absorption of forest ecosystems, thereby alleviating climate problems. However, forest management should not only be considered from the perspective of natural carbon sequestration, so we have considered more angles and considered how to carry out comprehensive and effective forest management.

General Management

Through analysis, we should recognize that in forest management, it is not the best policy to maintain the status quo. From the perspective of nature, economy and society, the implementation of different forest management plans in different situations, the setting of logging periods. Today, when the concept of ESG and carbon neutrality is proposed, the popularity of this view is of great significance to achieving sustainable development.

Acknowledgements

The role of forests in addressing climate change cannot be underestimated. In order to better manage forests, we first selected eight indicators and performed multiple regression analysis with carbon sequestration, and found that the forest coverage area had the greatest impact on carbon sequestration. At the same time, we extended the model from forests to countries. Next, we used K-

MEANS++ cluster analysis to cluster the selected indicators into three categories: economic, natural and social, and then used the entropy weight method (EWM) to calculate the scores of various indicators, established a forest management decision-making model, and proposed eight categories Forest management plan. Finally, we discussed in detail the need for selective forest harvesting and proposed feasibility.

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