

Research on Ecological Civilization Construction of Urban Agglomeration in Yangtze River Delta based on Principal Component Analysis

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Abstract

In view of the current situation and differences of the development level of ecological civilization construction of urban agglomeration in the Yangtze River Delta, in order to improve the development level of ecological civilization construction of urban agglomeration in the Yangtze River Delta, 26 prefecture level cities in the Yangtze River Delta are selected as the research object. Based on the relevant data of Anhui Statistical Yearbook in 2021, 14 indicators from three aspects of economic development, social development and environmental protection are selected to establish a comprehensive evaluation system, a principal component analysis model is constructed to comprehensively evaluate the ecological civilization construction level of urban agglomeration in the Yangtze River Delta, and a k-means clustering model is established to turn it into a high, high, general and low-level development area for spatial dimension analysis. Finally, reasonable suggestions are put forward for the construction and development of ecological civilization in the urban agglomeration of the Yangtze River Delta.

Keywords

Ecological Civilization Construction; Principal Component Analysis; K-means Clustering Comprehensive Evaluation; Yangtze River Delta Urban Agglomeration.

1. Introduction

The Yangtze River Delta plays an important role in national economic and social development. The integrated development of the Yangtze River delta needs to stimulate more powerful driving forces and shoulder more arduous responsibilities in the era of epidemic. During the "14th five year plan" period, China's ecological civilization construction has entered a key period focusing on carbon reduction, promoting the synergy of pollution and carbon reduction, promoting the comprehensive green transformation of economic and social development, and realizing the improvement of ecological environment quality from quantitative change to qualitative change.[1]The construction of ecological civilization is an important part of the overall layout of the "five in one". Strengthening the construction of ecological civilization requires innovative institutional arrangements, overall development planning, protecting the ecological environment, strengthening foreign exchanges and sharing a better life.[2]In view of the internal differentiation of urban agglomerations in the Yangtze River Delta, there are not only the economically developed coastal city Shanghai, but also several prefecture level cities in Anhui Province whose economic level accounts for the middle reaches of the country, as well as more developed prefecture level cities in Jiangsu and Zhejiang, which are typical urban agglomerations in China. Therefore, this paper selects 26 cities in the Yangtze River Delta urban agglomeration, establishes an evaluation index system according to their ecological document

construction level, collects relevant data, integrates the methods of principal component analysis and K-means cluster analysis, and uses SPSS software to explore the development level of ecological civilization construction in the Yangtze River Delta Urban Agglomeration.

2. Construction of Comprehensive Evaluation Index System for the Construction Level of Ecological Civilization

The level of ecological civilization construction in the Yangtze River Delta is related to many factors and affects a wide range. Therefore, in order to accurately evaluate the level of ecological civilization construction of urban agglomeration in the Yangtze River Delta, it is necessary to select multiple impact indicators for comprehensive evaluation. This paper selects 14 indicators from three aspects: economic development, social development and environmental protection. Including per capita GDP, social minimum security, regional GDP, CO2 emissions, etc. The comprehensive evaluation index system of ecological civilization construction level of urban agglomeration in the Yangtze River Delta is constructed for comprehensive evaluation. See Table 1 for evaluation indicators.

Table 1. Comprehensive evaluation index system of ecological civilization construction and development level in the Yangtze River Delta urban agglomeration

Level 1 indicators	Level 2 indicators	Level 3 indicators
The level of ecological progress (A)	Economic development (B1)	Per capita GDP(X1)
		Per capita consumption level(X2)
		The tertiary industry index(X3)
		Regional GDP(X4)
		Urbanization rate(X5)
	Social development (B2)	Minimum employment security(X6)
		Education expenditure (X7)
		Health expenditure (X8)
		Per capita employment rate (X9)
	Environmental protection (B3)	Wastewater discharge volume (X10)
		CO2 Emissions (X11)
		CO2 Emissions (X11)
		Vegetation coverage rate (X13)
		SO2 Emissions (X14)

Economic development reflects the economic development level of the region and has an absolute impact on the construction of ecological civilization in the region; Social development includes all aspects, such as education and health. We should work together with the region to build the development of ecological civilization and support it; Environmental protection is the best reflection of the development of ecological civilization, reflecting the actual level of ecological civilization construction in the region.

3. Comprehensive Evaluation Model based on Principal Component Analysis

3.1. Research Ideas

According to the data of each evaluation index in Anhui statistical yearbook 2021, combined with the principle of principal component analysis and its model, due to the delay of statistical data, it is based on spss24 0 software to comprehensively evaluate the development level of 26 urban areas in the selected Yangtze River Delta Urban Agglomeration in 2021.

3.2. Research Methods

(1) Standardize the original data

Suppose that there are m index variables for principal component analysis: $x_1, x_2, \dots, x_m$, a total of N evaluation objects, and the value of the j index of the I evaluation object is A_{IJ} . Convert each index value A_{IJ} into standardized index.

$$\tilde{a}_{ij} = \frac{a_{ij} - \mu_j}{s_j}, (i=1,2,3,\dots,n; j=1,2,3,\dots,m) \text{ thereinto } \mu_j = \frac{1}{n} \sum_{i=1}^n a_{ij}, s_j = \frac{1}{n-1} \sum_{i=1}^n (a_{ij} - \mu_j)^2, (j=1,2,\dots,m),$$

That is, it is the sample mean and sample standard deviation of the j-th index. Correspondingly, it is called $\tilde{x}_i = \frac{x_i - \mu_j}{s_i}$ (i=1,2,3...,m) is a standardized indicator variable.

(2) Calculate the correlation coefficient matrix R

Correlation matrix $R=(r_{ij})_{m \times n}$.

$$r_{ij} = \frac{\sum_{k=1}^n \tilde{a}_{ki} * \tilde{a}_{kj}}{n-1}, (i=1,2,...m).$$

Where $\rho_{ij} = 1$, is the correlation coefficient between the i-th index and the j-th index.

(3) Calculate eigenvalues and eigenvectors

Calculate the eigenvalue of the correlation coefficient matrix $R \geq 0$ and the corresponding eigenvector. Among them, m new index variables are composed of eigenvectors:

$$\left\{ \begin{array}{l} y_1 = u_{11}\tilde{x}_1 + u_{21}\tilde{x}_2 + \dots u_{m1}\tilde{x}_m \\ y_1 = u_{12}\tilde{x}_1 + u_{22}\tilde{x}_2 + \dots u_{m2}\tilde{x}_m \\ \text{,,,,,,,,,,,,,,,,,,,,,,,,,,,,,} \\ y_1 = u_{1m}\tilde{x}_1 + u_{2m}\tilde{x}_2 + \dots u_{mm}\tilde{x}_m \end{array} \right.$$

Where is the first principal component, the second principal component,..., and the M principal component.

(4) Select P ($P \leq m$) principal components and calculate the comprehensive evaluation value

Calculate the information contribution rate and cumulative contribution rate of eigenvalues ($J = 1, 2, \dots, m$). Call:

$$b_j = \frac{\lambda_j}{\sum_{k=1}^m \lambda_k} \quad (j=1,2,\dots,m)$$

information contribution rate of main components;

$$\alpha_p = \frac{\sum_{k=1}^p \lambda_k}{\sum_{k=1}^m \lambda_k}$$

When the cumulative contribution rate of the main components,,,,, is close to 1 (= 0.85,0.90,0.95), the first P index variables,,,,, are selected as P principal components to replace the original m index variables, so that the P principal components can be comprehensively analyzed.

Calculate the comprehensive score:

$$Z = \sum_{j=1}^P b_j y_j$$

Where is the information contribution rate of the j-th principal component, which can be evaluated according to the comprehensive score value.

3.3. Evaluation and Analysis of Ecological Civilization Construction of Urban Agglomeration in the Yangtze River Delta

Using spss24 0 carry out principal component analysis on the ecological civilization construction level of urban agglomeration in the Yangtze River Delta, and obtain the principal component coefficient matrix of variance decomposition diagram, as shown in Table 2.

Table 2. variance decomposition diagram of principal component analysis

principal component	original variable			The principal components were extracted		
	characteristic value	Variance contribution rate is (%)	The cumulative contribution rate is (%)	characteristic value	Variance contribution rate is (%)	The cumulative contribution rate is (%)
1	5.643	35.681	35.681	5.643	35.681	35.681
2	3.081	19.215	54.896	3.081	19.215	54.896
3	1.549	9.815	64.711	1.549	9.815	64.711
4	1.354	8.564	73.275	1.354	8.564	73.275
5	1.015	6.800	80.075	1.015	6.800	80.075

According to table 2, the eigenvalues of the first five principal components are greater than 1. Therefore, according to the principal component analysis, five principal components are selected to describe the construction level of ecological civilization. Using spss24 0 to get the coefficient matrix of five principal components, and then according to the principal component calculation formula and comprehensive score evaluation function, get the principal component score and comprehensive score of the ecological civilization construction level of the Yangtze River Delta urban agglomeration, as shown in Table 3.

Table 3. principal component scores and comprehensive scores of ecological civilization construction level of Yangtze River Delta Urban Agglomeration

Region	F1 score	F2 score	F3 score	F4 score	F5 score	Comprehensive score	ranking
the Yangtze River Delta city group	3.256	1.812	0.006	1.435	-0.106	2.031	
Shanghai	6.023	2.421	0.325	1.458	-0.213	3.442	1
Suzhou	4.765	2.428	0.028	1.125	0.804	2.898	2
Hangzhou	4.805	2.138	0.042	0.544	0.501	2.760	3
Nanjing	4.059	2.051	0.019	1.512	0.709	2.525	4
Wuxi	3.846	2.557	0.166	0.982	0.690	2.511	5
Ningbo	3.894	1.752	-0.004	0.310	0.554	2.235	6
Nantong	2.851	2.861	-0.452	1.625	0.528	2.120	7
Changzhou	2.385	3.021	0.820	0.864	0.481	2.021	8
Hefei	2.886	1.866	-0.325	0.571	0.310	1.781	9
Yancheng	2.415	2.032	0.369	1.341	0.128	1.763	10
Yangzhou	1.759	3.015	0.258	1.165	0.345	1.693	11
Shaoxing	1.952	3.023	-0.345	0.913	0.336	1.679	12
Taizhou	2.443	1.500	0.354	1.354	0.361	1.667	13
Jiaxing	1.752	2.762	-0.123	1.381	0.128	1.587	14
Taizhou	1.966	2.338	-0.056	1.158	0.212	1.572	15
Zhenjiang	1.421	2.851	0.351	1.340	0.355	1.534	16
Jinhua	1.449	3.062	0.642	0.654	-0.018	1.528	17
Wuhu	1.546	3.009	-0.109	0.994	0.164	1.518	18
Huzhou	2.266	1.955	-0.752	1.058	0.125	1.510	19
Anqing	1.954	1.901	-0.106	1.351	0.281	1.482	20
Maanshan	1.238	3.251	-0.125	1.352	0.201	1.478	21
Chuzhou	1.310	3.154	0.215	0.854	0.208	1.476	22
Xuancheng	1.352	2.905	-0.009	0.953	0.150	1.413	23
Zhoushan	1.624	2.345	0.044	0.684	0.288	1.389	24
Tongling	1.156	3.002	0.305	0.841	0.192	1.379	25
Chizhou	1.224	2.814	0.264	0.873	-0.103	1.338	26

4. Based on K-means Cluster Analysis, this Paper Classifies the Development Level of Urban Agglomeration in the Yangtze River Delta

4.1. Research Ideas

Based on the above factor comprehensive score of the ecological civilization construction and development level of the Yangtze River Delta urban agglomeration, the K-means clustering analysis algorithm is used to classify the 26 cities in the Yangtze River Delta urban agglomeration according to their regional ecological civilization development level, so as to study the spatial heterogeneity of the ecological civilization development level in the Yangtze River Delta.

4.2. Research Methods

It is divided into different categories for analysis by K-means clustering.

Table 4. clustering results of ecological civilization construction and development level of urban agglomeration in the Yangtze River Delta

Development level of ecological civilization construction	City name
High level development area	Shanghai, Suzhou, Hangzhou
High level development area	Nanjing, Wuxi, Ningbo, Nantong, Changzhou, Hefei, Yancheng
General level development area	Yangzhou, Shaoxing, Taizhou, Jiaxing, Taizhou, Zhenjiang, Jinhua, Wuhu, Huzhou
Low level development area	Anqing, Ma'anshan, Chuzhou, Xuancheng, Zhoushan, Tongling, Chizhou

According to the clustering results in Table 4, the development level of ecological civilization of urban agglomerations in the Yangtze River Delta is divided into four categories: high-level development areas, high-level development areas, general level development areas and low-level development areas. Its overall development level is relatively balanced, but the phenomenon of polarization is also serious.

5. Conclusions and suggestions

Based on spss24 software, this paper makes a comprehensive evaluation of the development level of ecological civilization in the Yangtze River Delta by using the collected data. It can be seen that the development level of ecological civilization of urban agglomeration in the Yangtze River Delta is high. Using k-means cluster analysis, the 26 cities in the Yangtze River Delta urban agglomeration are divided into the following four categories: Shanghai, Suzhou and Hangzhou belong to high-level development areas; Nanjing, Wuxi, Ningbo, Nantong, Changzhou, Hefei and Yancheng are high-level development areas; Yangzhou, Shaoxing, Taizhou, Jiaxing, Taizhou, Zhenjiang, Jinhua, Wuhu and Huzhou are areas of general development level; Anqing, Ma'anshan, Chuzhou, Xuancheng, Zhoushan, Tongling and Chizhou are low-level development areas. However, there are still many problems in its regional development: unbalanced urban development and serious polarization. According to the results of the above comprehensive evaluation model, this paper analyzes and obtains the relevant factors affecting the development level of ecological civilization construction of urban agglomeration in the Yangtze River Delta, and puts forward the following relevant suggestions for further improving the development level of ecological civilization construction in the Yangtze River Delta in the future:

(1) Promote the construction of ecological civilization system

Improve the supervision system and strengthen supervision. We will actively promote the pilot work of monitoring, supervision and vertical management of environmental protection institutions, further define the functions of government departments, clarify departmental responsibilities, ensure the consistency of rights and responsibilities, and effectively form a rural ecological environment management system of "local governments taking overall responsibility, environmental protection departments exercising unified supervision, and relevant departments taking joint management". We will improve the compensation mechanism for ecological protection, explore the value realization mechanism of ecological products, implement eco-economic projects such as ecotourism, ecological agriculture and ecological forestry according to local conditions, and build a solid ecological foundation for turning "green water and green mountains" into "golden mountains and silver mountains".

(2) Strengthen the construction of Ecological Culture Education

Vigorously promote the cultivation of ecological values, strengthen the construction of ecological system, integrate ecological values into moral culture, open up a lecture hall of

ecological civilization values, and deeply implant ecological values into citizens' daily life. Strengthen publicity and education, make full use of television, Internet, radio, newspapers and other news media, widely carry out all kinds of publicity for the construction of ecological civilization, support all kinds of environmental protection volunteers to carry out ecological civilization construction activities, guide more public to participate in public welfare undertakings such as environmental protection and ecological construction, and commend and reward units and individuals that have made outstanding contributions to the construction of ecological civilization.

(3) Promote the development and construction of ecological economy

Adhere to green development, make greater efforts to implement the ecological development strategy, walk out of a sustainable development path of harmonious coexistence between man and nature, take green growth and low-carbon development as an important starting point and core task of building a well-off society in an all-round way, and earnestly put the concept of green development through all aspects and the whole process of economic and social construction. Through the transformation and upgrading of industrial structure, change the traditional industrial model at the cost of ecological damage, environmental pollution and resource waste, build a green industrial system with low resource consumption, less environmental pollution and good ecological benefits, and realize the "greening" of the whole life cycle.

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