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Measurement and Evaluation of Urban Resilience in Yangtze River Delta

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Abstract

Cities are the homes that people depend on for survival. The level of urban resilience is an important index to test the city's ability to resist risks. This paper uses the panel data of the Yangtze River Delta from 2003 to 2018, takes the expansion of the Yangtze River Delta as a quasi-natural experiment, constructs the evaluation system of urban resilience index, uses the objective entropy weighting method to determine the weight, calculates the urban resilience level of Chinese prefecture-level cities through the measurement system, and quantifies the urban resilience. The entropy method is used to calculate the comprehensive value of the resilience index of various regions in the Yangtze River Delta urban agglomeration, and then the relevant development policy suggestions are put forward for the improvement of the resilience index of the Yangtze River Delta region.

Keywords

Resilience; Yangtze RiverDelta; Anti-risk Ability; Objective Entropy Weighting Method; Entropy Method.

1. Introduction

The epidemic, which started in late 2019, has had a huge impact on people's lives and caused lasting and indelible damage to urban development. During the pandemic, many cities in China, such as Wuhan, demonstrated their resilience in coping with the sudden, changing and threatening epidemic. Their ability to bear the brunt and risk was well recognized by the public. However, some cities also lost the battle against the epidemic and paid a terrible price. It is obvious that the resilience of these cities is not satisfactory.

In our daily life, the risks cities have to deal with are not only major infectious diseases, natural disasters, terrorist attacks and other factors will cause great security risks to people's lives and property. For example, extreme weather El Nino will cause grain production reduction, hard hit energy, transportation and other industries, leading to food crisis, energy crisis and other adverse situations. Under the objective natural conditions of drought and water shortage, how to ensure the normal water supply for production and life of cities in western China; Disasters such as wind, earthquake, snow and ice have caused great damage to urban power, challenging cities' ability to restore normal power supply in a short period of time and ensure normal production, life, circulation and operation to the greatest extent. Sudden terrorist attacks test a city's ability to cope with the protection of people's lives, safety and property, and are also an important source of people's happiness and sense of gain.

The written meaning of the word toughness is the ability of materials to absorb deformation forces when they deform. The definition of "toughness" here is closely related to vulnerability, elasticity, and adaptability. Resilience means both elasticity and adaptability. It refers to the degree of stress that can be withstood by the blow of risk. It is similar to the maximum tension that a strained bow can bear. Urban resilience refers to a city's ability to cope with emergencies and adapt to risks in the long term. The higher the resilience of a city, the lower the vulnerability, the stronger the resilience and adaptability.

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1.1. Literature Review

The concept of resilience originated from engineering resilience, and its development has gone through the process from engineering resilience to ecological resilience, and from ecological resilience to evolutionary resilience. It refers to the ability of the whole system to maintain self-renewal and sustainable development through the process of resilience, recovery, adaptation and path innovation in the event of sudden risk impact.

At present, there are different understandings of the term "resilience" at home and abroad, but it is generally emphasized that urban resilience is developing in the direction of system integration and element diversification. In this paper, urban resilience means that the urban system can still maintain the urban structure and basic attributes after the long-term disturbance or short-term impact, so as to ensure the urban operation mode with sufficient redundancy.

The assessment of urban resilience can be discussed and studied from ecology, economics, engineering, public management, sociology and other disciplines. After consulting a large number of data and references, it is finally determined that the 2016 OECD resilient city assessment framework shall prevail. This paper evaluates urban resilience from four dimensions: economic resilience, social resilience, ecological resilience and engineering resilience.

1.2. Research Design

On November 3, 2020, the Fifth Plenary Session of the 19th CPC Central Committee proposed for the first time to build "resilient cities". According to the proposal, "We will promote a new type of urbanization that puts people at the core. We will strengthen historical and cultural protection, shape the urban landscape, strengthen the renovation of old urban neighborhoods and community building, strengthen the flood control and drainage capacity of cities, and build sponge cities and resilient cities. We will improve urban governance and strengthen risk prevention and control in the governance of megacities. "The assessment of urban resilience needs to be carried out from multiple disciplines and perspectives. The assessment measures have important reference value for the development of cities. Although epidemic control has been abolished in China and the epidemic has been effectively contained after herd immunity, the complicated international environment situation is still grim. It is still of great significance to explore a more comprehensive and operational assessment system for urban resilience.

As the region with the most active economic development, the highest degree of openness and the strongest innovation capacity in China, the Yangtze River Delta is a bellwether for the economic development of the rest of the country. To promote the integrated development of the Yangtze River Delta and maximize the strategic advantages of the Yangtze River Delta is an important part of the optimization of China's regional economic layout. Measuring the resilience of the Yangtze River Delta is of great significance to the development of the Yangtze River Delta. Therefore, we need to explore the current situation of the urban resilience construction of the Yangtze River Delta, the differences of the current situation of the urban resilience construction of the three provinces and one city in the Yangtze River Delta, the differences of the urban resilience of prefecture-level cities in the Yangtze River Delta in different years, if any, what are the reasons behind the differences and what measures should be taken to improve and cope with them.

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2. Selection of Indicators, Data and Methods

2.1. Research Scope and Index Selections

We set the research scope as prefecture-level cities in the Yangtze River Delta region, including Shanghai, prefecture-level cities in Jiangsu, Zhejiang and Anhui provinces, and the selected data interval is from 2003 to 2018.

2.2. Current Research Status of Urban Resilience

In 2002, the International Council for Regional sustainable Development proposed the term "urban resilience" for the first time and introduced it into the study of cities and disaster prevention. As a result, the research on urban resilience focusing on urban disaster risk management started a boom. With the development of time, the coverage of urban resilience has become more and more extensive, gradually expanding to economic, social and other aspects. Major research institutions such as the Resilience Alliance, the United Nations Disaster Prevention and Mitigation Programme, and the Organization for Economic Cooperation and Development have also carried out further research.

The Urban Resilience Development Index, released by the Arup&Rockefeller foundation from 2013 to 2018, defines urban resilience as the ability of a city (individual, community, institution, business entity or system) to survive, adapt and grow in the face of any sustained, chronic stress or sudden disaster impact. Zhao Ruidong and other scholars believe that urban resilience is a coupled system composed of urban economy, society, institution, ecology, infrastructure and other systems; Tang Fanghua and other scholars regard resilience as an essential feature of a city, and through preparation in advance, the normal operation of public safety, social order and economic construction can be realized.

On the basis of synthesizing existing research results, this paper argues that urban resilience refers to a city's ability to resist risks, reduce disaster losses and reasonably deploy resources to recover, rebuild and develop quickly from disasters under the impact of foreseeable or unforeseeable risks and disasters.

2.3. The Assessment of Resilient Cities in the Yangtze River Delta based on the Socio-Ecological System

The social-ecosystem is a huge system composed of people, society and nature. The social relationships in this system affect the development of society. Among them, the modes of social development, such as social vulnerability, social sustainability, social change and social diversity, etc.

2.3.1. The Impact of Economic Resilience on Urban Resilience

Economic base determines the superstructure, and economic resilience is the basis of urban resilience. Per capita gross regional product, per capita fiscal revenue and the proportion of tertiary industry added value in GDP can basically measure the level of economic development of a region. The stronger a city's economy is, the stronger its resilience and risk resistance will be.

2.3.2. The Impact of Social Resilience on Urban Resilience

The stable and healthy development of society is very beneficial to the development of a city. The employment rate, the number of college students, the number of medical and health institutions, the number of Internet broadband users, the number of buses, the number of books in public libraries per capita, these indicators can reflect the stability index of a society, as well as the level of knowledge and culture of a city. The more stable the society, the higher the knowledge and culture level of the city, the stronger the ability to predict risks, resist risks, and rebuild after disasters.

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2.3.3. The Impact of Ecological Resilience on Urban Resilience

Harmony between man and man, between man and nature, and between natural systems is an important content of eco-city construction. The harmonious development of ecology is of great significance to cities. Per capita green area of parks, green coverage rate of built-up areas, sewage treatment rate, and harmless treatment of household garbage can reflect the current situation of urban ecological environment to some extent.

2.3.4. The Influence of Engineering Toughness on Urban Toughness

Engineering construction is an important part of urban construction, which can improve human life and promote sustainable development. The per capita bonus payment for urban maintenance construction, per capita daily living water consumption, per capita urban road area, drainage pipe density of built-up areas and other indicators can reflect the status quo of urban engineering construction. The higher the quality of urban engineering construction, the stronger the city's ability to resist risks, and the stronger the ability to rebuild after disasters.

To sum up, in view of domestic and foreign scholars' and their own cognition of the meaning, 17 indicators from four dimensions of economy, society, ecology and engineering are selected as the component indicators of the comprehensive evaluation index system table of urban resilience.

2.4. Data Sources

This paper takes 41 cities in the Yangtze River Delta as research objects, including Shanghai, 13 cities such as Nanjing, Wuxi, Xuzhou, Changzhou, Suzhou and Nantong in Jiangsu Province, 11 cities such as Hangzhou, Ningbo, Wenzhou, Jiaxing and Huzhou in Zhejiang province, and 16 cities such as Hefei, Wuhu, Bengbu, Huainan and Ma 'anshan in Anhui province. All the data were collected from the National Bureau of Statistics, provincial Bureau of Statistics and relevant city Statistical bulletins, the database of the Research Center for Cities and Competitiveness of the Chinese Academy of Social Sciences from 2003 to 2018, and data from Baidu and People's Daily Online from 2003 to 2018.

2.5. Research Methods: Entropy Weighting Method

The measure of comprehensive index system usually has two kinds: subjective weighting method and objective weighting method. Supervisor weighting method determines attribute weight according to decision-makers subjectively importance to each attribute. The original data is obtained by experts according to their subjective judgment. Objective weighting method determines the weight according to the relationship between the original data through certain mathematical methods, and its judgment results do not depend on the subjective judgment of people, which has a strong mathematical theoretical basis. In this paper, we choose the objective entropy weighting method to determine the weight, the main purpose is to eliminate the influence of subjective factors. According to the change degree of each index, calculate the weight.

Table 1. Comprehensive evaluation system of urban resilience

Target layer	Level 1 indicators	Secondary indicators	Indicator units	Weight (%)
Urban resilience	Economic resilience	Gross regional product per capita	yuan	3.718
		Per capita fiscal revenue	yuan	5.568
		Value added of tertiary industry as a percentage of GDP	%	0.768

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	Social resilience	Employment rate	%	0.379
		College students in school per 10,000 people	people	6.535
		Number of health facilities per 10,000 people	people	4.335
		Internet broadband users per 10,000 people	households	5.607
		Buses per 10,000 people	Standard station	4.465
		Public library books per capita	Copies of the	23.55
	Ecological resilience	Per capita park green space	m^2	0.82
		Green coverage of built-up areas	%	0.463
		Sewage treatment rate	%	0.904
		Harmless disposal rate of household waste	%	0.668
	Engineering toughness	Per capita bonus expenditure for urban maintenance and construction	yuan	5.985
		Per capita daily domestic water consumption	L	3.058
		Per capita urban road area	m^2	2.761
		Density of drainage pipe in built-up area	Km/square kilometers	30.417

3. Analysis of Results

3.1. Urban Resilience Assessment and Spatial-Temporal Distribution Differences

In this paper, the evaluation system of urban resilience index is constructed first, and then the urban resilience is quantified. The comprehensive value of the resilience index of all regions in the Yangtze River Delta urban agglomeration during 2003-2018 is calculated by using the entropy method, and the current situation map of the urban resilience index in the Yangtze River Delta is obtained, as shown in Figure 1.

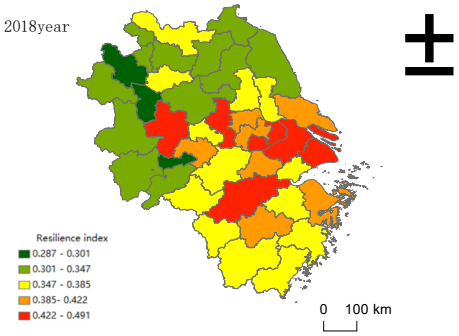

Figure 1. Spatial distribution of urban resilience index in the Yangtze River Delta

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It can be seen from the figure that Shanghai, Suzhou, Wuxi, Nanjing, Hefei and Hangzhou have the highest urban resilience index in the Yangtze River Delta region, followed by Yangzhou, Taizhou, Wuhu, Ningbo and Jinhua, while Yancheng, Huai 'an, Lianyungang, Lu 'an and Fuyang have the lowest.

In this paper, the natural fracture point classification method and ArcGIS 10.0 software were used to analyze the comprehensive values of 2003, 2008, 2013 and 2018, and the urban toughness was divided into five types. The spatial visualization of the results was carried out to analyze the spatial pattern evolution characteristics of resilience in the Yangtze River Delta, and Figure 2 was obtained.

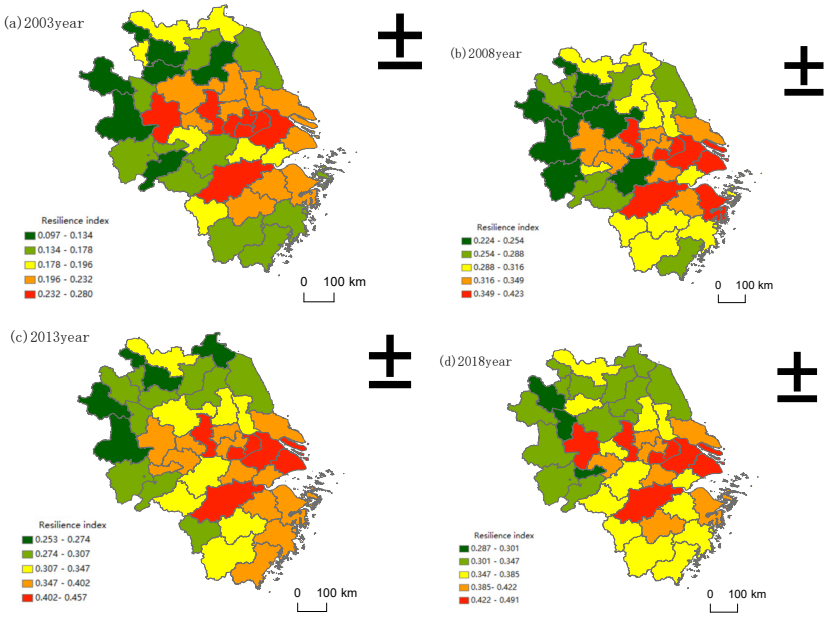

Figure 2. Spatial distribution and evolution of urban resilience index

The following information can be obtained from Figure 2: First, the distribution of urban resilience index in the Yangtze River Delta shows an overall rising trend. During the period from 2003 to 2018, the urban resilience index of three provinces and one city showed an overall upward trend; Second, the distribution of the urban resilience index showed an uneven situation. The urban resilience of Shanghai, Jiangsu and Zhejiang provinces is significantly higher than that of Anhui Province. Thirdly, the resilience strength of the Yangtze River Delta urban agglomerations shows certain spatial agglomeration characteristics. In the high-value toughness areas such as Shanghai, Suzhou and Hangzhou, the toughness values of the surrounding cities are also high. In low-value toughness areas such as Hefei, the toughness values of the surrounding cities are also low.

3.2. Spatial Distribution of Various Dimensions of Urban Toughness

In this paper, the entropy method is used to calculate the values of each dimension of urban toughness of the Yangtze River Delta urban agglomerations during 2003-2018. The values of each dimension of urban toughness of the Yangtze River Delta in 2018 are selected, and the natural fault point classification method in ArcGIS10.0 is used to divide the urban toughness into five categories, namely, low-value, low-toughness, medium-value, high-value, low-toughness and high-value toughness areas. The spatial pattern distribution maps of economic, social, ecological and engineering resilience were obtained (Figure 3). It can be seen from Figure 3 that:

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Economic resilience dimension. In general, the economic resilience of Shanghai, Jiangsu and Zhejiang provinces is at the leading level of the Yangtze River Delta urban agglomeration; The economic resilience of Anhui province is at a lower level.

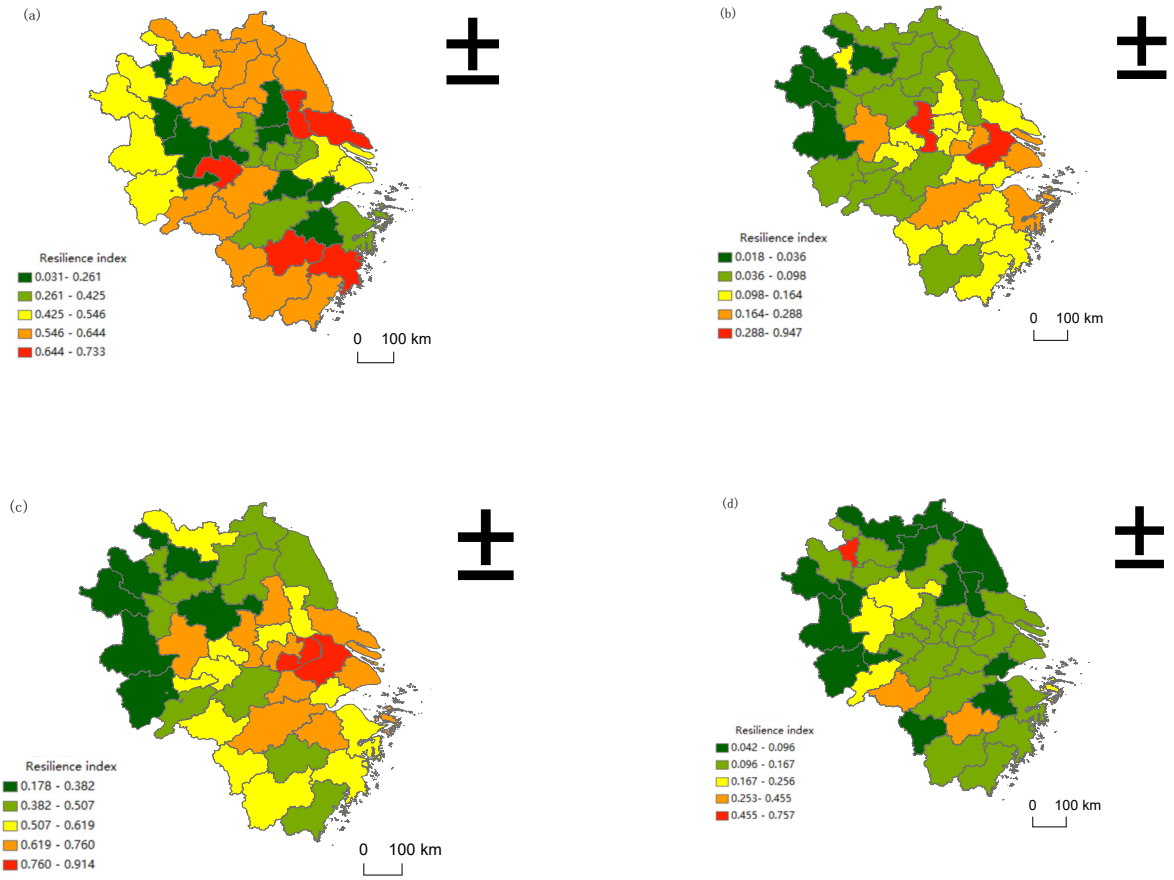

Figure 3. Spatial distribution of urban toughness in each dimension

Social resilience dimension. The social resilience of Shanghai and most cities in Zhejiang Province is higher, followed by that of Jiangsu Province. In Anhui Province, social resilience of other cities is lower except Hefei, Wuhu and Maanshan.

Ecological resilience dimension. The central region of the Yangtze River Delta urban agglomeration has a relatively high value of ecological resilience, such as Suzhou, Wuxi, Nanjing and other regions; Low-value and low-value resilience areas are scattered around the periphery of the Yangtze River Delta urban agglomeration, such as Bozhou, Fuyang, Lu 'an, Anqing and other cities.

Project toughness dimension. Huaibei City, Chuzhou City, Hefei City, Chizhou City, Jinhua City and Huangshan City have high engineering toughness value, while other cities in the Yangtze River Delta region have low engineering toughness value.

4. Conclusion

4.1. Overall Evaluation

The panel data of the Yangtze River Delta urban agglomeration from 2003 to 2018 are used to measure the urban resilience of the Yangtze River Delta urban agglomeration, and the main conclusions are as follows:

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In general, the urban resilience level of the Yangtze River Delta urban agglomerations shows an upward trend. The resilience index values of the central and eastern regions are higher, while those of the western and southern regions are lower.

There are differences in the spatial distribution of urban resilience in different dimensions in the Yangtze River Delta urban agglomerations, and the spatial distribution of urban resilience has certain agglomeration characteristics. The cities with higher urban resilience values also have higher urban resilience values around them. An area with a lower urban toughness value also has a lower urban toughness value around it. In general, the overall resilience level of the Yangtze River Delta region still needs to be improved.

The resilience level of the Yangtze River Delta urban agglomeration varies in different dimensions. In general, the economic and social resilience of the Yangtze River Delta is relatively high, especially in the central and eastern regions, while the western region is relatively low. On the other hand, the values of ecological resilience and engineering resilience of the Yangtze River Delta urban agglomeration are generally low, which still has great room for improvement.

4.2. Related Suggestions

Based on the above analysis results, this paper suggests improving the resilience of the Yangtze River Delta urban agglomeration from the following aspects.

First, with Shanghai, Nanjing, Hangzhou and Hefei as the core of the urban coordination and cooperation mechanism, we should promote development before development, coordinate with the development mechanism of the Yangtze River Delta urban agglomeration, promote infrastructure connectivity within the region, and improve the overall resilience of the Yangtze River Delta region.

Second, we should promote balanced regional resilience in the Yangtze River Delta urban cluster. To improve the overall resilience of cities in the Yangtze River Delta, in addition to strengthening cities with high levels of urban resilience, more attention should be paid to areas with low levels of resilience, and resources should be coordinated to support the development of western and southern regions.

Third, it is necessary to improve the resilience of cities in the Yangtze River Delta according to local conditions. Cities have different development conditions and environments, as well as different constraints on their development. Corresponding development measures should be formulated according to the characteristics of each city.

Fourth, siphon effect should be avoided as far as possible in the Yangtze River Delta urban agglomeration. Siphon effect will lead to a negative spillover effect of urban resilience on the development of surrounding areas, hindering its development. Cities with low urban resilience level should make good use of the positive spillover effect brought by surrounding areas, and at the same time, constantly improve their own level and narrow the difference between them and other cities.

Acknowledgments

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