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Comprehensive Evaluation of Forestry Development in Various Regions of China

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Abstract

Taking the forestry development level of provinces and cities in China as an example, this paper first constructs a comprehensive evaluation system with 17 indicators, and obtains its comprehensive score by using the principal component analysis method. Among them, Guangdong, Hunan and Sichuan have the best forestry development. Through the systematic clustering method, the forestry development level of 31 provinces and cities in China is clustered. It is found that 31 provinces can be divided into three categories: first, Tibet, Heilongjiang, Sichuan, Yunnan and Inner Mongolia are characterized by their special geographical location, slow industrial development, vast territory and abundant natural resources; Second, Guangdong, Guangxi, Hunan, Fujian, Zhejiang, Jiangxi, Hubei and Guizhou are generally located in the southeast of China, with rich natural resources and high economic strength; Third, Ningxia, Qinghai, Shanghai, Anhui and other regions can be regarded as the remaining part. The forestry development level of this region is the same as that of most provinces in China. The forestry development is progressing steadily. The overall development level is relatively low, but its governance level is high.

Keywords

Forestry Development Level; Principal Component Analysis; Clustering.

1. Introduction

China's forestry is an important part of the world's forestry. The exploration of the forestry development level in various regions of China is also helpful to judge the global forestry development and the development of forestry derivative industries. At present, the assessment of the current situation of China's forestry development can be summarized in two sentences: first, great achievements; Second, the problem is serious. The achievements of forestry are mainly reflected in three aspects. First, the momentum of artificial afforestation is very strong. The reserve area of artificial forest ranks first in the world, accounting for about 26% of the world's artificial forest area. Second, the forestry industry continues to develop and strengthen. Third, the level of forestry science and technology has been significantly improved, and the legal system has been continuously improved. The existing problems of forestry are mainly reflected in the fact that the situation of ecological deterioration has not been fundamentally changed, mainly from three aspects: first, land desertification; The second is serious soil erosion, and the third is serious drought and flood disasters. Among them, the level of forestry development in various regions of China is different, and the forestry management ability is obviously different. This paper attempts to explore the status of forestry development in various regions of China, which is helpful to speculate the main areas of forestry industry development in China.

For the overall comprehensive evaluation, there are many research methods, such as principal component analysis (factor analysis) [1-5], which can use a small number of principal components to contain most of the index information; Analytic hierarchy process [6-7]

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comprehensively compares multiple indicators to determine the weight; Fuzzy comprehensive evaluation [8-9], and conduct mathematical fuzzy processing for the indexes that are difficult to quantify; Grey correlation method [10-11], ranking based on data relevance; Entropy weight method [7,12] determines the index weight based on the degree of data variation, or combines them with each other [7-8,12]. However, at present, the most commonly used method is the principal component analysis method, which can not only obtain good comprehensive benefit evaluation results, but also has the advantages and ideas of dimension reduction. The overall indicator evaluation system contains the information of all indicators, and each indicator will also have an impact on the overall. Due to the constraints of objective conditions, we can only select representative indicators to approximate the overall level. The comprehensive ranking we can get will change with the change of indicator selection! So a good comprehensive evaluation system is very important. Taking the forestry development level of provinces and cities in China as an example, this paper makes an exploratory empirical study. First, a comprehensive evaluation system with 17 indicators is constructed, and its comprehensive score is obtained by using the principal component analysis method. Then, the forestry development level of 31 provinces and cities in China is clustered by the systematic clustering method.

2. Evaluation Index Construction

2.1. Indicator Selection Principle

Scientific principle. First of all, the selection of indicators should have sufficient scientific basis. The index system established based on science can objectively reflect the high-quality development of forestry in Anhui Province, and can reflect the real dependency between various indicators. Secondly, the collection of index data should also have a certain scientific basis.

The indicators determined by the principle of operability must be easy to measure. We should reduce the complexity of index measurement and evaluation, reduce the cost of index measurement and evaluation, and achieve practicality, popularization and application.

Forward looking principle. The determined indicators must play a role in guiding the future development trend of Anhui forestry. The indicator system represents the "top-level design" at the provincial level, which is a combination of overall and directional, and is the direction to guide the forestry development of the whole province.

Systematic principle. Forestry system is a huge and complex system. It includes several subsystems, which are composed of various indicators. These indicators are interrelated and affect each other to form an organic whole. Based on systematic considerations, when determining the index system, it is necessary to have a clear hierarchy, from top to bottom, step by step, and finally build an inseparable evaluation index system.

The principle of representativeness. Although the establishment of the index system requires comprehensive consideration, the forestry system, as a complex large system, involves a wide range of contents, and the selection of indicators cannot be comprehensive. Therefore, the setting of the index system should select representative indicators according to the principles of simplicity, convenience and effectiveness, so as to accurately reflect the high-quality development of forestry in Anhui Province.

Stability principle. Forest resources, forestry construction and forestry ecological environment protection all need a long time and large space to implement and accumulate. Therefore, to determine the index system of future forestry development, we must highlight the principle of stability, so that the selected indicators have the stability of development goals. It also has the stability of long-term evaluation and space-time comparison.

2.2. Index System Construction

When establishing the index system, this paper considers from the four aspects of ecological index, quality index, cultural index and guarantee index. On the basis of referring to Liu Youduo [13] to build the evaluation index system of forestry high-quality development, according to the principle of index selection, combined with the forestry development situation in Anhui Province, this paper selects and deletes the indicators, and finally establishes a three-level forestry high-quality development evaluation index system structure framework, It consists of 1 target layer, 4 criteria layers and 17 indicators. See the table below for details.

Table 1. Index system

Primary index	Secondary index	Tertiary indicators
High quality development of forestry	Ecological indicators	High quality forestry development forest tending area
		forest coverage
		Area ratio of forest disasters
		Water and soil loss rate
		forest coverage
		afforestation area
	Quality indicators	Forest volume
		Restoration area of degraded forest
		Natural forest area retention
		Total forestry output value
	Cultural indicators	Annual reception of Forest Tourism
		Number of forest parks
		Total area of Forest Park
	Guarantee indicators	Forest land investment
		Number of professional technicians
		Industrial pollution control investment
		Pest control area

2.3. Principal Component Analysis

Principal component analysis is an effective dimensionality reduction method based on eigenvalue decomposition. It reflects most of the information in the matrix by retaining the main principal components, so as to achieve the purpose of dimensionality reduction. For the data matrix used in principal component analysis, through coordinate transformation, we can clearly find which vectors the data mainly depends on in the transformed orthogonal coordinate system. These vectors are the eigenvectors corresponding to the eigenvalues. For the following linear variation.

$$\begin{cases} F_1 = a_{11}X_1 + a_{12}X_2 + \cdots + a_{1p}X_p \\ F_2 = a_{21}X_1 + a_{22}X_2 + \cdots + a_{2p}X_p \\ \cdots\cdots \\ F_m = a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mp}X_p \end{cases}$$

The above equation meets:

(1) $\text{cov}(F_i, F_j) = 0$, $Var(F_i) = a_i^{'}\sum a_i$.

(2) F_i is $X_1, X_2, \cdots X_p$ linear combination, The obtained feature vector is the principal component after orthogonal coordinate transformation, in which the principal components are not related to each other. If $F_1, F_2, \cdots, (m \le p)$ of the variance information represented is sorted, the first and second principal components can be found.

2.4. Index Data Processing

The index data in this paper are mainly from the 2018 China Statistical Yearbook and China Environmental Statistical Yearbook. As there are some negative indicators in the forestry index evaluation system, for example, the larger the value of the rate of water and soil loss and the area ratio of forest disasters, the worse the comprehensive level of forestry development. Therefore, it is necessary to obtain "corrected" new indicators after conversion. There are many methods to process the original data, such as the reciprocal method, the minimum threshold method, the complementary method, the reciprocal distance method, etc. the conversion formula adopted in this paper is as follows:

$$x_i' = \max(X) - X_i$$

The corrected indicators become positive indicators, and then all indicators are standardiz.

3. Empirical Analysis on High Quality Forestry Development in Anhui Province

3.1. Evaluation Results and Analysis of Forestry Development Level of Each Province in 2018

Table 2. Total variance explanation table

component	Rotate sum of squares load		
	characteristic value	Variance contribution rate	Cumulative variance contribution rate
1	5.59759	32.93	32.93
2	3.2919	19.36	52.29
3	2.03585	11.98	64.27
4	1.50978	8.88	73.15
5	1.26485	7.44	80.59

Note: other principal components are not filled in.

It can be found that the eigenvalues of five principal components are greater than 1, and their cumulative variance contribution rate reaches 80.59%, which can reflect the main information of all indicators. The five characteristic values are 5.598, 3.292, 3.036, 1.510 and 1.265 respectively. Therefore, the five principal components are selected to build the evaluation model, and the eigenvalues are substituted to obtain the evaluation model of high-quality forestry development:

$$Y = 0.41F1 + 0.24F2 + 0.15F3 + 0.11F4 + 0.09F5$$

The results in the table below show the correlation between the 17 indicators and the five principal components. The four indicators of forest area, forest stock, natural forest area and total area of Forest Park are most closely related to the first principal component, which mainly

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reflects the natural ecological status. Therefore, the first principal component is called the natural ecological factor. Forest coverage rate, water and soil loss rate, pest control area and the second principal component have the greatest correlation, which reflects the information about forestry management. Therefore, the second principal component is called forestry management factor. The annual number of forest tourism visitors, the number of forest parks, and the investment in industrial pollution control have the greatest correlation with the third principal component, which reflects the relevant information of forestry humanities and is named as the humanistic flavor factor. The afforestation area, the restoration area of degraded forest and the number of professional technicians have the greatest correlation with the fourth principal component, which mainly reflects the quality assurance of forestry and is named as the ecological security factor. Forest tending area, forest disaster area ratio, total forestry output value and forest land investment have the greatest correlation with the fifth principal component, which reflects the forest land investment benefit and is named as the investment benefit factor.

Table 3. Principal component matrix after orthogonal rotation

	principal component				
	1	2	3	4	5
Forest tending area	0.11	0.17	0.07	-0.09	0.50
forest coverage	0.02	-0.36	0.05	0.34	0.17
Area ratio of forest disasters	-0.26	0.14	-0.18	0.00	-0.28
Water and soil loss rate	0.00	-0.51	0.11	-0.11	-0.04
forest coverage	0.43	0.02	-0.02	0.08	0.08
forest coverage	-0.03	0.36	0.01	0.38	0.07
Forest volume	0.52	-0.11	-0.06	0.00	-0.08
Restoration area of degraded forest	-0.03	0.03	0.06	0.63	-0.15
Natural forest area retention	0.48	0.02	-0.08	0.04	-0.02
Total forestry output value	-0.08	-0.23	0.14	0.14	0.38
Annual reception of Forest Tourism	-0.04	-0.05	0.57	0.15	-0.08
Number of forest parks	0.05	-0.02	0.60	0.00	-0.04
Total area of Forest Park	0.44	0.16	0.16	-0.15	-0.07
Forest land investment	-0.08	0.01	-0.14	-0.06	0.65
Number of professional technicians	0.05	0.10	-0.03	0.42	0.10
Industrial pollution control investment	-0.13	0.21	0.42	-0.27	0.06
Pest control area	0.01	0.54	0.09	0.01	0.05

From the table below, it can be found that Guangdong is the best in the overall level of forestry development in all provinces of China, and Anhui Province is in the middle position in the country, ranking 16th in the country in terms of comprehensive evaluation scores. Among them, natural ecological factors ranked 21st, forestry management factors ranked 11th, cultural atmosphere factors ranked 13th, ecological protection factors ranked 20th, and investment benefit factors ranked 25th. Compared with other provinces, the ranking of forestry governance and humanistic atmosphere is relatively high, which indicates that Anhui Province has good forestry governance and humanistic guarantee; The lower ranking of natural ecological factors, ecological security factors and investment benefit factors indicates that the overall ecological environment of Anhui Province is poor, and the forestry income is at a low level, which needs to be further improved.

Table 4. Comprehensive score

Comprehensive score								
ranking	province	score	ranking	province	score	ranking	province	score
1	Guangdong Province	2.29	12	Zhejiang Province	0.63	23	Hainan	-0.51
2	Hunan Province	2.1	13	Shaanxi Province	0.37	24	Shanxi Province	-0.52
3	Sichuan Province	1.7	14	Jilin Province	0.26	25	Gansu Province	-0.55
4	Jiangxi Province	1.69	15	Chongqing City	0.08	26	Jiangsu Province	-0.65
5	Guangxi	1.69	16	Anhui Province	0.02	27	Beijing	-0.88
6	Inner Mongolia	1.52	17	Xinjiang	-0.05	28	Ningxia	-1.04
7	Yunnan Province	1.44	18	Hebei Province	-0.08	29	Qinghai Province	-1.07
8	Fujian Province	1.37	19	Shandong Province	-0.14	30	Shanghai	-1.39
9	Heilongjiang	1.32	20	Liaoning Province	-0.16	31	Tianjin	-1.43
10	Guizhou Province	0.87	21	Henan Province	-0.33			
11	Hubei province	0.78	22	Tibet	-0.36			

3.2. Cluster Analysis

At present, the country is actively promoting the high-quality development of forestry. Each region has its own characteristics in terms of economic development level and resource and environmental endowments. Therefore, the situation of forestry development is different. However, there are some commonalities in some aspects of forestry development among different provinces. The study of these commonalities will help the forestry development among regions learn from each other, learn from each other, make the forestry development and its mechanism construction more open, and further improve the high-quality level of forestry.

This paper makes a cluster analysis of 31 provinces in China in order to get a more scientific and reasonable category, explore the internal characteristics and links between the provinces, find areas similar to the forestry development of Anhui Province, and further promote the high-quality development of forestry in Anhui Province by analyzing their similarities and characteristics and drawing lessons from similar provinces. The 31 provinces can be divided into three categories through systematic clustering: (1) Tibet, Heilongjiang, Sichuan, Yunnan and Inner Mongolia are characterized by their special geographical location, slow industrial development, vast territory and abundant natural resources; (2) Guangdong, Guangxi, Hunan, Fujian, Zhejiang, Jiangxi, Hubei and Guizhou are generally located in the southeast of China, with rich natural resources and high economic strength; (3) Ningxia, Qinghai, Shanghai, Anhui and other regions can be regarded as the remaining part. The forestry development is progressing steadily. The overall development level is relatively low, but its governance level is high.

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