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Research on the Coupling Coordination Level of Rural Economy-Society-Environment in Yangtze River Delta Region

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Abstract

In 2022, the Party's 20th National Congress proposed to comprehensively promote rural revitalization at this stage. The relationship between economy, society and environment is changing according to certain laws in the history of rural development, and it is also an important part of human life. In this paper, entropy method and coupling coordination model are used to measure the coupling coordination degree of rural areas in the Yangtze River Delta urban agglomeration. The research results show that the economic, social and environmental development of rural areas in the Yangtze River Delta are steadily improving from 2013 to 2021, and the gap in rural development status of prefecture-level cities in the Yangtze River Delta urban agglomeration is large, and the development gap is decreasing during the study period. From the perspective of provinces and cities, the order of development from good to bad is Jiangsu Province > Zhejiang Province > Anhui Province.

Keywords

Rural Revitalization, Rural Economic-Social-Environment, Coupling Coordination

1. Introduction

"If the nation is to be revived, the countryside will be revitalized." The report of the 20th National Congress of the Communist Party of China proposed to comprehensively promote rural revitalization. As early as the 19th National Congress of the Communist Party of China, it has been proposed to put rural revitalization on a strategic high level, and the key is to solve the problems of agriculture,

rural areas and farmers, and to coordinate the organizational mechanism and policy system of urban and rural development in accordance with the five principles, and accelerate the process of agricultural and rural modernization. The Yangtze River Delta region, referred to as the Yangtze River Delta, includes Shanghai, Jiangsu, Zhejiang and Anhui provinces, a total of 41 prefecture-level cities, covering an area of 210,700 square kilometers. It is located in the middle and lower reaches of the Yangtze River, which is one of the best regions for China's economic development.

The Yangtze River Delta region is a national leading demonstration area created by China, with the goal of becoming a world-class city cluster with the competitiveness of the world. Experts and scholars have conducted many studies on the Yangtze River Delta region. For example, Zhang (2019) used Dagum Gini coefficient decomposition to study the spatial difference and convergence of innovation development in the Yangtze River Delta urban agglomeration area. The research conclusion is conducive to improving the spatial imbalance of innovation development in the Yangtze River Delta region, promoting the development of innovation agglomeration in the Yangtze River Delta region and its radiation effect on surrounding areas. Xu & Tian (2019) established a green development index evaluation system with six dimensions of scientific and technological innovation, economic growth, resource utilization, environmental governance, environmental quality and green life, measured the green development level of the Yangtze River Delta urban agglomeration from 2006 to 2019 by using the Kernel density estimation and BP time series prediction model, and analyzed and put forward corresponding green development suggestions. Li *et al*., (2022) analyzed the dynamic evolution relationship between urbanization construction and carbon emission pressure of 16 cities in the core area of the Yangtze River Delta urban agglomeration from 2006 to 2020 by constructing the carbon balance pressure measurement model and the new urbanization level evaluation index system.

The existing literature has very important reference value, but there are still some deficiencies in the research level and research objects: first, most of the research objects are cities or urban-rural integration in the Yangtze River Delta, and there are few studies on the rural areas of the Yangtze River Delta. Second, the research contents of the Yangtze River Delta urban agglomeration are mainly the degree of integration, digital economy, carbon emissions, etc., and there are few studies on the relationship between the economy, society and environment in the rural areas of the Yangtze River Delta urban agglomeration. Therefore, this paper introduces the coupling coordination theory into the relationship between China's rural economy, society and environment, and establishes a comprehensive evaluation index system of the economic-social-environmental comprehensive evaluation system of rural areas in the Yangtze River Delta urban agglomeration from the perspective of the comprehensive implementation of rural revitalization.

2. Research Design

2.1. Establish an Indicator System

The index system of economy, society and environment in rural area of Yangtze River Delta covers a wide range, contains many elements and is complex. The change of economic-social-environment system is complex and uncertain, so it is one-sided to judge its correctness by only one index. Therefore, this paper adopts the evaluation system of comprehensive index composed of multiple indexes according to certain levels. On the premise that the design of the index system follows the principles of scientificity, typicality, systematization and data availability, after studying a large number of literatures and sorting out the index system of a number of scholars, a total of 21 indicators are selected to judge the coupling and coordination relationship between economy, society and environment under the first-level indicators dominated by economy, society and environment. Economic indicators are divided into income level and consumption structure. Based on the research literature of (Meng & Chen, 2022) and (Lu & Deng, 2022), seven three-level indicators are selected. Social indicators are divided into three second-level indicators: medical education, rural governance and quality of life. Seven third-level indicators are selected by referring to research literatures such as (He & Zhang, 2022) and (Wang & Tian, 2021). Environmental indicators are divided into three secondary indicators: natural ecological conditions, ecological environmental response and ecological environmental pressure. With reference to the literature of experts and scholars such as (Ren & Yu, 2021) and (Dong, 2022), seven third-level indicators are selected. The index system created in this paper is shown in **Table 1**.

2.2. Data Sources

The data in this paper are derived from the provincial statistical yearbook of Jiangsu, Zhejiang and Anhui provinces from 2013 to 2021, and the Yangtze River Delta city cluster includes Shanghai, Nanjing, Wuxi, Changzhou, Nantong, Suzhou, Yangzhou, Yancheng, Zhenjiang and Taizhou in Jiangsu Province, Hangzhou, Ningbo, Jinhua, Huzhou, Zhoushan, Jiaxing, Shaoxing and Taizhou in Zhejiang Province, and the cities of Jiangsu Province. The municipal statistical yearbook of 27 cities in Anhui province, including Hefei, Chizhou, Wuhu, Tongling, Maanshan, Anqing, Chuzhou and Xuancheng, among which Shanghai has more missing values and is at the forefront of development, the scope of this paper covers the rural areas of 26 cities except Shanghai. Some missing values were replaced by interpolation or the mean value of the next year, and relevant data were analyzed using python and matlab software.

2.3. Research Methods

When the entropy weight method is used to objectively assign weights to various indicators of the three subsystems of economy, society and environment and calculate the comprehensive score, the formula is as follows:

Table 1. Economic-social-environmental index system in rural areas of Yangtze River Delta.

subsystem	Criterion layer	Index level	Quantity unit	weight
economy	Income level	Rural-urban income ratio	-	3.81%
	Income level	Animal husbandry fishery output	Hundred million yuan	7.08%
	Income level	Per capita disposable income of rural residents	yuan	6.51%
	Consumption structure	Engel coefficient	%	1.36%
	Consumption structure	Per capita entertainment consumption	yuan	4.01%
	Consumption structure	Number of family cars per 100 households	car	5.83%
	Consumption structure	Total power of agricultural machinery	megawatt	8.11%
society	Medical education	Average years of schooling in rural areas	years	4.89%
	Medical education	Number of village health workers per 1000 people	number	5.18%
	Medical education	Number of rural cultural stations	number	4.22%
	Rural governance	Village committee director, secretary "shoulder to shoulder" ratio	%	4.63%
	Quality of life	Urbanization rate	%	3.47%
	Quality of life	Per capita road area	m^2/person	4.63%
	Quality of life	Per capita living space	m^2/person	3.77%
environment	Natural ecological condition	Vegetation coverage	%	4.99%
	Natural ecological condition	Per capita water resources	m^2/person	4.70%
	Eco-environmental response	Access to sanitary toilets	%	5.04%
	Eco-environmental response	Domestic sewage treatment rate	%	4.88%
	Eco-environmental response	Safe coverage of drinking water	%	5.19%
	Eco-environmental response	Harmless treatment rate of household garbage	%	4.77%
	Ecological environmental pressure	Fertilizer intensity	kg/ha hm^2	2.94%

$$U_i = \sum_{j=1}^{m} W_j * x'_{ij} \tag{1}$$

In formula (1), there are m evaluation objects; j represents the sample; i indicates the indicator. x'_{ij} is the value of the JTH index of the i sample after standardization; W_j is the weight of each indicator; U_i is final score for each indicator.

The coupling coordination degree model is used to measure the level of coordination development between two or more things. Three subsystem coupling models are used in this paper, as follows:

$$C = \frac{3 * (U_1 * U_2 * U_3)^{1/3}}{U_1 + U_2 + U_3} \tag{2}$$

In formula (2): C represents coupling degree; U_1, U_2, U_3 The comprehensive evaluation index of economy, society and environment is obtained from formula

(1).

The coupling degree model can only explain the strength of the coupling relationship between things, and cannot represent the coordinated development level among the three. Therefore, the coupling coordination degree model is introduced, as shown below:

$$D = \sqrt{C * T} \tag{3}$$

$$T = \alpha U_1 + \beta U_2 + \theta U_3 \tag{4}$$

In formula (4): represents the coupling coordination degree; A comprehensive assessment index representing economic, social and environmental factors; Since the importance of economy, society and environment is equal in this paper, the undetermined coefficient is set as $\alpha = \beta = \theta = 1/3$.

Based on the existing research results, this paper divides the system coupling coordination level into 10 levels [10]. The details are shown in **Table 2**.

3. Coupling Coordination Results and Analysis

According to formula (2)-(4), the coupling coordination degree of economy, society and environment in rural areas of provinces and cities in the Yangtze River Delta is calculated, as shown in **Table 3**.

It can be seen from **Table 3** that from 2013 to 2021, the coupling coordination degree among economic, social and environmental aspects in rural areas of the Yangtze River Delta is on the rise. In 2021, the average coupling coordination degree of rural areas in Jiangsu Province is 0.490, that of rural areas in Zhejiang Province is 0.483, and that of rural areas in Anhui Province is 0.341. The average coupling coordination level of rural areas in Jiangsu Province and Zhejiang Province has reached the stage of being on the verge of imbalance and has almost entered the level of barely coordination. Rural areas in Anhui province also

Table 2. Evaluation basis and classification standard of coupling coordination degree

First level	D	Second level	Third level (primitive types)
Third level (primitive types)	$0.90 \le D \le 1.00$	Effective coordination	If a, then it is a lagging type. If so, it is an economic-socio-environment synchronous type.
	$0.80 \le D \le 0.89$	Good coordination	
	$0.70 \le D \le 0.79$	Intermediate coordination	
intermediate category	$0.60 \le D \le 0.69$	Basic coordination	
	$0.50 \le D \le 0.59$	preliminary coordination	
	$0.40 \le D \le 0.49$	on the brink of disarray	
	$0.30 \le D \le 0.39$	mild dysfunction	
maladaptive decline class	$0.20 \le D \le 0.29$	moderate dysfunction	
	$0.10 \le D \le 0.19$	severe dysfunction	
	$0.00 \le D \le 0.09$	extreme dysfunction	

Table 3. Coupling coordination degree of rural areas in provinces and cities of Yangtze River Delta.

province	Prefecture-level city	2013	2016	2019	2021
Jiangsu	Nanjing	0.399	0.406	0.498	0.498
	Wuxi	0.386	0.433	0.462	0.492
	Changzhou	0.400	0.415	0.470	0.491
	Suzhou	0.423	0.429	0.461	0.491
	Nantong	0.403	0.440	0.512	0.495
	Yancheng	0.399	0.430	0.512	0.491
	Yangzhou	0.382	0.413	0.466	0.472
	Zhenjiang	0.404	0.446	0.453	0.490
	Taizhou	0.369	0.442	0.476	0.494
	Mean value	0.396	0.428	0.479	0.490
Zhejiang	Hangzhou	0.408	0.460	0.500	0.492
	Ningbo	0.424	0.448	0.475	0.508
	Wenzhou	0.376	0.440	0.458	0.494
	Jiaxing	0.391	0.448	0.467	0.481
	Huzhou	0.391	0.416	0.464	0.481
	Shaoxing	0.366	0.423	0.450	0.472
	Jinhua	0.364	0.416	0.447	0.475
	Zhoushan	0.401	0.443	0.452	0.480
	Taizhou	0.406	0.446	0.467	0.466
	Mean value	0.392	0.438	0.464	0.483
Anhui	Hefei	0.271	0.311	0.360	0.389
	Wuhu	0.187	0.227	0.315	0.325
	Maanshan	0.235	0.217	0.270	0.316
	Tongling	0.207	0.227	0.312	0.309
	Anqing	0.169	0.298	0.301	0.356
	Chuzhou	0.191	0.259	0.282	0.321
	Chizhou	0.182	0.284	0.339	0.349
	Xuancheng	0.261	0.243	0.307	0.360
	Mean value	0.213	0.258	0.311	0.341

reached mild levels of imbalance.

In 2021, the coupling coordination degree of economy, society and environment in the rural areas of Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yancheng, Zhenjiang and Taizhou in Jiangsu Province will all exceed 0.490, which is

on the verge of imbalance and already approaching the stage of barely coordination. The coupling coordination degree of rural areas of Yangzhou in Jiangsu Province will also reach 0.472. On the verge of dysregulation. From 2013 to 2017, the coupling coordination degree of rural areas in Jiangsu Province increased by 0.042 on average, with an average annual growth rate of 2.552%. Among them, the fastest growth rate was Nanjing, with an average annual growth rate of 4.068%. During 2017-2021, the coupling coordination degree of rural areas in Jiangsu Province increased by 0.052, with an average annual growth rate of 2.844%. The coupling coordination degree of rural areas in Jiangsu Province increased slightly faster during 2017-2021 than that during 2013-2017, and the average annual growth rate was also slightly larger.

In 2021, the coupling coordination degree in the rural areas of Ningbo City, Zhejiang Province, reaches 0.508, which is barely in the coordination stage; the coupling coordination degree in the rural areas of Hangzhou City and Wenzhou city also exceeds 0.490; the coupling coordination degree in the rural areas of Jiaxing city and Huzhou city ranges from 0.480 - 0.481. The coupling coordination degree of Shaoxing City and Jinhua City is 0.472 and 0.475 respectively, and the rural area of Taizhou city also reaches 0.466. Except Ningbo City, the rural areas of other prefectural cities are on the verge of imbalance stage, and Hangzhou City and Wenzhou city will also enter the reluctant coordination stage. The average annual development rate of the overall coupling coordination level in Zhejiang Province during 2017-2021 was 2.417%, which was little different from the average annual development rate during 2013-2017.

In 2021, the coupling coordination degree of economy, society and environment in the rural areas of Hefei City, Anhui Province reached 0.389, the coupling coordination degree of Xuancheng city, the coupling coordination degree of Anqing City is 0.356, and the coupling coordination degree of other cities in the rural areas is between 0.300 and 0.350, which is in the mild imbalance stage. The rural areas of Hefei City and Xuancheng City in Anhui province developed well, and the development speed between 2017 and 2021 was better than that between 2013 and 2017. The development speed of the coupling coordination degree in the rural areas of other cities is first fast and then slow.

4. Conclusion and Suggestion

This paper takes the coupled and coordinated development of economic, social and environmental systems in the rural areas of the Yangtze River Delta as the research object. Starting from the fundamentals of economy, society and environment, and combining with the actual development status of the rural areas of the Yangtze River Delta, it constructs an index system with 21 indicators in 8 criterion layers. The coupling coordination model is used to measure and test the degree of coupling coordination among economy, society and environment in rural areas of Yangtze River Delta, and the following conclusions are drawn:

On the whole, from 2013 to 2021, the coupling coordination degree among

economic, social and environmental aspects in rural areas of the Yangtze River Delta is on the rise. In 2021, the average level of coupling coordination in rural areas of Jiangsu Province and Zhejiang Province has reached the verge of imbalance stage, and has nearly entered the level of barely coordination, and the rural area of Anhui province has also reached the level of mild imbalance. The rural areas of most prefecture-level cities in Jiangsu Province have almost entered the barely coordinated level, the rural areas of most prefecture-level cities in Zhejiang Province are also in the verge of imbalance stage, and the rural areas of Anhui Province are in the mild imbalance stage. This phenomenon shows that the development status of rural areas in Jiangsu Province is slightly better than that of rural areas in Zhejiang Province and Anhui province. The speed of rural development is different in different places, and the prefecture-level cities that have developed faster after 2017 are the prefecture-level cities that are at the forefront of development at this stage. According to the main hindrance factors of each prefecture-level city, the shortest plank of the wooden barrel should be "replenishment" to promote the healthy and sustainable development of the countryside.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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