Research on the Evolution and Development of Urban Resilience in Zhenjiang City

Kai Cheng*, Jianye Hua[a], Xiaoxuan Xie[b]

Art School, Jiangsu University, Zhenjiang, Jiangsu, 212013, China
*Email: kai_gift@ujs.edu.cn
[a]Email: 44896494@qq.com
[b]Email:2497419463@qq.com

Abstract. As the process of national modernization and urbanization accelerates, various issues related to urban construction continue to emerge, and the hidden risks are also increasing. This paper, based on resilience theory and combined with the current overall development planning and policies of Zhenjiang City, proposes feasible suggestions for the positive development of resilience in Zhenjiang, Jiangsu, from four perspectives: ecological resilience, social resilience, economic resilience, and engineering resilience[1].

Keywords: Resilience thinking, Resilient cities, Urban resilience, Planning methods.

1 Introduction

Sustainable urban development is the core goal of modern urban construction. Conducting scientific and systematic overall research on urban development to deeply understand the challenges and difficulties faced during the urban development process is essential for sustainable urban growth. This paper, through the collation and analysis of resilience-related theories and the processing of statistical data, constructs a resilience measurement model for towns and townships. It studies the factors affecting the urban development of Zhenjiang City and develops a city development research method mainly based on statistical data. Based on resilience theory and combined with the current overall development planning and policies of Zhenjiang City, this study proposes feasible suggestions for the positive development of resilience in Zhenjiang, Jiangsu, from four perspectives: ecological resilience, social resilience, economic resilience, and engineering resilience.

2 Research on Resilient City Theory

2.1 Resilient City Theory

Since the reform and opening up, the process of national modernization and urbanization has been accelerating, with various issues related to urban construction emerging

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continuously, and the hidden risks also increasing. In this context, domestic scholars, while exploring theories of sustainable development, have proposed theoretical strategies such as low-carbon cities, sponge cities, ecological cities, and resilient cities. In recent years, as exploration of these theories has progressed, resilience theory has gained attention from all sectors, serving as a supplement and refinement to the theory of sustainable development[2].

2.2 Analysis of Current Issues

Current urban development theories in China include sustainable development theory[3], synergy theory, and regional integration theory. In the process of exploring resilience theory, it is necessary to discern and draw upon existing urban development theories to refine the resilience theory system. Based on the national conditions of China, it is essential to propose resilience theories and solutions that are suitable for guiding the development of modern cities and rural areas.

3 Research Methods

3.1 Data Sources and Processing

Considering the complexity and dynamics of the socio-ecological system to ensure the authenticity, validity, and accessibility of the research data, this paper primarily sources its data from the "Zhenjiang Statistical Yearbook" editions from 2013 to 2022, along with related statistical bulletins. Data was obtained either directly or calculated based on existing related data, with missing data points filled in using interpolation methods. Therefore, the research data utilized in this paper possesses a certain degree of authenticity, accuracy, and scientific validity.

The required data were categorized and organized into four sub-units: ecological resilience, social resilience, economic resilience, and engineering resilience. The original data were then standardized, and weights for each subsystem were set. Based on prior research, for ease of calculation, the weights of each subsystem were set to 0.25. Finally, the processed data were used to measure resilience, yielding the resilience assessment results for Zhenjiang City from 2013 to 2022 [4].

3.2 Construction of the Resilience Measurement Model

Based on the standardized data and the respective weights of various indices obtained through calculations, the urban resilience measurement model for Zhenjiang City covering the years2013 to 2022 has been developed. This model integrates the processed data across ecological, social, economic, and engineering resilience dimensions, providing a comprehensive view of the city's resilience over time.

① The urban resilience measurement model

UrRe, is composed of models for economic resilience (EcRe), social resilience (ScRe), ecological resilience (EnRe), and engineering resilience (InRe). The focus of

this research is on the interaction between these subsystems, which collectively form the entire resilience system. For simplification, the model assumes equal weights for each component, resulting in the urban resilience measurement formula:

$$\mathrm{UrRe} = (\mathrm{EcRe} + \mathrm{ScRe} + \mathrm{EnRe} + \mathrm{InRe}) / 4$$

② For the resilience measurement model of urban subsystems:

For ecological resilience (EnRe), let α1,α2,α3,α4,α5, and α6 represent the weights of indicators A1, A2, A3, A4, A5, and A6, respectively. The formula for ecological resilience measurement is:

$$\mathrm{EnRe} = \alpha_1 * \mathrm{A1} + \alpha_2 * \mathrm{A2} + \alpha_3 * \mathrm{A3} + \alpha_4 * \mathrm{A4} + \alpha_5 * \mathrm{A5} + \alpha_6 * \mathrm{A6}$$

For economic resilience (EcRe), let β1,β2,β3, and β4 represent the weights of indicators B1, B2, B3, and B4, respectively. The formula for economic resilience measurement is:

$$\mathrm{EcRe} = \beta_1 * \mathrm{B1} + \beta_2 * \mathrm{B2} + \beta_3 * \mathrm{B3} + \beta_4 * \mathrm{B4}$$

For social resilience (ScRe), let γ1,γ2,γ3,γ4,γ5, and γ6 represent the weights of indicators C1, C2, C3, C4, C5, and C6, respectively. The formula for social resilience measurement is:

$$\mathrm{ScRe} = \gamma_1 * \mathrm{C1} + \gamma_2 * \mathrm{C2} + \gamma_3 * \mathrm{C3} + \gamma_4 * \mathrm{C4} + \gamma_5 * \mathrm{C5} + \gamma_6 * \mathrm{C6}$$

Lastly, for engineering resilience (InRe), let ε1,ε2,ε3,ε4,ε5,ε6, and ε7 represent the weights of indicators D1, D2, D3, D4, D5, D6, and D7, respectively. The formula for engineering resilience measurement is:

$$\mathrm{InRe} = \varepsilon_1 * \mathrm{D1} + \varepsilon_2 * \mathrm{D2} + \varepsilon_3 * \mathrm{D3} + \varepsilon_4 * \mathrm{D4} + \varepsilon_5 * \mathrm{D5} + \varepsilon_6 * \mathrm{D6} + \varepsilon_7 * \mathrm{D7}$$

③Constructing the Resilience Measurement Model

By applying the resilience measurement model formulas as described above, the resilience measurement model for Zhenjiang City from 2013 to 2022 has been constructed. The detailed outcomes of this model are presented in Table 1.

Table 1. Urban Ecological-Social Resilience Measurement Model for Zhenjiang City, 2013-2022

	ECOLOGICAL RESILIENCE	ECONOMIC RESILIENCE	SOCIAL RESILIENCE	ENGINEERING RESILIENCE	URBAN RESILIENCE
2013	0.06	0.14	0.12	0.03	0.09
2014	0.08	0.29	0.21	0.15	0.18
2015	0.34	0.35	0.30	0.42	0.35
2016	0.40	0.44	0.34	0.57	0.44
2017	0.31	0.51	0.63	0.87	0.58
2018	0.38	0.61	0.78	0.44	0.55
2019	0.42	0.67	0.72	0.42	0.56
2020	0.25	0.79	0.82	0.43	0.57
2021	0.62	0.80	0.75	0.45	0.65
2022	0.96	0.81	0.89	0.48	0.78

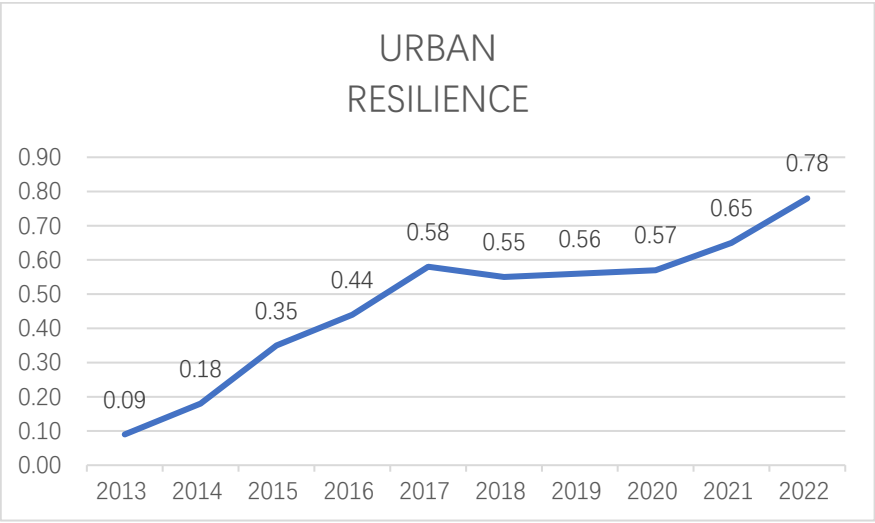

Fig. 1. Urban resilience measurement model of Zhenjiang City from 2013 to 2022

From this model, it can be seen that in terms of the overall development trend, the eco-social resilience of Zhenjiang City from 2013 to 2022 showed an obvious upward trend, increasing from 0.09 in 2013 to 0.78 in 2022 (Figure 1). During this period, the resilience change of Zhenjiang City presents three stages. In the period from 2013 to 2017, the resilience increased from 0.09 to 0.58. From 2017 to 2020, the resilience change was relatively stable, and the resilience changed steadily at about 0.58. The phase of rising resilience from 2020 to 2022 saw an increase in resilience from 0.57 to 0.78.

It is concluded that the development trend corresponds to the multi-scale nested adaptation cycle in resilience theory. The theoretical analysis shows that the resilience change of Zhenjiang City is in the stage of rapid growth until the resilience change is relatively stable, and then through entering another resilience process, the rapid growth of the resilience change of Zhenjiang City is once again accelerated.

4 Urban Resilience Adjustment Measures for Jurong City, Zhenjiang

Based on the research and analysis of the resilience measurement model for Zhenjiang City and grounded in urban resilience theory, this section proposes actionable recommendations for the positive development of resilience in the border towns of Zhenjiang City. These recommendations are made from the perspectives of ecological resilience, social resilience, economic resilience, and engineering resilience.

4.1 Ecological Resilience of Border Towns

The study of the evolutionary characteristics of ecological resilience in Zhenjiang City indicates that although the overall resilience level of Jurong City is gradually improving, it remains lower compared to other areas. Therefore, there is still a need to enhance its ecological resilience. In developing the city's characteristic industries and agricultural industries, it is essential to raise the standards for pollutant emissions management and improve the corresponding technologies to enhance the recycling rate of wastewater and waste. Increasing the construction of urban community plant diversity, transforming the existing green space ecological vegetation, and planning for ecological resilience in new developments are vital steps to protect local ecological diversity[5].

4.2 Economic Resilience of Border Towns

The analysis of the evolutionary characteristics of economic resilience in Jurong City reveals that, although its economic resilience has been continuously developing and improving, the overall economic level is very low. It is imperative to optimize the township industrial structure and improve operational efficiency across all aspects to promote rapid economic development of the townships. Efforts should be increased to explore and develop the unique resources of townships, encouraging outside investors and local residents to jointly innovate and start businesses, and to develop agricultural subsidiary industries[6].

4.3 Social Resilience of Border Towns

We should adopt a "people-centric" approach for township development, taking into account the ideas of local residents and actively involving them in the resilience-building of urban communities. Cooperation and communication among leaders, investors, and existing residents should be fostered, integrating their efforts cohesively. By promoting economic development in townships and increasing the per capita income of township residents, confidence in the resilience development of urban communities can be nurtured. Through relevant policy strategies, issues related to pensions and healthcare for urban residents should be assured, effectively safeguarding the livelihood needs of local residents.

4.4 Engineering Resilience of Border Towns

To strengthen the development efforts towards social resilience in Jurong and border towns, the construction of urban traffic networks should be reinforced, existing infrastructure should be optimized, and modern urban infrastructures should be built to establish a modern infrastructure system that supports sustainable urban development and maintenance. Aiming for the equalization of basic public services between urban and rural areas, public service facilities should be allocated according to the population size and actual functional needs, an infrastructure maintenance and update system based on

community units should be established to ensure the effective functioning of urban infrastructure and the recycling of discarded infrastructure.

5 Conclusion

This article, drawing on existing research achievements and utilizing data results, constructs a resilience measurement model and applies a resilience index to evaluate the resilience changes in the development of Zhenjiang City. The analysis of the evolution characteristics of the resilience measurement model serves a dual purpose: on one hand, it studies the spatiotemporal characteristics of township resilience evolution in Zhenjiang City through data, and on the other hand, it corroborates with resilience theory to verify the scientific validity and feasibility of this research method.

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