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Empirical Analysis of the Ecology Resources Value in Chaohu Area based on PCA Model

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Abstract

This paper constructs an empirical analysis of the ecology resources value for the Chaohu Lake area based on relevant theories and following certain principles. Secondly, the principal componet analysis was used to determine major component and to calculate the ecology resources value from 2010 to 2020. According to the empirical result, the overall ecology resources value of the Chaohu Lake area is on the rise.

Keywords

Ecology Resources Value; Index Calculation; Principal Componet Analysis.

1. Introduction

Ecological resources are the constituent substances and organisms of the ecosystem cycle. In the process of ecosystem cycles, living ecosystems provide ecological resource goods and services to humans. Arrow, Kenneth J. Sheldon Chang, pointed out that the most important aspect of contemporary human-nature relationship is the demand for natural resources and the dependence on the natural environment by production and consumption activities. The most widely used and influential criteria for evaluating the value of resources and the environment are based on the economic sense of the[1]. Natural resources and environmental values in an economic sense are divided into three value perceptions, namely equilibrium value theory, labor value theory, and utility value theory. According to Jinchang Li: The values of natural resources established based on labor value theory and utility value theory, the application of labor value theory and its pricing methods to analyze and determine the value of social labor contained in natural resources, and utility value theory and its pricing methods to analyze and determine the value of natural components in natural resources; Pricing is based on the usefulness, scarcity and natural abundance of the resource[2]. Chen Zhengfu pointed out that ecological resources include original ecological resources and ecological economic resources. Original ecological resources are not integrated with human labor, while ecological economic resources are the combination of human labor and original ecological resources, which contain the value of labor and original ecological resources[3]. Ecological resources refer to all ecosystem material, energy and spatial resources in the earth's ecosystem that are used by human beings for survival, reproduction and development. Ecological resources are the material basis for human economic and social development and an important part of the Earth's ecosystem, playing a bonding role in the relationship between humans and nature, and having both natural and social attributes[4].

Wetland ecological resources are the valuable wealth of human society. Protecting the balance of the ecosystem and achieving sustainable development and utilization of ecological resources are important tasks for human beings at present. Therefore, this paper places an emphasis on the empirical analysis of the ecology resources value in Chaohu area based on principal component analysis (PCA) model.

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1.1. Construction of the Evaluation Index

The data in this paper was compiled using data from the Anhui Provincial Statistical Yearbook, China Environmental Statistical Yearbook, Anhui Provincial Statistical Bulletin, and public government websites. In ecology resources value evaluation, the selection of indicators is significant, related to the reliability and accuracy of the evaluation results. This paper should be founded on the following concepts so that the chosen indicators can accurately reflect the ecology resources value of the Chaohu area: scientific principle, feasibility principle, comprehensiveness principle, and dynamicity principle.

Scientific principle: It is important to have a scientific mindset while choosing indicators and processing data, and both of these processes should be based on science.; In addition, indicators must be calculated and defined according to scientific principles.

Feasibility principle: the placing of evaluation symptoms ought to be effortless to understand and easy to operate, specially to be close to the genuine work, especially to select these indicatons that can draw close first-hand records via the genuine survey, or via instinct can draw conclusions.

Comprehensiveness principle: natural, resource, environmental, social, and economic issues are all included in the ecosystem resources value system. When selecting evaluation indicators, it is important to take into account their ability to fully describe the ecological resource value of the Chaohu area.

Dynamicity principle: Wetland resources are in a constant state of change, and at different points in time, the same wetland resources' status can alter noticeably. Additionally, the environmental pressures reflected by various resource conditions and the response behaviors used to lessen them vary, necessitating the description of the environmental pressure and the wetland's response behavior by the evaluation index system. This requires a certain amount of flexibility in the evaluation index system based on its capacity to describe objective reality.

1.2. Indicators System

In this study, four subsystems are used to develop an evaluation index of the ecological carrying capacity for the Chaohu Lake region: eco-adaptability, ecology resources, the ability to protect the environment, and and socioeconomic resiliency. Details of indicators are shown in table 1.

Table 1. Indicator's system

Subsystems	Indicators
eco-adaptability	Average annual precipitation X1
	Annual sunshine duration X2
	forest coverage X3
ecology resources capacity	per capita water resources X4
	farmland areas per person X5
	public green space area per capita X6
	per capita output of grain X7
the ability to protect the environment	industrial so_2 emissions X8
	industrial fumes emission X9
	sewage treatment rate X10

2. PCA Evaluation Model

2.1. Preliminary Analysis

To eliminate the impact of various data outlines and quantitative levels on the empirical analysis, this research uses the Z-score approach to normalize the raw data into dimensionless values. The following is the calculating formula:

$$Z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_i}, i = 1,2,\ldots,n, j = 1,2,\ldots,p \tag{1}$$

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{ij}}{n}, s_j^2 = \frac{\sum_{i=1}^{n}(x_{ij} - \bar{x}_j)^2}{n-1} \tag{2}$$

2.2. Communalities

Communalities are the proportion of each variable's variance that can be explained by the principal components. In the Communalities table, the initial communal variance (Initial) and the extracted communal variance (Extraction) of the factor loading array are given. As can be seen from Table 2, the selected indicators have strong explantory power.

Table 2. Communalities

	Initial	Extraction
X1	1.000	0.817
X2	1.000	0.929
X3	1.000	0.918
X4	1.000	0.818
X5	1.000	0.902
X6	1.000	0.904
X7	1.000	0.813
X8	1.000	0.912
X9	1.000	0.916
X10	1.000	0.927

2.3. Total Variance Explained

Table 3. Total variance explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.062	50.617	50.617	4.539	45.395	45.395
2	2.786	27.862	78.478	2.762	27.618	73.012
3	1.080	7.996	86.475	1.346	13.462	86.475
4	0.527	5.270	91.744			
5	0.425	4.246	95.990			
6	0.173	1.729	97.719			
7	0.097	0.969	98.688			
8	0.068	0.683	99.370			
9	0.045	0.448	99.818			
10	0.018	0.182	100.000			

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SPSS26.0 performs principal component analysis on data to obtain the total variance explained, and results are shown in Table 3 and figure 1. The outcome of the extraction is shown in Table 1, which lists the eigenvalues associated with each linear element both before and after rotation. This research extracts three common variables with about 86 percent of the cumulative variance contribution under the assumption that the initial eigenvalue is greater than one, and their eigenvalues are λ_1=5.602, λ_2=2.786 and λ_3=1.080 respectively, which indicates that three common factors can reflect most of the information of variables of the seven selected indicators. The rotation optimizes the factor structure, and one result for these data is that the relative significance of the three factors is equalized.

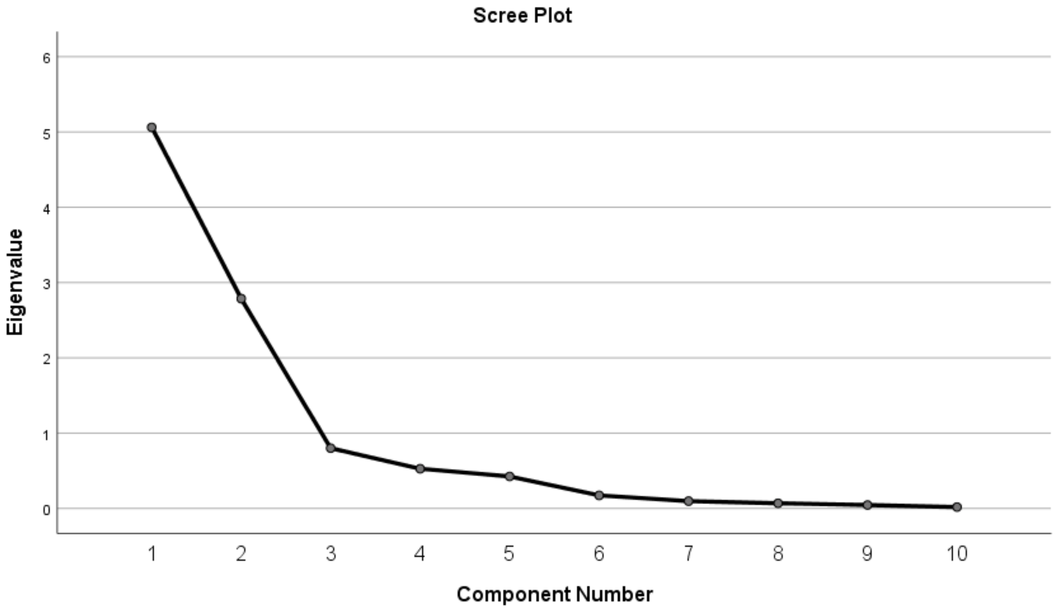

Figure 1. Scree plot

2.4. Rotated Component

$$R_{VARIMAX=}\ \arg\max\left(\sum_{j=1}^{k}\sum_{i=1}^{p}(\Lambda R)_{ij}^{4}-\frac{\gamma}{p}\sum_{j=1}^{k}\left(\sum_{j=1}^{k}(\Lambda R)_{ij}^{2}\right)^{2}\right) \quad (3)$$

Table 4. Rotated component matrix

	Component		
	F_1	F_2	F_3
X1	0.785	0.422	0.386
X2	0.907	0.150	0.338
X3	0.214	-0.163	0.803
X4	0.435	-0.567	0.346
X5	0.939	0.164	0.056
X6	0.929	-0.192	0.123
X7	0.219	0.753	-0.158
X8	0.775	0.493	0.267
X9	0.056	0.971	0.031
X10	-0.708	0.653	-0.093

The principal component analysis approach is used to extract common factors, which are then used to build the original loading matrix. The original component matrix is orthogonally rotated

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by Varimax with Kaiser Normalization in an effort to more equitably explain the connotations provided by the common factors [5]. As shown in table 4, rotation can successfully maintain the orthogonality of each common element. According to table 4, there are three major components: F_1, F_2 and F_3.

3. Empiricial Analysis

According to the above results, this paper obtain the index results of ecological resource value by SPSS 26.0, as seen in table 5.

Table 5. Index results

	F_1	F_2	F_3
X1	0.039	0.129	0.196
X2	0.141	-0.021	0.032
X3	-0.263	-0.022	0.880
X4	0.039	-0.232	0.113
X5	0.244	-0.006	-0.282
X6	0.231	-0.131	-0.236
X7	0.061	0.219	-0.219
X8	0.106	0.141	0.039
X9	-0.065	0.323	0.068
X10	-0.261	0.223	0.163

The comprehensive index (F) of ecological resource value is calculated as follow:

$$F = 0.52 \times F_1 + 0.32 \times F_2 + 0.16 \times F_3 \quad (4)$$

The weight of each common factor is the ratio of each factor's variance contribution after rotation to the total contribution. The comprehensive index is obtained by substituting each factor into formula (4), and the index results are exhibited in table 6.

Table 6. Score results

Year	ecological resource value score
2010	0.3243
2011	0.3262
2012	0.3301
2013	0.3377
2014	0.3597
2015	0.3677
2016	0.3736
2017	0.3850
2018	0.3894
2019	0.3925
2020	0.3983

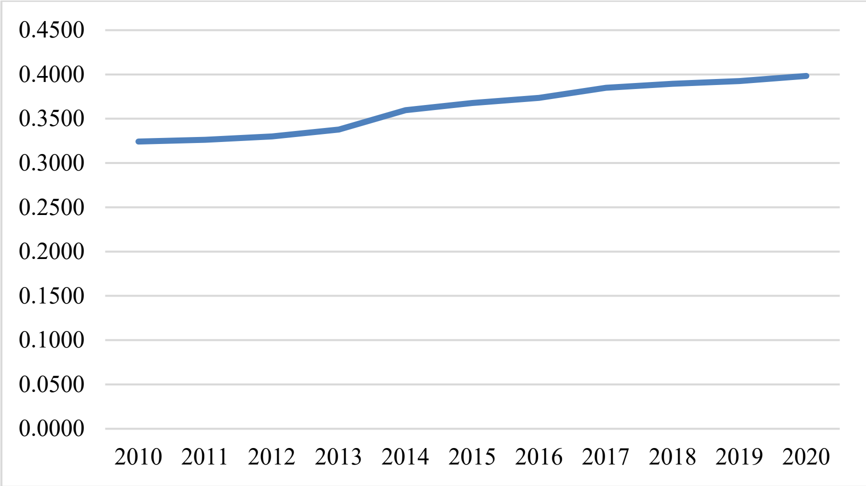

Figure 2. Ecological resource value score

From Table 6 and Figure 2, it can be seen that the overall ecological resource value of the Chaohu Lake area is on the rise. The score in 2010 is the lowest, and 2020 is the highest. The Chaohu region places a high value on ecological and environmental conservation, defends the crucial idea that green water and green mountains are the silver mountain of gold, and promotes the peaceful coexistence of people and nature. The government has recently improved land usage, created wetland parks and nature reserves, and increased public awareness of the need to maintain wetlands.

4. Conclusion

This paper firstly establishes the evaluation index system of the ecological resource value in the Chaohu area. It calculates the ecological resource value scores of each subsystem of Chaohu area from 2010 to 2020 by PCA model. According to the empirical results, the ecological resource value of the Chaohu Lake area is on the rise.

In determining the index weights, the principal component analysis used in this paper can objectively reflect the relative importance of different indexes but omits subjective factors, which should be combined with subjective methods in future research to improve the accuracy of index results.

Acknowledgments

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