Research on Path Enhancement of Urban Resilience Building Under the Perspective of Resilience Development

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Abstract. Urban disaster risks are characterized by their frequent, sudden, and recurrent nature. As hubs of population and wealth, cities face higher demands for resilient urban planning and development. By examining the evolution of the "urban resilience" concept, this paper analyzes the current state of resilient city standards in China and abroad. It summarizes assessment methods and applications, compares policy practices at different government levels, and proposes pathways to enhance resilient city construction. These pathways include theoretical and technical research, urban construction and operation system analysis, broad participation in top-level design, regular quantitative assessments, and long-term iterative optimization. The goal is to provide a reference for establishing an efficient and collaborative resilient city construction system.

Keywords: urban resilience; resilient city; system standards; policy practice; pathway enhancement

1 Introduction

"Resilient city" represents a new concept in urban development [1-3], focusing on enhancing the ability of cities to cope with chronic stresses and acute shocks. This ensures that urban systems can maintain basic functions amid external disruptions and internal disarray, recover quickly post-disaster, and continuously learn and improve from past events. As hubs of human activity and wealth, cities must withstand sudden events such as epidemics, extreme weather, and major safety incidents, while also addressing urban issues arising from ongoing urbanization. Urban development must account for both acute shocks and chronic pressures, demanding that cities maintain basic functions and recover swiftly from disasters. Consequently, "resilient cities" have become an essential component of urban development strategies.

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Cities are complex systems. Enhancing urban resilience requires not only strengthening the resilience of individual subsystems and components but also improving their connectivity and coordination 4. Therefore, it is essential to address operational safety across various spatial dimensions—individuals, families, communities, and cities—and temporal dimensions—short-term shocks and long-term pressures. This involves integrating spatial planning, infrastructure, urban management, and social culture, using interdisciplinary approaches from systems science, information science, engineering, management, and psychology to optimize urban resilience.

1.1 The Concept of Urban Resilience and Evaluation Methods

1.1.1 Evolution of the Concept of Urban Resilience.

The concept of resilient cities is diverse, with scholars proposing various definitions and characteristics from perspectives such as disaster incidents, physical infrastructure, ecological environment, social systems, and urban systems. However, it is essential to clarify their applicability and limitations in practical applications.

One is engineering resilience [5-7]. It is defined as "the ability of a system to return to a state of equilibrium or stability after a disaster." This state refers to the normal predicate state of functioning, focuses on short-term mitigation and recovery strategies, and lacks consideration of chronic stress.

The second is ecological resilience [8-14]. It refers to "a systemic rather than a component function, the ability of a system to maintain a single or new stable state." Emphasizing the isolation buffer capability of the system and the ability to recover to a new equilibrium state after a disaster, it is difficult to apply in practice due to the complex characteristics of the system.

The third is socio-ecological resilience 15-20]. "Expanded from the concept of ecological resilience, it provides a useful framework for understanding individuals, communities, organizations, and ecosystems that cope with a large number of known and unknown uncertainties, challenges, and opportunities." Core characteristics include the ability of a system to absorb perturbations within an acceptable state, the ability of system components to self-organize, and the ability to enhance resilience through learning and adaptation. However, the lack of clarity on causality in complex systems makes it difficult to apply in practice, the emphasis on subsystem self-organization makes it difficult to implement top-down governmental management systems, and it does not consider dynamic technological change and its interactions with socio-economic systems. The evolution of the concept of urban resilience is shown in Figure 1.

Fig. 1. Concept of urban resilience evolution. Source: Author's drawing.

Fourth is disaster resilience 21-24]. It is defined by the United Nations International Strategy for Disaster Reduction (UNISDR) as "the ability of a disaster-exposed system, community, or society to resist, absorb, adapt, and recover from a disaster in a timely and efficient manner, including the maintenance and restoration of essential infrastructure and functions." Disaster resilience is broadly conceptualized by focusing on short-term anthropogenic and natural hazards, and by not addressing chronic stresses, with little consideration of Multiple hazard mitigation strategies.

The fifth is evolutionary resilience [25-28]. "Emphasizes the nature of a system that can continue to change over time in the absence of external perturbations." Cities are viewed as dynamically changing systems in a constant state of growth, maintenance, creative destruction, and reorganization. Post-disaster reconstruction of cities requires longer-term political will and does not consider the dynamic role of urban technologies and the role of complex management networks in the reorganization phase.

Sixth is climate change resilience [29-31]. It emphasizes "the ability of cities, urban systems, and communities to recover quickly from climate-related shocks and stresses." The Asian Development Bank defines it as "improving the capacity of cities for climate change adaptation, mitigation, and disaster risk prevention and control by recognizing the complexity of rapidly growing urban areas and the uncertainty of climate change." This concept requires systems thinking, but policies are not sufficiently sustainable and do not consider other aspects of resilience.

Seventh, other concepts of toughness. Domestic and foreign scholars are still proposing different concepts, such as distinguishing the similarities and differences between the concepts of stable and unstable toughness and proposing the concept of

universal toughness, but at present these concepts have limited influence and few applications.

1.1.2 Resilient City Evaluation Methodology.

Urban resilience evaluation methods include three categories: qualitative methods, semiquantitative methods, and quantitative methods. First, qualitative methods. The conceptual framework is the main one, such as the conceptual framework including the five dimensions of physical, natural, economic, public institutions, and social, the resilience planning framework to cope with urban flood disasters; the comprehensive resilience framework considering the evolution capability, adaptive capacity, prevention and resistance under different spatial and temporal scales, and the resilience conceptual framework to cope with climate change, and so on. The second is a semi-quantitative approach. Usually based on the resilience conceptual framework, a systematic indicator system for different fields is further developed, such as the Shannon Diversity Indicator System (SHDI), Sharifi and Yamagata 32 extracted an urban energy resilience indicator system containing 196 resilience criteria, etc. Third, quantitative methods. Domestic and foreign scholars have proposed many quantitative urban resilience evaluation methods using interdisciplinary approaches, such as Bozza et al 33 developed a comprehensive evaluation model of HSPNs (Hybrid Physical-Social Networks) by integrating the physical, social, and engineering components of the city, and Simonovic and Srivastav 34 developed ST-DRM (Space-Time Dynamic Resilience Measurement) model.

In China, Han Qing et al 35 used the ArcGIS analysis method combined with the questionnaire survey method to carry out systematic resilience research on communities in Qingdao, constructed an evaluation system by evaluating the accessibility of facility points, spatial carrying capacity evaluation, and evaluation of community social network in three aspects, and chose a typical community of Qingdao to carry out empirical analysis, which provided a new way of thinking for the renewal of the community under the perspective of resilience. Zeng Liting 36 based on the theory of flow space and resilience, based on urban community space, specifically analyzed the resilience characteristics and functions of each spatial element in the community disaster response stage and constructed a conceptual framework of community spatial resilience. The study has already owned the basic resilience indicator system construction method, but there are limitations such as insufficient explanation of resilience theory and insufficient generalizability.

2 Resilient City Standards System

Resilience-related standards and norms are the basic basis for guiding the construction of resilient cities, which is conducive to clarifying the basic concept of resilient cities and guiding the formulation of easy-to-understand and sustainable development goals under a unified terminology system.

Internationally, the International Organization for Standardization (ISO) has developed or published a series of standards on safety and resilience covering basic

terminology, protective safety for economic and social development, urban resilience framework models, community resilience, organizational resilience, complexity assessment processes, emergency management for disaster incidents, crisis management, large-scale urban scale events, related products and documentation, business continuity management systems, vehicle Safety Barrier, Sustainable Cities and Communities, Sustainable Community Development, Local Government Financial Mechanisms for Climate Change Adaptation, Supply Chain Security Management System, Role of FM Communications, Emergency Risk Management, Building and Civil Engineering Resilience and Security Management System, etc., which form a more systematic technical standard to guide the evaluation and enhancement of resilience of different subjects and scales in cities.

In China, standards specifically targeting urban resilience are still in their infancy. Earthquake resilience evaluation is a relatively well-developed and systematically studied area. The national standard "Building Earthquake Resilience Evaluation Standard" (GB/T 38591-2020) outlines requirements for evaluating building earthquake resilience, determining building damage states, calculating repair costs and times, assessing casualties, and rating building earthquake resilience. The Beijing local standard "Guidelines for Earthquake Safety Resilient City Construction" (draft for comments) specifies goals for seismic resilience of urban disaster-bearing bodies, evaluation of seismic resilience capabilities, spatial layout guidance, construction of building earthquake safety resilience capabilities, and strategies for implementing earthquake safety resilient city construction. Additionally, in April 2024, the Ministry of Natural Resources issued the "Guidelines for Resilient Urban Planning and Land Policies with Integrated Normal and Emergency Functions, " which accurately grasp the concept of integrated normal and emergency functions, coordinating development and safety within a single plan. These guidelines further refine the requirements for resilient urban planning and land support policies, enhancing the effectiveness of planning in risk response. In the field of macro urban resilience evaluation, the "Guide for Safety Resilient City Evaluation" (GB/T 40947-2021) has established an evaluation index system and quantitative evaluation methods for safety-resilient cities. This guide effectively prevents and reduces various safety incidents, identifies potential adverse factors in urban operations, recognizes vulnerabilities in urban systems, and strengthens the safety responsibilities of local governments, departments, and units, ensuring the implementation of safety measures.

The deficiencies in China’s resilient city standards and regulations significantly hinder the promotion of the resilient city concept. These limitations restrict the development and application of related theories, models, and technologies. It is imperative to integrate existing regulations in social governance, economic development, and public safety at the national level. Establishing a foundational standard system with Chinese characteristics, including terminology, evaluation frameworks, and methods, is essential to advance the construction of resilient cities in China.

3 Resilient City Policy Practices

To promote sustainable urban development globally and build green, ecological, smart, safe, and livable cities, various international organizations, national governments, and local city governments have implemented numerous beneficial practices in resilient city construction. These efforts address challenges such as natural disasters, emergencies, urban diseases, social injustice, and economic disparities.

At the international level, the United Nations Office for Disaster Risk Reduction (UNDRR) launched the "Making Cities Resilient" campaign to help cities and local governments become resilient to risks and disasters. The Rockefeller Foundation initiated the "100 Resilient Cities" project, providing funding to hire a Chief Resilience Officer and offering technical support for comprehensive resilience strategies in each city.

At the national level, countries such as the United States, the United Kingdom, Australia, Hungary, Israel, and Japan have developed systematic action plans to enhance urban resilience against major risk factors. In China, the 19th Central Committee's Fifth Plenary Session approved the "Recommendations of the Central Committee of the Communist Party of China on Formulating the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035, " which first proposed the concept of "building resilient cities." The report of the 20th National Congress of the Communist Party of China emphasized accelerating the transformation of development modes in megacities, implementing urban renewal actions, strengthening urban infrastructure construction, and creating livable, resilient, and smart cities. The China Association for Disaster Prevention's Urban and Rural Resilience and Disaster Reduction Professional Committee issued the "Beijing Declaration on the Scientific Plan for Resilient Urban and Rural Construction " (draft), focusing on "promoting earthquake-resilient urban and rural construction and enhancing natural disaster prevention capabilities. "

At the local government level, cities such as London, New York, Chicago, San Francisco, Los Angeles, and Rotterdam have developed clear action plans addressing floods, hurricanes, climate change, and urban governance. In its urban planning, Beijing emphasizes "enhancing disaster prevention and mitigation capabilities and improving urban resilience." For instance, the "Beijing Resilient City Spatial Plan (2022-2035)" (draft) was published in November 2023. This plan aims to establish a safe, adaptable, quickly recoverable, organically organized, future-proof, and modernized resilient urban governance system for Beijing by 2035. Similarly, Shanghai's urban planning focuses on "strengthening the construction of foundational, functional, and networked urban infrastructure systems to enhance the capacity and service level of municipal infrastructure, thereby increasing the city's disaster response capability and resilience."

Additionally, Chengdu, Baofeng, Luoyang, Mianyang, Sanya, Xianyang, Xining, Deyang, and Huangshi in China have been selected for the UNDRR's "Making Cities Resilient" campaign and the Rockefeller Foundation's "100 Resilient Cities" project. These cities are actively engaged in resilient city planning and construction.

4 Resilient City Building Enhancement Path

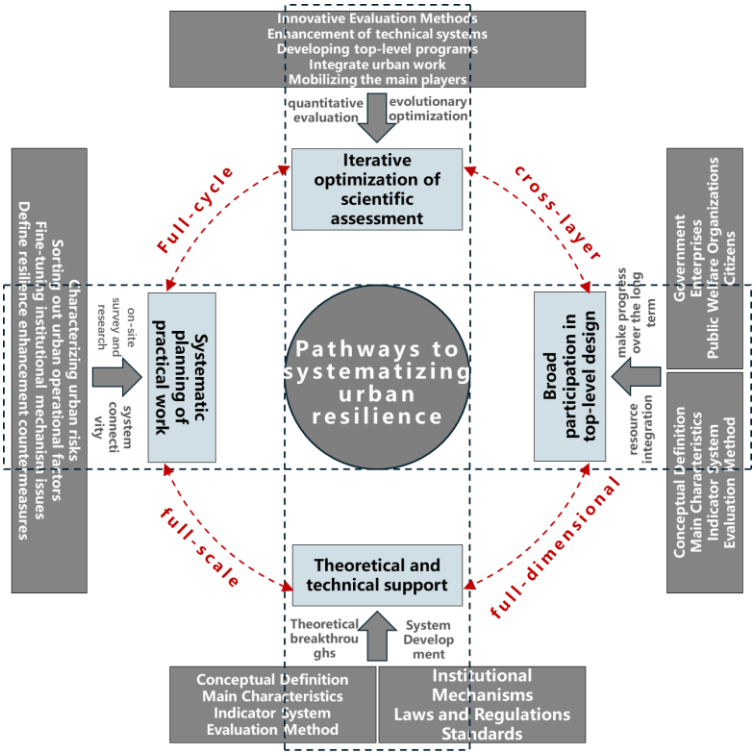

Fig. 2. Urban resilience systematization building enhancement pathway. Source: Author's drawing.

The concept of resilient cities as a guiding principle for urban construction and operation has gained the attention of high-level policymakers and local government officials in China. Consequently, resilient cities are transitioning from an academic concept to a fundamental principle and action guideline for urban development. In the future, it will become a key consideration for urban managers, residents, and other stakeholders. To accelerate the construction of resilient cities in China, efforts must focus on four key areas: foundational theoretical and technical research, analysis of urban construction and operation systems, top-level institutional design with broad participation, and regular quantitative assessments with long-term iterative optimization. This approach aims to advance the foundational theories of resilient city construction, develop evaluation and enhancement systems, and establish an efficient, collaborative framework. The goal is to create a systematic construction pathway that covers the entire lifecycle, scale, dimension, and level of urban operations. This paper proposes an improvement path for urban resilience construction as shown in Figure 2.

4.1 Theoretical and Technical Support

In human practice, actions based on simple experience often exhibit a certain degree of blindness, heavily influenced by inherent biases determined by brain physiology. These actions are highly subjective and lack consistent evaluation standards. Scientific theory abstracts and refines general laws from empirical knowledge, offering universal applicability within specific research scales and precision requirements. It is the most effective tool for humans to overcome physiological limitations and achieve systematic, precise decision-making. Therefore, breakthroughs in the foundational theory of resilient cities are crucial for practical work in urban resilience and essential for developing evaluation and enhancement systems for urban resilience.

In academia, scholars in different research fields have proposed a series of conceptual definitions, key features, indicator systems, and evaluation methods for resilient cities from different perspectives of disasters, physical facilities, ecological environments, social systems, and urban systems, The relevant results still have major limitations in analyzing problems at different spatial and temporal scales and in different dimensions. The incompleteness of the theory limits the guiding role and promotion of the concept of resilient cities in practical work. Therefore, in the process of China's resilient city construction, on the one hand, we should encourage the promotion of major innovations at the level of first principles in the field of resilient cities; on the other hand, we must also recognize that the concept of resilient cities is unfriendly to city management, construction, and operation parties and the general public and that it is necessary to carry out the popularization of resilient city concepts and theories by using a more lively and vivid language so that all the stakeholders can have an in-depth understanding of the concept and consciously follow the scientific principles.

Under the same conceptual and theoretical framework, taking important public safety emergencies, urban infrastructure, community and township resilience management, and other important areas affecting urban resilience as the starting point, integrate multidisciplinary knowledge and achievements in science, engineering, management, sociology, psychology, communication and other disciplines, carry out resilience evaluation and enhancement technology research and development, and establish a complete resilient city construction system of institutional mechanisms, laws and regulations, standards and norms.

4.2 Systematic Planning of Practical Work

Cities are the most important entities carrying human civilization, which are decided by the subjective will of human beings and constrained by the objective laws of natural resources and geographic environment and have been changing and growing along with the progress of human civilization. Nowadays, the scale of cities continues to expand, population, energy, and wealth continue to gather, all kinds of emerging risks accelerate, and the risk of safe urban operation increases significantly. To cope with all kinds of acute impacts and chronic pressures, the urban operation and management system has been continuously optimized, technological means have been continuously inno-

vated, the safety culture of citizens has been cultivated, and several effective mechanisms for pre-warning, mid-control and post-recovery have been formed.

Therefore, the construction of resilient cities must not be a blank sheet of paper for planning, let alone 'starting a new stove and starting all over again.' The first thing to do is to conduct detailed and in-depth research to find out the risk characteristics of different cities, sort out the core factors affecting the safe operation of the cities, and clarify the institutional mechanisms and problems of urban operation and management. The first task is to determine the risk characteristics of different cities, sort out the core factors affecting the safe operation of the city, clarify the system and mechanism of urban operation and management and the existing problems, and make clear the countermeasures and special projects conducive to the enhancement of toughness. Resilient city construction work is continuous, and the concept of resilience can connect the existing work of the city and the future development of the city; resilient city construction work is efficient through the introduction of multidisciplinary cutting-edge technology can realize intelligent and refined operation and management; resilient city construction work is systematic, dedicated to solving the emerging risk problems of high complexity and high relevance in the city in the future.

4.3 Broad Participation in Top-Level Design

The urban system is characterized by high complexity and strong correlation, and the construction of resilient cities will involve all dimensions of urban facilities, management, culture, etc., and run through the underground, aboveground, and in the air and space and connect the history, present, and future of the whole spatial and temporal dimensions. Therefore, China's socioeconomic, and institutional mechanisms and cultural traditions are suitable for efficiently promoting resilient city construction work, following the government's top-level design, relying on a handful of coordination and integration of urban resources, and some of the important nodes of the work should also be solidified through the laws, regulations, standards and norms, to overcome the constraints of the administrative sector of the compartmentalization, the ruling governor to mobilize, and other constraints, and to adhere to the long term, and promote the long-term efforts. Various tasks and aims. At present, national and important urban plans such as the "Proposal of the Central Committee of the Communist Party of China on Formulating the Fourteenth Five-Year Plan for National Economic and Social Development and the Visionary Goals for the 23rd Five-Year Plan", 'Beijing Urban Master Plan (2016-2035)', 'Shanghai Urban Master Plan (2017-2035)', etc., have explicitly proposed the construction of resilient cities, specifying important areas, construction goals and evaluation indicators.

Full participation is an important aspect of the construction of resilient cities. The government, enterprises, public welfare organizations, and citizens are all stakeholders in the safe operation of cities, and only when the main parties have their duties, responsibilities, and coordination can the resilience level of cities be fundamentally enhanced. Among them, the government should be established as a hand project, do a good job of integrated work, use political, legal, economic, and other means to enhance the enthusiasm of the main body of the multi-party in the production safety, social

relief, public welfare action; enterprises should strengthen management, to ensure that the production and operation of the enterprise premises and the surrounding area are safe, several large-scale enterprises, high-risk enterprises of the permanent emergency rescue team initiative to take the social responsibility in moderation in extreme situations play a proactive role. Extreme conditions play an active role; public interest groups and organizations should keep pace with the times, make full use of their flexibility, play a role in bridging the government and the public, undertake the resilience culture of science and publicity work, enhance the resilience atmosphere of the whole society; the public is both the victims of shock perturbations, but also the first time in extreme conditions of self-help mutual aid, at the community level, to encourage the public to take the initiative to enhance their knowledge in the main risks and hazards, the particular situation At the community level, people are encouraged to take the initiative to enhance their resilience literacy in terms of major risk hazards, countermeasures in specific situations, training in rescue skills, and stocking of rescue facilities.

4.4 Iterative Optimization of Scientific Assessment

The quantitative evaluation of urban resilience is the standard for assessing the effect of resilient city construction work, which can guide the direction of resilient city construction work focused on the long term. At present, the rapid development of information technology, computing technology, artificial intelligence, biotechnology, complexity science, and other theoretical technologies, based on the urban operation of big data resources and related theoretical methods, forms a new research paradigm of urban science, resilient cities can evolve in the direction of real-time simulation, intelligent early warning, assisted decision-making, to achieve the rapid iteration of the technical methods and optimize the evaluation results.

To implement the construction of resilient cities, it is necessary to break through the concept and theoretical framework of resilience, innovate the urban resilience evaluation methodology and enhance the technical system, formulate the top-level design plan for resilient cities, coordinate the work of urban culture, management, and technology, mobilize the strength of all urban stakeholders, and build intelligent, ecological and safe resilient cities for the future.

5 Conclusion

This paper has explored the multifaceted concept of urban resilience, emphasizing its critical role in contemporary urban planning and development. By analyzing the evolution of the urban resilience concept and evaluating current standards and practices both domestically and internationally, we have identified key pathways to enhance resilient city construction. The following conclusions are obtained:

(1) Diverse Definitions and Applications: The concept of urban resilience encompasses various dimensions, including engineering, ecological, socio-ecological, disas-

ter, evolutionary, and climate change resilience. Each perspective offers unique insights but also presents limitations in practical applications.

(2) Evaluation Methodologies: Urban resilience evaluation methods range from qualitative frameworks to quantitative models, each contributing to a comprehensive understanding of resilience across different spatial and temporal scales.

(3) Standards and Policies: While international standards on urban resilience are relatively mature, China's standards are still evolving. The integration of existing regulations and the establishment of a foundational standard system with Chinese characteristics is imperative.

(4) Policy Practices: Effective resilient city construction requires coordinated efforts at international, national, and local levels. Successful examples from various cities highlight the importance of systematic planning, broad participation, and iterative optimization.

To advance the construction of resilient cities in China, it is essential to focus on foundational theoretical and technical research, systematic planning, top-level institutional design, and regular quantitative assessments. By fostering interdisciplinary collaboration and leveraging cutting-edge technologies, we can create a resilient urban environment that is safe, adaptable, and sustainable.

In conclusion, the transition from an academic concept to a practical guideline for urban development underscores the importance of resilience in ensuring the long-term sustainability and livability of cities. Future research and policy efforts should continue to refine and implement resilience strategies, contributing to the creation of resilient cities that can withstand and thrive amid various challenges.

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