Research on healthy urban resilience public space planning

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Abstract

Since the outbreak of the COVID-19 in early 2020, cities in China and even around the world have encountered great challenges, placing higher demands on urban governance and urban resilience, and the creation of healthy urban resilience public spaces is imminent. As an important stage of life for urban residents, urban public space is a complex manifestation of urban functions and an indispensable link in strengthening the city's resilience. In this paper, through the analysis of the connotation of urban resilience and related research at home and abroad, we further interpret the connotation and characteristics of urban public space resilience, and build a model of urban public space resilience based on the timeline of disasters. 1. Optimize the structure of public space and create a resilient spatial pattern; 2. Improve the infrastructure of public space and reserve emergency sites during disasters to use urban land flexibly; 3. Adjust the internal and external transportation system of public space to create healthy and green transportation; 4. Optimize the city Ventilated corridors to improve the resilience of the public space environment; 5. Make full use of the intelligent analysis of the GIS platform to improve the ecological disaster prevention capabilities of public spaces.

Keywords

Resilience, Public space, Healthy city, Resilience public space

1. Introduction

As the most complex social ecological system, the city has continuously suffered various shocks and disturbances from the outside world and itself since its formation. Including natural disasters such as floods, earthquakes, and droughts, man-made disasters such as diseases, environmental pollution, and terrorist attacks, as well as cumulative shock disasters such as energy shortages and climate change (Shao, Xu, 2015), have a serious impact on the future development of the city. According to the 《2019 China Statistical Yearbook》 (Table 1), 《2018 China Meteorological Statistics Yearbook》 (Table 2), the development of the COVID-19 that broke out in early 2020 (Till July 23) has caused serious losses to countries around the world (Table 3). Under this disturbance, different urban structures have different stability and vulnerability, and different coping methods will bring different results. Public space is one of the important components of the city. Both the natural and artificial environment in the urban public space have an important impact on the resilience of the city. In recent years, urban resilience has become a hot topic for planning scholars. For the time being, it appears as an element in the urban resilience framework, and has not yet formed a systematic theoretical positioning and framework system. This article attempts to analyze the theories of resilience, urban resilience and public space resilience, combing relevant domestic and foreign literature, and establish a model of urban public space resilience before and after disasters, and finally propose urban public space planning strategies, aiming to provide future urban public the theory and construction of space resilience system provide reference.

Types of disasters	Geological disasters	Forest fires	Earthquake	Marine disaster	Environmental emergencies	Sum
frequency (time)	2966	2478	11	97	266	5818
Casualties (Person)	185	39	85	73		382
Economic losses (10000yuan)	147128	20444.7	302716	449200		919488.7

Table 1. Statistics of China's Disaster Data in 2018.Source:2019 China Statistical Yearbook.

Types of disasters	Heavy rain and flood	Gale, hail, thunder and lightning	Cryogenic freezing	Drought	Tropical wind	Sum
Damaged crops (Ten thousand hectares)	541.5	226.8	52.5	987.5	39.4	1847.7
Casualties (Person)	7625	2089.4	161.7	4998.2	622.9	15497.2
Economic losses (100 million yuan)	1909.9	200.4	18.9	375	346.2	2850.4

Table 2. Statistics of China's Meteorological Disaster Data in 2017.Source: 2018 China Meteorological Statistics Yearbook.

Epidemic status	Existing confirmed	Cumulative diagnosis	Cumulative cure	Cumulative deaths
Number (Person)	5347365	15361318	9388006	625947

Table 3.Statistics on the global COVID-19 in 2020. Source: Information available from their website (IFENG NEWS, 2020)

2. Connotation analysis: urban resilience and public space resilience

2.1. Connotation and characteristics of resilient city

Modern resilience theory originated from the ecologist Holling, who first combined resilience theory with ecology (Holling,1973), which is considered to be the origin of resilience thinking applied to scientific research. The concept of resilience has undergone two revisions, from engineering resilience characterized by long-lasting stability before 1973, to ecological resilience characterized by the balance between multiple states from 1973 to 1998, and then to integrated engineering since 1998. Resilience and ecological resilience emphasize the evolutionary resilience of variability characteristics. At the end of the 1990s, Professor Mileti of the United States first introduced the idea of resilience into urban planning, focusing on improving the urban physical environment and infrastructure to deal with social and environmental disturbances and threats. Afterwards, scholars have successively put forward ideas such as "textual resilience", ecosystem resilience, social crisis resilience, etc. Due to the inconsistency of focus and connotation in different periods, the concept of resilience is constantly evolving and changing, and its complexity and diversification of disciplines make it ultimately Did not form a unified concept. After reading and sorting out the relevant literature, this article defines resilience as the system reacts after being disturbed by external forces. During the reaction process, it constantly adjusts, adapts, and learns. The system does not have a final equilibrium state, but is constantly changing dynamically. Spiral rises to the "optimum" state (Table 4).

Resilience perspective	Time	Characteristic	Definition	Nature
Engineering Resilience	Before 1973	Single state: stable	The speed at which the system recovers to its original state after being disturbed	Restore original state
Ecological Resilience	1973-1998	Multiple balance	The energy absorbed by the system before its structure changes	Shaping a new balance
Evolutionary Resilience	1998-Now	Give up the pursuit of balance: variable	It is a dynamic attribute linked to the ability to adjust in constant change	Constantly adapt and adjust in the change, emphasizing the learning and innovation

Table 4. Summary and Comparison of Three Different Views on Urban Resilience. Source: According to (Folke, 2006; Shao and Xu,2015; Yan and Tang,2020) literature summary.

The research on resilient cities originated in the 1980s, from a social-ecological system to a social-economic system (Huang and Huang,2015), Although the research on resilient cities involves multiple disciplines, the definition of resilient cities is still vague, leading to difficulties in quantitative research and

specific implementation. Therefore, we first need to clearly define the connotations and characteristics of resilient cities.

Godschalk (Godschalk,2003)、Rockefeller Foundation (Lin and Wang,2020)、Jha、Miner、Stanton-Geddes all have relevant research on resilient cities. On this basis, Meerow compiled relevant documents after 1973 and proposed the definition of resilient city: resilient city refers to the social-ecological-technical network of the urban system and all its components at all time and space scales. In the case of interference, maintain or quickly restore the desired function to adapt to changes and quickly convert the current limit or future adaptive system (Meerow *et al.*,2016). This definition is currently a more comprehensive and systematic interpretation. After sorting out relevant documents, the characteristics of resilient cities are summarized as follows: diversity, redundancy, stability, adaptability, restorative and innovative (Table 5).

Diversity	Redundancy	Stability	Adaptability	Restorative	Innovation
Multiple urban functions and multiple urban system elements reduce urban vulnerability	There are replaceable elements, a certain degree of superposition of functions to prevent system failure	Resistance to external forces	The ability to adapt to the environment, the ability to adjust the state, structure and function of the system	Ability to recover from disturbance	Ability to learn and apply in the impact

Table 5. Resilient city characteristics.Source: According to (Shao and Xu,2015;Xiao *et al.*,2020) literature summary.

2.2. Research on Resilience Cities at Home and Abroad

The current research can be summarized into three categories, ecological landscape, spatial hierarchy and architectural details. Foreign scholars Iojă and others have conducted research on the role of school green areas in urban green infrastructure (Iojă *et al.*,2014). Hong *et al.* conducted ecological vulnerability assessment through GIS platform (Hong *et al.*,2016). Joyce *et al.* conducted coupling analysis of infrastructure resilience and flood risk assessment through coastal drainage systems and proposed corresponding measures (Joyce *et al.*,2018). Domestic scholars of China use hydrological calculations, GIS platforms, landscape pattern indexes and other methods to assess landscape resilience. At the spatial level, scholars can be divided into studies on water systems (Wang *et al.*,2018; Zhao,2018; Li *et al.*,2019; You,2019; Trundle,2020) and roads horizontally. (Ma *et al.*,2018; Mang *et al.*,2020), and studies on communities (Wei,2019; Sun and Tian,2019; Yu *et al.*,2020), villages. (Xie,2017; Ni *et al.*,2020), and towns vertically (Guo,2018; Xu and Zhu,2020).

3. Resilience connotation and characteristics of public space in resilient city

3.1. Definition and Connotation of Urban Public Space

The concept of public space originated in the 1950s, and then began research in different fields such as architecture, psychology, sociology, and politics. Different scholars have different specific definitions of urban public space, resulting in a certain ambiguity in its concept.

After reading and sorting out the literature, the definition of urban public space in this article is as follows: urban public space refers to the open areas that are open to the public, such as rivers, mountains, etc., that are intended to serve residents. Areas, such as squares, streets, libraries, etc., underground public areas, such as underground parking lots, power supply and drainage facilities, etc.

Urban public space is the carrier of the daily life of urban residents. The diversity and complexity of the population will inevitably lead to the multi-level composite of urban public space. Therefore, urban public space has the following characteristics: public, ecological, systemic, social, and complex, creativity and variability (Table 6).

Public	Ecological	Systemic	Social	Complex	Creativity	Variability
Open place for the public, different from private space	Adhere to the design principles of ecology first and respect for nature	Various elements are organized to form a system with a certain manual operation mode	People express their consciousness and lifestyle through the creation of public spaces	The public space has multiple objects, multiple functions, rich types, and multiple evaluation methods, which determine its complex nature	Urban public space users have the initiative to combine the city with times to create, and have the subjective ability to reflect urban characteristics and express human thoughts	The functions and characteristics of urban public space may change with the development and changes of historical times, thereby reflecting the characteristics of different times

Table 6. Urban public space characteristics. Source: According to. (Li,2007; Liu,2015) literature summary.

3.2. Related literature research

In the collation of the existing literature, there are few studies on urban resilience public space, and most of them stay at the level of macro-resilient city theory. In recent years, scholars have conducted related research on the micro-level of community resilience and community space resilience. Wei Yi (2019) analyses the resilience of community living spaces from the perspective of rural communities and proposes the adaptive cycle theory of community resilience; Sun and Tian (2019) through the analysis of the limitations of the current community, put forward community resilience theory guidance for emergencies; Xu Hui et al. (2019) evaluated and studied the influencing factors of urban resilience public space based on the ISM-AHP method. Some scholars have analyzed the landscape microclimate of the community to improve resilience from the micro level (Wang, 2019). Generally speaking, the current research on resilient urban public space mostly starts from the community level, with strong individuality and weak universality. The public space at the city level has not yet formed a more systematic framework.

3.3. Elements and characteristics of resilient urban public space

Urban public space can be divided into natural public space and artificial public space (Figure 1). Natural public space includes natural environments such as mountains, rivers, forests, fields, rivers and lakes. It is the core component of the urban ecological security system, the background foundation of urban restoration, and the ecological carrier of a strong city. Artificial public space can be summarized into three levels: macro, meso and micro. This article discusses the resilience design of urban public space mainly at the macro and meso level.

Figure 1. Public space composition diagram. Source: Author self-painted.

With the continuous expansion of urban population and scope, the impact of disasters on cities is increasing. As one of the factors affecting resilient cities, the public space of resilient cities should be taken seriously in planning and design. According to the elements of urban public space and the characteristics of resilient cities, resilient public spaces should have the basic characteristics of resilient cities, and combined with the characteristics of public spaces themselves, the resilient characteristics of urban public spaces are embodied in three aspects: space environment, basic services and management systems (Figure2).

Figure 2. Resilience public space feature expression vector. Source: Author self-painted.

The resilience characteristics of urban public space in the space environment are as follows:
 ① Spatial structure: a unified whole, combining points, lines and surfaces; strong structural connectivity, forming a good urban ventilation corridor.
 ② Spatial layout: clear functional partitions, dense and dense,

distinct primary and secondary, to ensure orderly resistance to external interference. ③Space form: According to local conditions, plan the most suitable urban public space according to the localization of urban society and culture. The basic services are as follows: ①Infrastructure: Complete infrastructure: water, electricity, gas, communications, etc. help the city to better maintain during disasters and restore urban functions after disasters. ②Emergency facilities: The city should reserve a site and corresponding emergency equipment so that the city can respond quickly in the event of an emergency, without occupying the city's normal facilities and space, and ensuring the normal operation of the city. ③Traffic system: A reasonable and convenient transportation system can guarantee the normal flow of people and vehicles and timely transportation of materials during a disaster, speeding up the progress of post-disaster recovery. ④Landscape design: In a city with a good ecological background, the richer the species diversity, the stronger the city's resistance. The rich landscape design provides the diversity of urban plant species, improves the urban microclimate, and enhances urban resilience while beautifying the city. In the management system: ①Management agency: As the top designer, the government must play a leading decision-making role. It varies from city to city. It makes corresponding plans for urban vulnerabilities, and does a good job of prevention before disasters, response during disasters, and relief programs after disasters. plan. ②Management system: establish a sound system, formulate a district, level, and classification management system for urban public space, and give priority to ensuring the ecological safety of emergency public space. ③Database platform: Establish a cloud platform for urban public space to grasp space dynamics in time.

4. Model construction: based on the disaster timeline

Adhering to the principles of ecological priority, system planning and smart platform, Establish a model based on the disaster time axis.

Before disasters, public spaces need to assume a certain amount of early warning reserve capacity. Public space can alleviate the impact of conventional disasters. Based on the characteristics of redundancy and stability of resilient cities, focus on analyzing urban foundations, optimizing spatial structure, spatial layout and spatial forms, enriching urban functions, and improving overall urban resistance To maintain stability; do a good job in infrastructure services, material reserves, etc.; through real-time information analysis of the database platform, monitor forecasts and issue real-time warning information.

Undertake resistance and response capabilities during disasters. Public space can be used as refuge space and emergency evacuation isolation space. Based on the diverse and innovative characteristics of resilient cities, we attach importance to improving urban basic services, and respond to disasters through urban infrastructure and reserved urban emergency facilities; rational planning The urban transportation system guarantees the normal flow of urban traffic during disasters; attaches importance to the design of ecological landscapes, increases the rate of urban greening, and the rich urban diversity can improve urban resistance, while beautifying the city and improving the living environment.

Undertake adaptation and repair capabilities after the disaster. The public space can be used as a place for restoration and reconstruction. Based on the characteristics of adaptability and resilience of resilient cities, we will do a good job in disaster recovery management measures, and emphasize the optimization and adjustment of the management system. Learn from disaster experience, actively reflect on it, and improve the information construction of the database platform based on the management organization and management system. At the same time, do a good job in psychological counseling for the masses after the disaster.

The whole process of resilience planning guarantees public participation. The people will be reminded through the platform before the disaster, the health and safety of the people's livelihoods will

be protected through resilience planning during the disaster, the people's psychological counseling will be done after the disaster, the opinions of the people will be listened to and relevant resilience planning feedback work(Figure 3).

Figure 3. Resilience public space model diagram. Source: Author self-painted.

5. Planning strategy: research on the strategy of healthy urban resilience public space

5.1. Resilient public space structure optimization

① Clarify the development direction of the city and attach importance to the overall planning of the city. First, the public space layout is laid out at the macro level, the urban public space pattern is planned as a whole, and the blue-green space network (urban blue line and urban green line) is constructed to form a comprehensive and difficult-to-divide urban green public space network at the city level.

② Optimize the layout of land use. Identify the key development zones and secondary development zones of the city, and allocate urban public resources in a targeted manner. All functional areas shall be allocated reasonably and appropriate urban renewal shall be carried out. According to the location of the land and the Landtax Theory, the functional division of the public space is re-integrated, and the function is replaced according to the actual flow of people, the environmental base and the public needs of the area, and the integration of multiple (multiple small plots into one large land) Optimize public space land, improve land utilization rate and public space diversity, and adjust the public space layout structure at the block level by various methods such as decentralized penetration (large plots are scattered across multiple regions).

③ Pay attention to detailed planning, strictly control the proportion of various types of land, such as open spaces such as parks and green spaces, especially the construction of various forms of public space such as community-level parks and street green spaces, and promote open communities and block layouts to increase communities Land for public space enriches the diversity of urban ecosystems and improves resistance. Flexible planning through integration, re-layout, etc., leave enough leisure space and reserve emergency land at the same time, and it is strictly forbidden to occupy in later construction(Zang *et al.*,2019).

Dutch spatial planning has made great achievements in the research of resilience theory. The province of Groningen in the Netherlands has created a high-density area with diversified functions and increased species diversity by constructing an ecological corridor in the south. The city of Rotterdam

created a water plaza with stormwater management and public space functions by maintaining a multi-center geographical layout, and designated the Maas River as the main public area to store rainwater, creating a resilient water system, and enhancing the resilience of public spaces (Lu *et al.*,2020).

5.2. Optimize urban ventilation corridors and improve the environmental resilience of public spaces

①Through the optimization of the urban public space structure layout, the public space is used as the carrier, and the dotted public spaces are connected to form a complete and continuous linear public space, and finally form a city ventilation corridor connecting the inside and the outside. Using the flow characteristics of wind, clean and fresh air is introduced into the city, and the polluted air is discharged out of the city, forming a virtuous circle. By establishing a hierarchical corridor model, different corridor directions can be constructed for different areas of the city, according to local conditions. Taking the central city of Beijing, China as an example, through the analysis of meteorological data, field observations and GIS technology, an auxiliary strategy for the construction of five first-level corridors, second-level corridors and third-level corridors is proposed for Beijing central city. Achieve the effect of “first-level corridors to induce wind, second-level corridors for air supply, and third-level corridors to string wind” (Du *et al.*,2016).

②Based on the construction of overall ventilation corridors, the internal ventilation of each corridor is planned in detail to enhance the ventilation potential of urban street public spaces. Emphasis on locality, based on the analysis of the city's basic wind environment, simulation evaluation through GIS, CFD, and meteorological data. The ventilation potential of urban street public space is mainly affected by street length, orientation, and windward area of buildings on both sides. The three elements are quantified and analyzed to obtain the results. The city of Wuhan, China previously simulated the Optics Valley Venture Street, using the interactive method of GIS system and CFD numerical simulation to get the comprehensive ventilation potential evaluation of the block, and then put forward different optimization suggestions for the public space in the east and west areas of the block.

5.3. Improve infrastructure and reserve emergency facilities during disasters

①Improve public space infrastructure at all levels. Improve the pipe network facilities of municipal infrastructure projects, accelerate the construction of comprehensive pipe corridors, and establish an open pipe network system to ensure the water and power supply of urban public spaces. Expand the connotation of infrastructure, focus on urban stormwater management, and focus on special facilities for public health safety. The urban rainwater pipeline network is handled through a combination of above and below ground. Based on this epidemic, for sanitary risk facilities, careful planning of site selection, management practices, post-treatment, and surrounding environmental issues, such as breeding farms, live poultry markets, garbage dumps, and slaughterhouses, are closely related to public health. Research and real-time monitoring to respond to disaster situations.

② Reserve public space for emergency facilities during disasters. Reserve vacant land in open areas such as urban parks for emergency response during disasters (earthquake, tsunami, fire, etc.), post-disaster resettlement land, and store sufficient materials to deal with the resettlement of people with different scales of disasters. Take the construction of resilient public space in Berkeley in the United States as an example. Earthquakes, fires, and droughts and floods have severely affected the safety of Berkeley. Berkeley has actively formulated policies and measures, proposed community connections, created community-level shelters, and designed 7 communities and high-level centers as disasters. Refuge points and establish an inter-community liaison mechanism for mutual support before and after the disaster. Flexible layout of medical facilities, according to the urban land and infrastructure conditions, consider the reservation of spare diagnosis areas and isolation areas.

5.4. Adjust the transportation system inside and outside public spaces to create healthy and green transportation

① Enhance the connectivity and accessibility of the transportation system. Optimize the urban road network structure, improve the urban external express road network, plan the emergency transportation system, ensure the accessibility of the urban external transportation system and the smooth operation of the disaster; integrate the internal roads of the city, and merge the roads by opening the broken roads and T-shaped roads, Upgrade the road system. Green wave traffic can be achieved through policies such as the time setting of traffic lights and other traffic facilities, and limited and time-limited vehicle passing, and improve the passing efficiency. At the same time, attention is paid to the planning of the people-vehicle diversion system and the setting of vehicle traffic and pedestrian traffic transfer nodes to ensure health, safety and fast passage. Combine disaster relief with flexible transportation planning and do a good job in logistics management. The transportation of medical supplies and the supply of daily necessities for residents in the disaster area, as well as the cross-regional deployment of medical staff and the transfer of patients all rely on an efficient emergency transportation system. The government must pre-establish evacuation routes, isolation plans and emergency logistics management plans during disasters.

② Optimize public transportation and parking management. Improve bus routes, increase bus routes, stations and shifts to increase the coverage of public transportation, rationally set bus entrances and exits, plan bus lanes, and improve the efficiency of public transportation. Try to plan living roads around public spaces, strictly control the width of the red line, limit the speed of motor vehicles, and set up parking lots (combination of flat and three-dimensional parking) and emergency backup lanes based on the layout of public spaces, population and traffic flow, and make appropriate advances. Reserve land for development.

③ Improve the slow-moving system. Follow the principle of ecological priority, pay attention to the construction of slow traffic, divert people and vehicles, and divert machines from non-machines, and plan trails, overpasses, planks, ropeways and other types of slow-travel experiences. With parks and squares as the center, public facilities such as bus stops, shops, restaurants, etc. will be built around, equipped with leisure areas and barrier-free facilities. Improve the walking path system (scale, streamline organization), pay attention to the construction of the ecological landscape of the slow-moving system, and use the existing vegetation and water body combined with artificial design to create a green, pleasant and ecologically healthy slow-moving system.

④ Increase road greening. On the premise of protecting the existing road greening, increase the green area of the newly planned road, and on the basis of protecting the local vegetation species, enrich the plant species, select the suitable and tenacious plants in the region, increase the urban species diversity, and improve the urban atmosphere. The environment also enhances the ability of urban public space to resist disasters.

5.5. Make full use of the intelligent management of the GIS platform to enhance ecological disaster prevention capabilities

Big data can monitor the status quo before disasters, analyze trends and provide early warning, so that relevant departments can establish emergency plans while monitoring the distribution of people flow, predict the evolution of time and space, identify areas with high disaster risks, and assist in the formulation of prevention and control measures; monitor the trend of disasters in real time during disasters. Achieve timely notification of residents to transfer, find the best emergency transportation route and make response plans; continue to monitor the trend of the disaster after the disaster to prevent losses caused by secondary disasters, and use the GIS system to establish a database to store the

disaster information for future analysis and learn from experience in time . Using GIS spatial information analysis technology as a platform, it can accurately obtain relevant spatial environmental data: slope, aspect, elevation, vegetation and community distribution, etc., predict the population size and density in a certain area, and effectively guide urban public space defense. The structure, layout and capacity of the disaster system(Wang and Zang,2017). Through data sharing, cross-regional linkage mechanisms are established, and information exchange guarantee measures are scientific and efficient.

6. Conclusion

The COVID-19 poses a huge challenge to the emergency level and resilience governance of global cities. Urban resilience has become a key topic of current scholars' attention, and public space, as one of the elements of a city, its resilience value has an important impact on the city's resistance. How to improve the resilience of public space and enhance the ability of urban resistance, adaptation and recovery is a topic that planning scholars need to study in depth. From the perspective of urban planning, this article summarizes and summarizes the characteristics of resilient public space through the analysis of the concept of resilience, the concept and characteristics of public space, constructs a model framework diagram of resilient public space, and proposes the 5 Item strategy. Attempt to first form a set of theoretical systems. The models and strategies are both outlines and have not yet been substantively and quantitatively verified. After that, further research is needed on this basis. With the joint efforts of planning scholars from all over the world, I firmly believe that a resilient public space—resilient city—healthy human settlement system can finally be established to truly achieve the goal of sustainable development.

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