

Research Paper

Resilience Planning and Evaluation of Urban Central Park

A Case Study of Jinan Central Park

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Abstract

Resilience has become the important criterion for urban safety and sustainable development under the background of continuous development of urbanization, global climate change, increasing uncertainties and risks. Research of urban central park based on resilience theory was helpful for urban system in research and practical experience by nature-based solutions. The study case was Jinan Central Park, which was expected to demonstrate resilience and become the key node by connecting ecological network in and outside central area in north bank of the Yellow River. This paper combined planning and assessment framework with typical characteristics of urban resilience: robustness, rapidity, redundancy and diversity, which contained ecology, transportation, infrastructure and social activity factors in 4 first-level and 16 second-level indicators. The research contributed to the urban central park planning and evaluation method in resilience thinking, which will help a better understand of green spaces resilient characteristics through scientific evidence, as well as the reference for urban safety resilient improvement.

Keywords

Resilience theory; Urban central park; Resilient city; Resilience evaluation framework; Resilience evaluation method

1. Introduction

Cities have been continuously sustained unprecedented environmental and social challenges that bring pressure on local infrastructure operation in the context of urbanization processes and climate change^[1]. Among these negative impacts which weaken social equality, environmental vulnerability and ecological resilience, resilient city could form strong adjustment ability through internal and external intervention, and form a safe, stable and sustainable living environment^[2].

Resilience was used to describe the concept of being able to perceive and maintain a balanced state of existence in reaction to a wide array of disruption, which has attained much attention by multiple relevant disciplines in the last decade^[3-4]. In environment research field, resilience theory has gradually evolved into a comprehensive concept intersect multiple subjects, applied to the interactions between human society and ecosystems in potential of renewal, reorganization and development. Therefore, urban planning and construction should integrate flexible and adaptable elements of resilience, to enhance management system, climate, economy and ecology environmental, as well as social cohesion. To function effectively, cities were usually operation based on robust grey infrastructure systems,

connecting the network to support the provision of transportation, energy, water and building services^[5]. Research showed that enhancement of robustness and adaptations in grey infrastructure produced new fragilities and vulnerabilities inevitably, which was not enough to withstand adverse impacts of urbanization and climate change^[6-7]. Thus, urban planning needed to become flexible for vulnerability and robustness, especially embedding green space as the critical nature complement^[8].

Green space (GS) was of great significance to regional climate regulation, biodiversity conservation and living environment under the pressure of rapid urbanization. GS was also contributed to resilience in improving urban ecological environment quality and natural disaster recovery ability with abundant natural elements. GS has been incorporated into urban resilience planning system in many cities around the world to combine natural and artificial structure^[9]. The urban park (UP) was one of the most important natural components among GS system, including trees, shrubs, grasslands, water bodies, open spaces, activity spaces and management land within green coverage, which provided important ecological service functions for regional environment. At the same time, UP could cope with risk interference such as urban climate change and sudden crisis by continuously exerting social and ecological benefit. Facing increasing pressure of land use and social production, urban park needed to attain characteristics of resilience, that was the ability to absorb interference and change^[10]. Through the large scale and core location, constructing urban central park (UCP) has become a typical mode of urban new area planning to maintain biodiversity, display city culture and promote economic development, which could continuously improve the urban social and environmental space and achieve a new dynamic balance^[11].

Existing resilience research mainly focused on persuasive evaluation with multiple goals and benefits^[12], including ecosystem services^[13], biodiversity^[14], economic conditions^[15], environmental inequality^[16], and sustainability^[17], which were typically implemented with a single or a few factors of city operation. The evaluation of GS planning based on urban resilience was often multi-dimensional, including ecology, health, social network and cohesion, economic development and other positive benefits, considering fairness and effective implementation, and measuring connectivity and versatility^[18-19]. Therefore, a comprehensive planning and assessment framework was lacked to guide UCP construction based on resilience theory. And combine quantitative and qualitative measurements into the indicator framework can be difficult because of limited measure method and complexity of systems^[20].

To understand the environment effects of urban central park, it was necessary to assess UCP resilient performance in terms of urban resilience thinking. For this research, a framework was assumed to support UCP planning and assessment, allowing results to promote building in the future. After identified how resilience theory developed an assessment system to facilitate planning processes in the case of Jinan Central Park, emerging questions could be addressed that how to enhance regional stability to cope with risk stress and sustainable development from the perspective of central park construction, how do urban park systems response regional environment extremes over long term, so as to enrich research findings of resilient city by nature-based solution in block research scale.

2. Materials and methods

2.1. UCP planning and design thinking based on resilience theory

Resilient city was the specific application of resilience theory in the complex city social-ecosystem, so main characteristics of could be seen relatively consistent in general^[21]. And typical characteristics of resilient city can be emphasized by robustness, rapidity, redundancy and diversity of urban system functions^[22-25]. Robustness and rapidity could intuitively reflect the resistance and resilience of the city

system to cope with external shocks, while redundancy and diversity can provide material basis for resistance and recovery through pre-or post-disaster preparedness ^[21].

(1) Robustness

Robustness referred to the ability of urban environment for resisting a certain degree of external impact interference. In UCP planning and construction, the most prominent value for the urban environment was the ecological service value, such as protecting natural habitat, promoting ecological concept in spot design, protecting ecologically vulnerable region and conforming natural succession process. After all these, sightseeing, science popularization, leisure and other ecology-related experience activities were introduced, so as to create a harmonious atmosphere between artificial and natural. Specific contents involved UCP water system, native plant groups, waterside eco landscape, and rainwater utilization facilities (Figure 1).

(2) Rapidity

Rapidity was pointed to the ability of respond external disturbances timely and make flexible organizational adjustments, for UCP was to communicate variety resource elements fully in the regional area, that was spatial connectivity. UCP helped to promote migration of organisms and enhance biodiversity, and visual alignment could strengthen the hierarchical sense of landscape sequence and viewing, improve the correlation between park nodes and green patches, as well as strengthen the overall structure of the park. Specific measures included the construction of regional blue-green network system, biological corridors, landscape sequence guidance and slow-moving system.

(3) Redundancy

Redundancy meant the reserved capacity on the basis of the system additional needs. When disturbance occurred, conventional system elements may lose operation while several necessary functions could still be maintained, so as to avoid instantaneous collapse of system. In UCP planning concept, redundancy was reflected in extra reservation various service facilities. UCP usually undertook larger celebration activities, accommodating amounts of instantaneous visitors during holidays or festivals, so the service facilities face huge external pressure instantly and redundant facilities can maintain stable function continuously at this time. Detailed strategies included transportation facilities, service buildings, disaster prevention and avoidance space, and saving garden facilities.

(4) Diversity

Diversity meant multiple functional components and more choices to weaken the impact of external shocks. Diversity could also be understood as compatibility and multiple ideas of city ecosystems and social organizations. In UCP, diversity reflected in richness of social culture, which can be developed through relevant theme nodes. Abundant activities can promote social interactions among residents by general entertainment and leisure, shaping cultural inclusiveness and urban cohesion. When dealing with external shocks, urban residents can actively exchange information and provide more solutions, enhancing resilience by the linkage of various region resource. Concrete contents comprised cultural activities, characteristic nodes, social interaction space, and surrounding function extension.

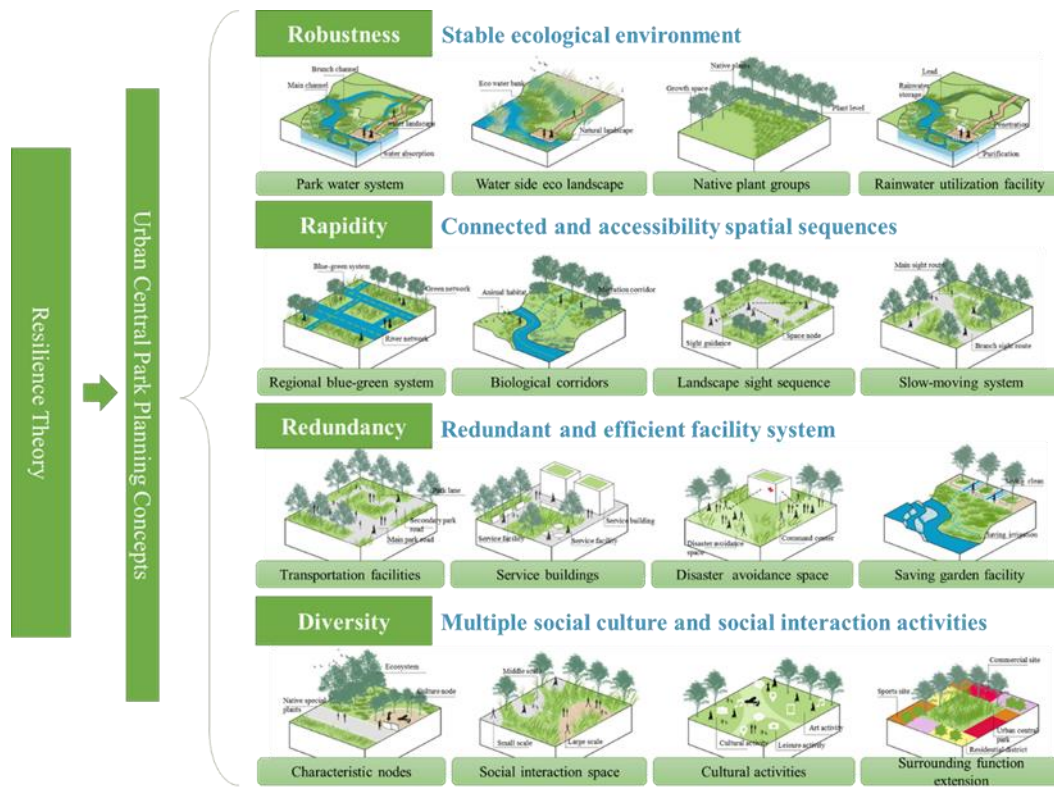


Figure 1. Resilient planning and design concepts of UCP. Source: author self-painted.

2.2. UCP evaluation framework by resilience theory

A conceptual framework was developed to incorporate resilience thinking in UCP performance evaluation. Based on above, assessment system of UCP based on resilience theory contained 4 first-level and 16 second-level indicators, whose content was oriented to the four typical characteristics of resilient city. Among these indicators, robustness mainly evaluated the stability of the ecological environment; rapidity reflected the spatial connectivity and accessibility; redundancy assessed the degree of facility coverage and completeness; diversity exposed the capacity of activity organization and cultural performance. By scoring and weighting average each evaluation index, individual and overall results of UCP resilience were obtained, which was helpful to propose future improvement strategies. Analysis was the combination of qualitative and quantitative. Qualitative analysis included physical survey of the site, visitor interviews, and literature research. Quantitative analysis included map calculation and monitoring data analysis. The results were divided into 5 grades from low to high, corresponding score from 1 to 5 (Table 1).

First-level indicators	Interpretation	Second-level indicators	Interpretation	Evaluation Method
Robustness	Analyze the resilience of UCP in ecological aspects, such as ecological facilities, landscape, rainwater	Water system	Stability of entire river system in the park	Analysis of river measurements
		Eco water landscape	Water landscapes help protect river banks from erosion	Physical survey of the site
		Native plant groups	Plant more native tree species	Physical survey of the site and map calculation

	utilization, local materials	Rainwater utilization facility	Rainwater collection and utilization	Physical survey of the site
		Blue-green system	Form blue-green network together with regional green space	Map calculation
Rapidity	Measure the accessibility and resource mobilization of the park	Biological corridors	Biological communities move through freely from one area to another	Analysis of biological monitoring data
		Landscape sight sequence	view and reach other nodes smoothly	Map calculation and visitor interviews
		Slow-moving system	Sightseeing routes connecting major nodes	Visitor interviews
		Transportation facilities	Arrived at various places in the park quickly and abstractly by road system	Physical survey of the site and map calculation
Redundancy	Assess the layout and service capacity of park in face of unanticipated disturbances	Service buildings	Various service facilities, commercial, sports, public toilets, rest, etc	Physical survey of the site
		Disaster avoidance space	The space that can accommodate people evacuation	Physical survey of the site and map calculation
		Saving garden facility	Garden facilities to save water and electricity resources	Physical survey of the site
	Analyzing community cohesion by various activities, which can	Characteristic nodes	Nodes involve unique cultural design elements	Physical survey of the site and visitor interviews
Diversity	generate multiple options, information and solutions under external pressures	Social interaction space	activities in node promote emotion and attachment of residents	Visitor interviews
		Cultural activities	Entertainment that reflects local history and culture	Visitor interviews and literature research
		Surrounding function extension	the potential to contribute adjacent land use economically	Physical survey of the site and map calculation

Table 1. Resilience performance evaluation indicators of UCP. Source: author self-painted.

3. Results

3.1. Planning and design of Jinan Central Park based on resilience theory

In the context of the city core area in future construction, the site of Jinan Central Park was located in the gateway zone of the Yellow River north bank, adjacent to Queshan Lake and Huashan Mountain. Through the exploration of the park master plan and node design, the concept of resilience was injected. Jinan central park was in contemporary design approaches, such as a sustainable space merging artificial, natural and historical features. And three general ideas were the north to south spatial axis, river ecological sightseeing, local cultural activities and slow-moving leisure nodes (Figure 2). In addition, robustness reflected in ecological wetland and biological protection scenic spots; rapidity demonstrated in corridor node such as waterfront walkway and lake appreciation; redundancy embodied in sunshine lawn-disaster prevention spot and exhibition hall service facilities; entrance square and nature education space were the diversity concept nodes (Figure 3).



Figure 2. Master plan of Jinan Central Park. Source: author self-painted.

	Design spot	Design rendering	Design spot	Design rendering
Robustness				
	Ecological wetland		Biological protection	
Rapidity				
	Waterfront walkway		Lake appreciation	
Redundancy				
	Sunshine lawn-Disaster prevention		Exhibition hall	
Diversity				
	Entrance square		Nature education	

Figure 3. node design of Jinan Central Park. Source: author self-painted.

3.2. Discussion on the resilient performance evaluation of Jinan Central Park

Since Jinan Central Park was still in planning stage, this study adopted a single qualitative analysis method to explore the construction of evaluation indicators. Delphi method was used to preliminarily analyze the planning scheme, and 15 relevant practitioners were invited as evaluation experts to conduct resilient performance analysis of indicators. The results showed that indicators of characteristic nodes, cultural activity and social interaction space, which on behalf of public activities while below the average, needed subsequent adjustments; indicators of biological corridor, native plant group, disaster avoidance space and water system, which represented ecology intuitively, was considered to better reflect resilience performance. In addition, the consequence may indicate that existing research on UCP resilience mainly focuses on ecological resilience, and the correlation and potential of social resilience need further study (Figure 4).

Evaluation results of the pilot indicators

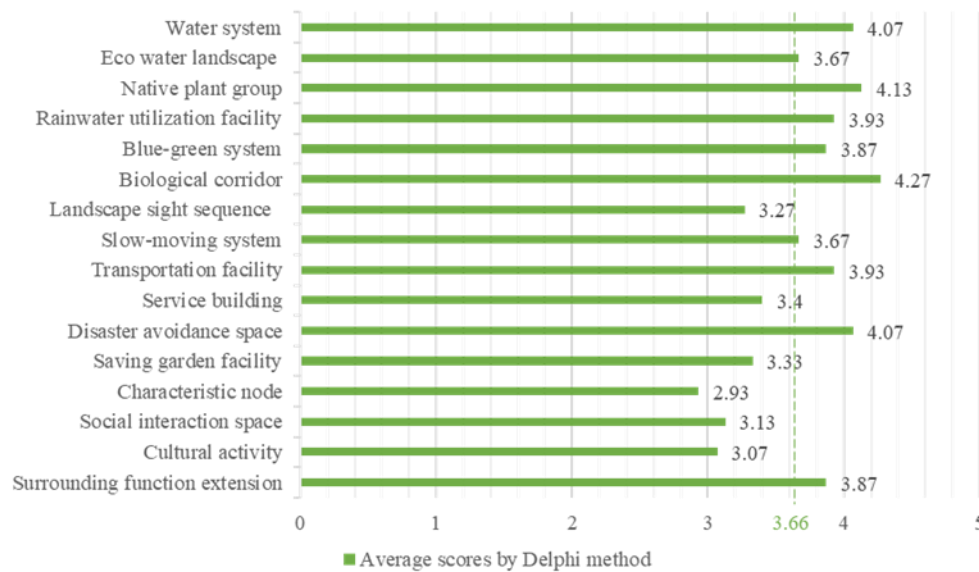


Figure 4. Evaluation results of the pilot indicators. Source: author self-painted.

4. Discussion

4.1 Applicability of resilience theory to urban central park planning

In urban planning and design studies, resilience theory has been applied in comprehensive contents, such as architectural space, social culture, ecological system, historical context and so on. This study employed the resilient concept into UCP, which was public open space and green core of the city, undertaking variety functions of displaying urban historical and cultural deposits, organizing public activities, and preventing disaster interference. Therefore, UCP was not independent of urban system as the green isolated island, but affiliation with larger open space system and multi-factor constitution, needed to resolve urban ecological risk, mobilized urban resources quickly, provided multiple service selections, fast recovery toughness duties, and stable ecological environment. These functional responsibility of restoration and stability made UCP accord with guidance scope of the resilience theory.

In the meanwhile, compared with the general large-scale comprehensive parks, UCP in resilience theory brought out more sustainable development goals and comprehensive construction guideline, paying attention to the correlation and coordination among multiple complex elements, which could generate different landscape visual and ability to define uncertain interference as the Nature Based Solution. The introduction of resilience into master and special planning could replete grasp and coordinate the relationship between various elements, improve the integrity and resistance in face of social and environmental challenge.

4.2 Evaluation of urban central park based on resilience theory

It was suggested that evaluation of resilient ability was usually focused on city open space in different scale, which was loosely connected with the urban green environment. UCP fulfilled multiple social-ecological demands, also including variety scales and relevant to the public interest profoundly. Thus, research in the past appreciated seriously in single feature such as economic benefit, landscape aesthetics and ecological value, neglecting its compositive resilient functions of risk buffering, resource

mobilization and rapid restoration of operation order in city context. The resilience relevant performance of UCP could be revealed profoundly by constructing the evaluation system, so as to improve the development and update in the future.

At the same time, UCP cannot be ignored as an integral part in regional environment, affecting environmental quality of the surrounding district immediately and strongly. The application of resilience theory in evaluation can strengthen the close connection of various functional service elements between UCP and surrounding residential area. So the assessment of UCP resilience should not only focus on internal site but also expand research perspective to surrounding environment, and incorporate regional resilience performance and perception into evaluation system as one study exploration, so as to ensure the stability and sustainable development of the regional environment.

5. Conclusion

In this study, we proposed the planning and assessment framework to assess UCP for improving urban new area resilience capacity. Four main characteristics of resilience city robustness, rapidity, redundancy, diversity was used as planning and assessment principles, forming 4 first-level indicator and 16 second-level indicators to facilitate UCP resilient ability by stable eco environment, reachable spatial sequences, redundant facility system and diverse cultural activities. The relevant evaluation index and calculation method are described in detail. It also took Jinan Central Park as the study case to promote planning concept and resilience assessment. Research in the future could explore quantitative analysis based on multivariate data and continuous detection, and analyse the indicator relevance of UCP by multiple dimensions on city resilience. Our results indicated a reference for the construction of urban central park and resilient city environment.

6. References

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