Urban Resilience in China

Subjects: Urban Studies

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As modern cities increasingly face environmental disasters and inherent challenges, the creation and enhancement of resilient cities have become critical. China's urban resilience exhibits significant imbalances and inadequacies at the provincial level.

Keywords: urban resilience ; spatial correlation ; influencing factors

1. Introduction

An alarming increase in environmental disasters profoundly affect urban systems worldwide. The continuous expansion and growth of urban areas has heightened their vulnerability and introduced greater uncertainty in urban governance when facing a range of disaster risks. Currently, frequent environmental disasters such as typhoons and floods are occurring globally, which pose great challenges for cities' safety [1]. Specifically, in 2022, China was hit with a series of environmental disasters, impacting an estimated 112 million people. The mainland endured 27 earthquakes with magnitudes of five or higher. Typhoon-induced disasters alone led to direct economic damages amounting to CNY 5.42 billion, and ten provinces suffered direct economic losses exceeding CNY 10 billion due to various disasters over the year [2].This pattern of significant direct economic losses from environmental disasters in China is not an isolated incident of 2022 but has been a persistent issue over the years. Moreover, this challenge is not unique to China. The world is facing enormous economic losses due to disasters (refer to **Figure 1**). Consequently, the development and advancement of resilient urban areas have emerged as urgent worldwide issues.

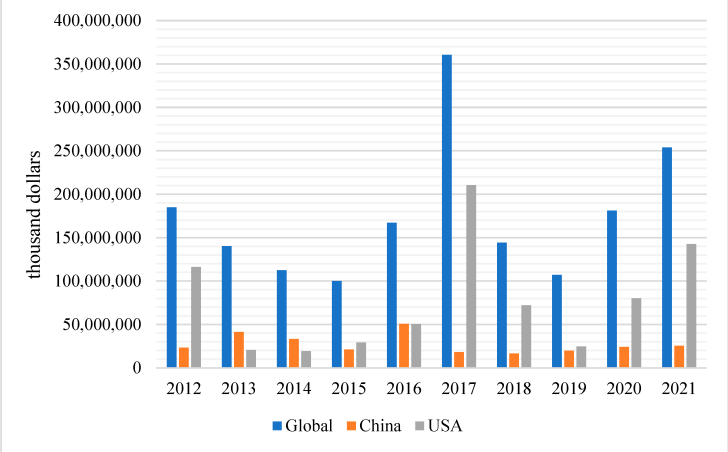

Figure 1. Yearly direct economic losses due to environmental disasters; date resource: https://www.gddat.cn/newGlobalWeb/#/NationalScale (accessed on 20 June 2023).

Beyond the increasingly challenging external environment, the ongoing march of industrialization and urbanization also leads to disparities in urban development which have emerged globally. These variations have led to numerous issues, including overpopulation, traffic congestion, insufficient infrastructure, and environmental pollution [3][4]. The resilience of cities is being tested by both internal challenges and external pressures [5]. The critical question is how cities can effectively counter these external forces and manage internal inefficiencies within their unique constraints and the unpredictability of external shocks, in pursuit of enhancing their resilience and achieving sustainable development. This remains a global challenge that all countries must confront [6].

Recently, China's economic boom and rapid urbanization have thrust its cities into a phase of accelerated development. However, this development has been uneven, leading to significant disparities in economic growth, infrastructure advancement, and environmental management across China's 31 provinces [7]. Consequently, a scenario of imbalanced and inadequate development prevails across these regions. Urban areas, increasingly interconnected and

interdependent, face heightened vulnerability to a variety of risks, including environmental disasters and socioeconomic upheavals [8]. In light of this disparate development, it becomes imperative to tailor strategies at the provincial level [9]. By analyzing the temporal pattern of urban resilience and discerning the drivers behind its variability, policymakers and urban planners can formulate nuanced strategies to strengthen the resilience of specific regions. In the context of China, marked by its diverse regional development trajectories, investigating the spatial- and temporal-distribution characteristics of urban resilience and its determinants at the provincial level is crucial for formulating effective strategies that promote sustainable development and enhance the nation's overall resilience.

2. Concept of Urban Resilience

The concept of "resilience" initially rooted in physics, as the capacity of a material to withstand energy during plastic deformation and fracture, has evolved significantly over time [10]. Its application extended to modern urban research, first introduced in the context of ecology by ecologist Holling in 1973. This concept has since undergone a transformation, especially as urban economies and ecological environments have evolved. In 2002, the International Council for Local Environmental Initiatives pioneered the idea of "resilient cities", integrating it into the realm of urban disaster prevention research. Since then, related concepts like "economic resilience [11][12]", "ecological resilience [13][14]", and "industrial resilience [15][16]" have gained significant scholarly attention. In China, the establishment of the Research Center for Resilient Cities at Zhejiang University in 2012, as the country's inaugural research center focusing on urban resilience and disaster prevention, marked a milestone in this field. Currently, scholars and research institutions increasingly view urban resilience as a composite of various capabilities, encompassing a city's ability to resist, adapt, maintain, recover, and develop, as outlined by X. Luo et al. in 2022 [17].

3. China's Urban Resilience Development

The increasing focus among Chinese scholars on advancing urban resilience extends beyond theoretical models. This shift is marked by a heightened emphasis on studying urban agglomerations, as evidenced in the research conducted by Tang [18], B. Wang [19], and Ye [20]. Additionally, there is a growing body of research exploring the resilience of cities within individual provinces, such as the studies by K. Zhao [21] and Cao [22]. These scholars are also delving into the differential development of resilience between provincial capitals and their surrounding urban areas, aiming to provide bespoke strategies that cater to the unique needs of each province. The scope of the research encompasses broader themes, including urbanization dynamics [3], carbon emissions [23], and high-quality development [24], with a particular focus on the provincial level. This body of work collectively examines China's overall developmental trajectory and the disparities across different provincial regions. However, there is a notable gap in the literature that specifically addresses urban resilience from a provincial perspective in China. Considering the uneven pace of development across provinces, enhancing urban resilience at this level is pivotal, aiming for comprehensive improvements in the resilience of Chinese cities. This targeted approach is essential for addressing the diverse challenges and needs of different regions, thereby contributing to a more balanced and sustainable urban development across the country.

4. Evaluation Index for Urban Resilience

Developing a comprehensive evaluation index system for urban resilience is critical for accurately gauging the resilience of cities or regions. However, currently, there is no consensus on a unified evaluation index system or assessment model for urban resilience. This lack of standardization in defining urban resilience indices stems from the diverse perspectives held by various scholars such as urban composition [25][26], socioecological systems [27][28], and the stress-state-response model [29].

In the field of resilience research concerning natural ecosystems, the evaluation framework is considerably comprehensive and well-developed [30]. Contemporary studies have introduced the perspective that ecological resilience involves the capacity to recover from external shocks, encompassing preventative measures, responses, and recovery capabilities [31]. Subsequent researchers have refined the concept further by introducing socioecological resilience, emphasizing that systems confronted with external disruptions should possess proactive resistance, inherent adaptability, and post-event transformation capacity [32]. Ultimately, in the context of natural ecosystems, resilience, adaptability, and transformative capacity are regarded as the three fundamental elements of ecological resilience, embodying an ecosystem's ability to withstand shocks, adapt to external influences, and adjust based on both internal and external factors.

Based on the aforementioned research, the resilience of cities is defined as the ability to withstand disasters, reduce disaster losses, and allocate resources effectively in order to recover quickly from disasters and the ability to learn from

past disaster incidents and continuously improve their adaptive capacity. Therefore, three core attributes are recognized in the context of urban resilience: resistance, adaptability, and recovery [33]. According to this evaluation framework, a total of 24 indicators were ultimately selected, as detailed in **Table 1**. Urban resistance is defined as a city's ability to diminish the impact of disasters through its infrastructure. Urban adaptability refers to the capacity of cities to maintain effective management and stability under various levels of disaster pressure. Urban recovery is characterized by the city's capability to rapidly re-establish equilibrium after experiencing the effects of disasters.

Table 1. Evaluation indicator system of urban resilience.

Index	Units	References	Directivity
Group 1: Urban resistance			
Per Capita Road Area	**m^2**	[34]	**Positive**
Total Electricity Consumption	**1000 kWh**	[35]	**Positive**
Natural Gas Supply Level	**m^3/person**	[36][37]	**Positive**
Number of Urban Road Lighting Lights	**1000 units**	[38]	**Positive**
Density of Drainage Pipelines in Built-up Areas	**km/km^2**	[37]	**Positive**
Public Buses and Electric Vehicles Per 10,000 People	**car**	[39][40]	**Positive**
Number of Beds in Health Facilities Per 10,000 People	**bed**	[41]	**Positive**
Group 2: Urban adaptability			
Green Coverage Rate in Built-up Areas	**%**	[20]	**Positive**
Per Capita Park Green Area	**m^2**	[14][18]	**Positive**
Public Toilets Per 10,000 People	**1000 units**	[42]	**Positive**
Rate of Domestic Garbage Hamless Treatment	**%**	[43]	**Positive**
Centralized Treatment Rate of Sewage Treatment Plant	**%**	[44]	**Positive**
Per Capita Daily Water Consumption	**liter**	[39]	**Positive**
Population Density	**person/km^2**	[45][46]	**Positive**
Natural Population Growth Rate	**%**	[20]	**Positive**
Group 3: Urban recovery			
Per Capita GDP	**CNY/person**	[47][48]	**Positive**
Per Capita Disposable Income of Urban Residents	**CNY**	[13][25]	**Positive**
Per Capita Consumption Expenditure of Urban Residents	**CNY**	[49][50]	**Positive**
Fiscal Expenditure/Income Ratio	**%**	[45]	**Negative**
The Proportion of the Tertiary Industry in the GDP	**%**	[35]	**Positive**
Average Students Enrolled in Higher Education Institutions Per 100,000 People	**person**	[51][52]	**Positive**
The Number of Participants in Year-End Unemployment Insurance.	**person/10,000 people**	[53]	**Positive**
Registered Urban Unemployment Rate	**%**	[54][55]	**Negative**

5. Factors Influencing Urban Resilience

In recent years, a growing number of scholars have been leveraging spatial econometric models to dissect the factors influencing urban resilience. Chen [56] utilized multi-scale geographically weighted regression to delve into the spatiotemporal dynamics of urban resilience in China and its driving factors. Similarly, Wang et al. (2022) [57] conducted comprehensive empirical surveys and a quantitative analysis to identify critical factors affecting urban community resilience, including marketization, urbanization, industrial structure, emergency facilities, and population resources.

Moreover, various spatial detection methods, such as the Geographical Detector [58] and the Spatial Durbin Model [41], have been commonly utilized to analyze the influencing actors for urban resilience.

Based on previous studies, the research probes into the factors affecting urban resilience from six distinct perspectives: urban economic, social services, infrastructure improvement, urban digitization, urban ecology, and urban science and education, as detailed in **Table 2**. Urban economic development can provide additional resources to support urban resilience improvement. The GDP per capita is used to represent the economic level of a city. Social services' capability is crucial for a city's resilience, which can be represented by the proportion of public fiscal expenditure to GDP. Infrastructure improvement not only directly affects a city's daily resource supply capability, but also its ability to resist disasters. The total urban water supply is used to reflect the completeness of infrastructure. Urban digitization plays a crucial role in improving urban governance and future development. The percentage of internet users in each region to the whole country is used to represent a city's digital level. Urban ecology, as an important component of sustainable development for modern urban systems, is inseparable from the resilient cities' development. The per capita green space area is used to represent its ecological level. The level of scientific and educational development is an important indicator of a city's innovation capabilities, which can be represented by the percentage of its expenditure in fiscal expenditure.

Table 2. Influencing factors for urban resilience and corresponding variables.

Influencing Factor	Variable	Representation	References
Urban Economic	**GDP per capita**	X_1	[52]
Social Service	**Proportion of public fiscal expenditure to GDP**	X_2	[16][29]
Infrastructure Improvement	**Total urban water supply**	X_3	[5]
Urban Digitization	**Percentage of internet users in each region to the whole country**	X_4	[14][21]
Urban Ecology	**Per capita green space area**	X_5	[52][56]
Urban Science and Education	**Percentage of science and technology expenditure in fiscal expenditure**	X_6	[29][59]

References

1. Gunderson, L.H. Ecological Resilience—In Theory and Application. Annu. Rev. Ecol. Syst. 2000, 31, 425–439.
2. Masnavi, M.R.; Gharai, F.; Hajibandeh, M. Exploring Urban Resilience Thinking for Its Application in Urban Planning: A Review of Literature. Int. J. Environ. Sci. Technol. 2019, 16, 567–582.
3. Peng, K.; He, X.; Xu, C. Coupling Coordination Relationship and Dynamic Response between Urbanization and Urban Resilience: Case of Yangtze River Delta. Sustainability 2023, 15, 2702.
4. Han, S.; Wang, B.; Ao, Y.; Bahmani, H.; Chai, B. The Coupling and Coordination Degree of Urban Resilience System: A Case Study of the Chengdu–Chongqing Urban Agglomeration. Environ. Impact Assess. Rev. 2023, 101, 107145.
5. Liu, L.; Luo, Y.; Pei, J.; Wang, H.; Li, J.; Li, Y. Temporal and Spatial Differentiation in Urban Resilience and Its Influencing Factors in Henan Province. Sustainability 2021, 13, 12460.
6. Song, Q.; Zhong, S.; Chen, J.; Yang, C.; Zhu, Y. Spatio-Temporal Evolution of City Resilience in the Yangtze River Delta, China, from the Perspective of Statistics. Sustainability 2023, 15, 1538.
7. Li, Y.; Gao, K. The Impact of Green Urbanization on Carbon Emissions: The Case of New Urbanization in China. Front. Environ. Sci. 2022, 10, 1070652.
8. Jones, L.; d'Errico, M. Whose Resilience Matters? Like-for-like Comparison of Objective and Subjective Evaluations of Resilience. World Dev. 2019, 124, 104632.
9. Wang, J.; Wang, J.; Zhang, J. Spatial Distribution Characteristics of Natural Ecological Resilience in China. J. Environ. Manag. 2023, 342, 118133.
10. Walker, B.; Holling, C.S.; Carpenter, S.R.; Kinzig, A.P. Resilience, Adaptability and Transformability in Social-Ecological Systems. Ecol. Soc. 2004, 9, art5.
11. Montrimas, A.; Bruneckienė, J.; Gižienė, V. Measuring Economic Resilience through Industrial Portfolio: The Cases of New EU Member States Since 2004. Inžinerinė Ekon. 2023, 34, 593–611.

12. Yu, Z.; Li, Y.; Dai, L. Digital Finance and Regional Economic Resilience: Theoretical Framework and Empirical Test. Financ. Res. Lett. 2023, 55, 103920.
13. Subramaniam, R.C.; Ruwet, M.; Boschetti, F.; Fielke, S.; Fleming, A.; Dominguez-Martinez, R.M.; Plagányi, É.; Schrobback, P.; Melbourne-Thomas, J. The Socio-Ecological Resilience and Sustainability Implications of Seafood Supply Chain Disruption. Rev. Fish Biol. Fish. 2023, 33, 1129–1154.
14. Jiang, F.; Chen, B.; Li, P.; Jiang, J.; Zhang, Q.; Wang, J.; Deng, J. Spatio-Temporal Evolution and Influencing Factors of Synergizing the Reduction of Pollution and Carbon Emissions—Utilizing Multi-Source Remote Sensing Data and GTWR Model. Environ. Res. 2023, 229, 115775.
15. Di Tommaso, M.R.; Prodi, E.; Pollio, C.; Barbieri, E. Conceptualizing and Measuring “Industry Resilience”: Composite Indicators for Postshock Industrial Policy Decision-Making. Socio-Econ. Plan. Sci. 2023, 85, 101448.
16. Pan, S.-C.; Hu, T.-S.; You, J.-X.; Chang, S.-L. Characteristics and Influencing Factors of Economic Resilience in Industrial Parks. Heliyon 2023, 9, e14812.
17. Luo, X.; Cheng, C.; Pan, Y.; Yang, T. Coupling Coordination and Influencing Factors of Land Development Intensity and Urban Resilience of the Yangtze River Delta Urban Agglomeration. Water 2022, 14, 1083.
18. Tang, D.; Li, J.; Zhao, Z.; Boamah, V.; Lansana, D.D. The Influence of Industrial Structure Transformation on Urban Resilience Based on 110 Prefecture-Level Cities in the Yangtze River. Sustain. Cities Soc. 2023, 96, 104621.
19. Wang, Z.; Fu, H.; Zhou, L. Multiple Urban Resilience Evaluation of Resource-Based Cities’ Sustainable Transformation Effect. Resources, Conservation and Recycling 2023, 191, 106912.
20. Ye, C.; Hu, M.; Lu, L.; Dong, Q.; Gu, M. Spatio-Temporal Evolution and Factor Explanatory Power Analysis of Urban Resilience in the Yangtze River Economic Belt. Geogr. Sustain. 2022, 3, 299–311.
21. Zhao, K.; Ma, X.; Zhang, H.; Dong, Z. Performance Zoning Method of Asphalt Pavement in Cold Regions Based on Climate Indexes: A Case Study of Inner Mongolia, China. Constr. Build. Mater. 2022, 361, 129650.
22. Cao, F.; Xu, X.; Zhang, C.; Kong, W. Evaluation of Urban Flood Resilience and Its Space-Time Evolution: A Case Study of Zhejiang Province, China. Ecol. Indic. 2023, 154, 110643.
23. Zhang, H.; Zhang, X.; Yuan, J. Driving Forces of Carbon Emissions in China: A Provincial Analysis. Env. Sci Pollut Res 2021, 28, 21455–21470.
24. Yang, G.; Deng, F.; Wang, Y.; Xiang, X. Digital Paradox: Platform Economy and High-Quality Economic Development—New Evidence from Provincial Panel Data in China. Sustainability 2022, 14, 2225.
25. Zakaria, N.H.; Ishak, N.R.; Salleh, S.A.; Isa, N.A.; Suhana, E.; Ooi, M.C.G.; Latif, Z.A.; Ustuner, M. Conceptualizing Spatial Heterogeneity of Urban Composition Impacts on Precipitation within Tropics. Int. J. Sustain. Constr. Eng. Technol. 2023, 14, 145–160.
26. Wang, X.; Wang, C.; Shi, J. Evaluation of Urban Resilience Based on Service-Connectivity-Environment (SCE) Model: A Case Study of Jinan City, China. Int. J. Disaster Risk Reduct. 2023, 95, 103828.
27. Afriyanie, D.; Akbar, R.; Suroso, D.S.A. Socio-Ecological Resilience for Urban Green Space Allocation. IOP Conf. Ser. Earth Environ. Sci. 2018, 145, 012120.
28. Nikpour, A.; Ashoori, M. Evaluation of the Principles and Criteria of Resilience in Urban Management (Case Study: Qazvin). Sustain. Cities Soc. 2023, 95, 104590.
29. Zhu, S.; Li, D.; Feng, H.; Zhang, N. The Influencing Factors and Mechanisms for Urban Flood Resilience in China: From the Perspective of Social-Economic-Natural Complex Ecosystem. Ecol. Indic. 2023, 147, 109959.
30. Saikia, P.; Beane, G.; Garriga, R.G.; Avello, P.; Ellis, L.; Fisher, S.; Leten, J.; Ruiz-Apilánez, I.; Shouler, M.; Ward, R.; et al. City Water Resilience Framework: A Governance Based Planning Tool to Enhance Urban Water Resilience. Sustain. Cities Soc. 2022, 77, 103497.
31. Liu, Z.; Ma, R.; Wang, H. Assessing Urban Resilience to Public Health Disaster Using the Rough Analytic Hierarchy Process Method: A Regional Study in China. J. Saf. Sci. Resil. 2022, 3, 93–104.
32. Obasi, O.; Baird, J.; Dale, G.; Pickering, G.J. An Approach to Measuring Individual Endorsement of Social-Ecological Resilience of Water Systems. Environ. Sustain. Indic. 2023, 18, 100249.
33. Meerow, S.; Pajouhesh, P.; Miller, T.R. Social Equity in Urban Resilience Planning. Local Environ. 2019, 24, 793–808.
34. Esteban, T.A.O.; Edelenbos, J. The Politics of Urban Flood Resilience: The Case of Malabon City. Int. J. Disaster Risk Reduct. 2023, 88, 103604.
35. Liu, L.; Zhang, Z.; Ding, S.; Yang, F.; Fu, T. Combined Effects of Climate Change on Urban Resilience in the Tibetan Plateau. Environ. Impact Assess. Rev. 2023, 102, 107186.

36. Verhoog, R.; Ghorbani, A.; Dijkema, G.P.J. Modelling Socio-Ecological Systems with MAIA: A Biogas Infrastructure Simulation. Environ. Model. Softw. 2016, 81, 72–85.
37. Fu, H.; Hong, N.; Liao, C. Spatio-Temporal Patterns of Chinese Urban Recovery and System Resilience under the Pandemic New Normal. Cities 2023, 140, 104385.
38. Rezaei, H.; Macioszek, E.; Derakhshesh, P.; Houshyar, H.; Ghabouli, E.; Bakhshi Lomer, A.R.; Ghanbari, R.; Esmailzadeh, A. A Spatial Decision Support System for Modeling Urban Resilience to Natural Hazards. Sustainability 2023, 15, 8777.
39. McGill, R. Urban Resilience—An Urban Management Perspective. J. Urban Manag. 2020, 9, 372–381.
40. Guo, X.; Kapucu, N. Assessing Social Vulnerability to Earthquake Disaster Using Rough Analytic Hierarchy Process Method: A Case Study of Hanzhong City, China. Saf. Sci. 2020, 125, 104625.
41. Dehghani, A.; Alidadi, M.; Soltani, A. Density and Urban Resilience, Cross-Section Analysis in an Iranian Metropolis Context. Urban Sci. 2023, 7, 23.
42. Abdillah, A.; Widianingsih, I.; Buchari, R.A.; Nurasa, H. Implications of Urban Farming on Urban Resilience in Indonesia: Systematic Literature Review and Research Identification. Cogent Food Agric. 2023, 9, 2216484.
43. Xie, W.; Sun, C.; Lin, Z. Spatial-Temporal Evolution of Urban Form Resilience to Climate Disturbance in Adaptive Cycle: A Case Study of Changchun City. Urban Clim. 2023, 49, 101461.
44. Wagenaar, H.; Wilkinson, C. Enacting Resilience: A Performative Account of Governing for Urban Resilience. Urban Stud. 2015, 52, 1265–1284.
45. Shamsuddin, S. Urban in Question: Recovering the Concept of Urban in Urban Resilience. Sustainability 2023, 15, 15907.
46. Zhang, T.; Sun, Y.; Zhang, X.; Yin, L.; Zhang, B. Potential Heterogeneity of Urban Ecological Resilience and Urbanization in Multiple Urban Agglomerations from a Landscape Perspective. J. Environ. Manag. 2023, 342, 118129.
47. Wernli, D.; Søgaard Jørgensen, P.; Parmley, E.J.; Majowicz, S.E.; Lambraki, I.; Carson, C.A.; Cousins, M.; Graells, T.; Henriksson, P.J.G.; Léger, A.; et al. Scope and Applicability of Social–Ecological Resilience to Antimicrobial Resistance. Lancet Planet. Health 2023, 7, e630–e637.
48. Chenhong, X.; Guofang, Z. The Spatiotemporal Evolution Pattern of Urban Resilience in the Yangtze River Delta Urban Agglomeration Based on TOPSIS-PSO-ELM. Sustain. Cities Soc. 2022, 87, 104223.
49. Mitrović, S.; Vasiljević, N.; Pjanović, B.; Dabović, T. Assessing Urban Resilience with Geodesign: A Case Study of Urban Landscape Planning in Belgrade, Serbia. Land 2023, 12, 1939.
50. Wang, H.; Liu, Z.; Zhou, Y. Assessing Urban Resilience in China from the Perspective of Socioeconomic and Ecological Sustainability. Environ. Impact Assess. Rev. 2023, 102, 107163.
51. Leitner, H.; Sheppard, E.; Webber, S.; Colven, E. Globalizing Urban Resilience. Urban Geogr. 2018, 39, 1276–1284.
52. Zhao, M.; Wang, H.; Sun, J.; Tang, R.; Cai, B.; Song, X.; Huang, X.; Huang, J.; Fan, Z. Spatio-Temporal Characteristics of Soil Cd Pollution and Its Influencing Factors: A Geographically and Temporally Weighted Regression (GTWR) Method. J. Hazard. Mater. 2023, 446, 130613.
53. Sensier, M.; Bristow, G.; Healy, A. Measuring Regional Economic Resilience across Europe: Operationalizing a Complex Concept. Spat. Econ. Anal. 2016, 11, 128–151.
54. Chelleri, L.; Waters, J.J.; Olazabal, M.; Minucci, G. Resilience Trade-Offs: Addressing Multiple Scales and Temporal Aspects of Urban Resilience. Environ. Urban. 2015, 27, 181–198.
55. Yu, S.; Yuan, M.; Wang, Q.; Corcoran, J.; Xu, Z.; Peng, J. Dealing with Urban Floods within a Resilience Framework Regarding Disaster Stages. Habitat Int. 2023, 136, 102783.
56. Chen, Y.; Zhu, M.; Zhou, Q.; Qiao, Y. Research on Spatiotemporal Differentiation and Influence Mechanism of Urban Resilience in China Based on MGWR Model. Int. J. Environ. Res. Public Health 2021, 18, 1056.
57. Ba, R.; Wang, C.; Kou, L.; Guo, X.; Zhang, H. Rethinking the Urban Resilience: Extension and Connotation. J. Saf. Sci. Resil. 2022, 3, 398–403.
58. Yao, Y.; Shen, Y.; Liu, K. Investigation of Resource Utilization in Urbanization Development: An Analysis Based on the Current Situation of Carbon Emissions in China. Resour. Policy 2023, 82, 103442.
59. Chen, Y.; Su, X.; Zhou, Q. Study on the Spatiotemporal Evolution and Influencing Factors of Urban Resilience in the Yellow River Basin. Int. J. Environ. Res. Public Health 2021, 18, 10231.