

A Study on the Resilient Design of Coastal Urban Parks

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Abstract:

In the context of rapid urbanization and the growing emphasis on sustainable “Park Cities,” coastal urban parks act as critical socio-ecological interfaces that provide both environmental and social value. However, these spaces face pressures from environmental change and evolving urban demands, which traditional static designs struggle to address. This study develops a comprehensive framework for resilient coastal park design that integrates ecological integrity with social functionality, emphasizing both sustainability and long-term public value. Using Qingdao’s coastal parks as case studies, the research combines literature review, comparative analysis, and practical design guidelines to examine adaptive management strategies that enhance ecological performance, community engagement, and economic and social benefits. The findings highlight that shifting from static, resistance-based design to dynamic, resilience-oriented management can improve urban waterfronts’ adaptability, optimize public resource use, and foster sustainable urban development. This framework provides actionable insights for planners, policymakers, and stakeholders to maximize the ecological, social, and economic returns of urban coastal spaces.

Keywords: Waterfront Space, Urban Resilience, Sustainable Development, Space Planning

1. Introduction

With the rapid progress of urbanization, the sustainable utilization of urban space and ecological restoration have become central issues for achieving resilient and livable cities. Coastal urban parks not only provide ecological and recreational benefits but also contribute to social well-being and economic vitality by enhancing public spaces, attracting visitors, and supporting community engagement. In recent years,

extensive research has been conducted on urban waterfront open spaces, covering aspects such as recreational behavior needs and their interrelationships. The study of these behaviors has generated a wealth of theoretical and practical insights, showing that coastal parks serve functions such as leisure, entertainment, and sightseeing, while their quality directly influences urban vitality and social engagement. However, existing research mainly focuses on overall layouts of urban green spaces or individual ecologi-

cal elements, with limited attention to integrating resilient landscape design with public value, social participation, and multi-scale sustainability. Therefore, this paper takes Qingdao's coastal parks as examples to explore how resilient design can enhance ecological stability, social adaptability, and long-term urban benefits. It specifically investigates how to integrate resilience into coastal spaces to boost disturbance resistance, optimize public use, and maximize social and ecological returns. Through literature review and case analysis, the study examines spatial planning, functional features, and community needs, proposing strategies that inform sustainable urban management and policy.

2. Urban Waterfront Open Space and Resilient Landscape Design

2.1 The Structure and Functions of Waterfront Open Spaces

Waterfront open Spaces are an important part of the urban open space system, integrating ecological, landscape and social functions, and offering diverse leisure, recreation, and sightseeing experiences for both residents and visitors. Specifically, its structure and function are reflected in three aspects: spatial function, cultural and historical value, as well as social and economic value. In terms of spatial functions, waterfront open spaces host multiple activities such as entertainment, relaxation, social interaction, fitness and sightseeing, and are a direct correspondence between urban supply space and recreational demands. The physical space for urban recreation must align with the needs and behaviors of its users to ensure effective and comfortable utilization. As such, these spaces not only fulfill recreational needs but also support cultural, economic, and research functions. Their multifaceted value underscores the key role and significance of urban open space planning. There are multiple ways of knowing an urban waterfront spaces, and these different ways in turn shape the policy intervention. The waterfront, when viewed as an environmental policy target, emphasizes conservation, regulation, restoration, and protection. As an economic policy target, it focuses on job creation, tax revenues, property values, and growth. As a social equity policy target, it centers on access, opportunity, public space, and environmental justice [1].

2.2 The Application of Resilient Landscape design

In the context of urban planning, resilient design plays a crucial role in adapting to environmental uncertainties

and fostering long-term sustainability. Therefore, a resilient city is one that ensures long-term sustainability and preserves essential functions and urban structure. This is achieved via adaptation and transformation in response to disasters, shocks, and pressures [2].

Traditional design typically focuses on how much external interference the landscape system can withstand, treats external changes as threats, and attempts to control them through artificial means. This approach makes the system passive in the face of change, making it difficult to truly adapt to environmental uncertainties. The concept of urban resilient design, on the other hand, emphasizes tolerance and utilization of change, viewing disruption as part of the landscape composition, and enhancing the system's diversity and vitality through dynamic design. For instance, in coastal parks, resilient design mitigates coastal erosion by preserving natural tidal flats and vegetation buffer zones, and integrates adjustable walkways and seating areas to accommodate changes in visitor behavior. These measures enhance the adaptability of coastal parks to environmental changes, thus improving the visitor experience and the overall value of the space.

3. Resilient Framework and Practice of Urban Coastal Parks

3.1 The Ecological and Social Resilience of Coastal Park Landscapes

Through the coordination of ecological and social elements, and in combination with the constituent elements of coastal park landscapes, the components of resilient landscapes are classified into ecological and social resilience. As such, the resilient development and optimization of coastal park landscapes are carried out under the coordinated promotion of ecological resilience adaptation and social resilience. Ecological resilience represents an objective adaptation dimension, consisting of both natural and human-made environmental elements. Among them, natural elements encompass topography, landforms, water bodies, climate, flora, and fauna. Artificial environmental elements include garden paths, landscape buildings, and landscape ornaments. Ecological resilience primarily refers to an ecosystem's ability to absorb disturbances, as well as its capacity for reorganization, adaptation, and the sustained development of its health. Besides, social resilience mainly embodies a subjective, coordinated dimension composed of humanistic service elements as well as economic management components. It is impacted by hazardous environments, the forecasting of catastrophic events, and the breakdown of systems, along with their

social and economic implications [3]. Also, ecological resilience directly impacts the spatial configuration of coastal parks. It may be weakened or even disappear in certain areas due to external impacts. However, both natural and human-made environmental factors permeate the entire spatial structure of coastal parks, ultimately shaping the trajectory and direction of their resilient landscapes.

3.2 Strategies for Enhancing Ecological Landscape Resilience

Using the Wan Chai Waterfront Promenade landscape design as an example, the lengthy coastline of Victoria Harbour is usually hindered by accessibility issues in several waterfront areas, caused by buildings and infrastructure. This disrupts the promenade's continuity and limits



a) Public art seating

its functionality. In a high-density urban environment, enhancing the resilience of ecological landscapes and protecting biodiversity within limited space is a pressing challenge. The ecological landscape resilience of Victoria Harbour will be strengthened through thoughtful planning and design, focusing on the adaptive resilience of both natural and human-made elements.

3.3 Adaptation of Resilience of Artificial Environmental Elements

The seaside promenade includes artist installations and sustainable features such as wind-powered lighting, solar lamps, and public art seats made from typhoon-fallen trees, blending practicality with aesthetics, as shown in Figure 1.



b) Rest stop

Figure 1: Night View of the Resting Station [4]

The designer incorporated various bench styles and rest areas for different activities, improving the seaside leisure experience. This space can also double as an open-air theater for small events. It has become one of the prime spots to enjoy sunset views of the core business districts along Victoria Harbour, offering tourists a chance to unwind while taking in the panoramic scenery.

3.4 Adaptation to the Resilience of Natural Environmental Elements

Natural environmental elements typically involve a multi-level species combination, such as large trees, small trees, and shrub ground covers, to enrich spatial layers. Meanwhile, landscape design should account for seasonal changes, with a careful balance of evergreen and deciduous plants.

To preserve and enhance local biodiversity, wildlife-friendly plant species were chosen to offer food, shelter, and a suitable habitat within the urban environment. Trees and shrubs with seasonal flowers were selected to ensure visual variety throughout the year. In order to form larger, more comfortable habitats for local wildlife,

species like *Crateva*, *Delonix regia*, *Jacaranda mimosifolia*, and *Melia azedarach* were introduced, boosting their living conditions [5]. Besides, green plants are arranged in different forms according to the behavioral needs of tourists. The green area near Tamar Park is mostly composed of randomly distributed shrubs and lawns, forming a smooth transition on the overall plan. In the central area, the designer has set up a characteristic pavilion in the shape of a photo frame. Therefore, the viewing side facing the sea view is not blocked by greenery. Instead, a row of trees, consisting of single rows of trees and shrubs, is placed behind the pavilion. Near the Hong Kong Convention and Exhibition Centre, the space gradually narrows. Tall trees are planted along the road to direct people and link with public buildings, guiding tourists from the pavilion to the Hong Kong Convention and Exhibition Centre.

3.5 Strategies for Enhancing Social Landscape Resilience

Taking the landscape design of Bishan-Ang Mo Kio Park as an example, the park showcases a new approach to tropical urban hydrological landscape treatment through

tropical landscape facilities, meeting Singapore's dual requirements of independent water supply and flood control, while also creating a riparian ecosystem within the compact city. The design team, in collaboration with the park and water departments, uses traditional methods to maximize economic and cultural benefits. For instance, in 2006, the government launched the Active, Beautiful, and Clean Waters Programme (ABC Waters) to integrate water spaces into daily life and encourage community involvement in maintaining water cleanliness [6].

3.6 Adaptation to the Resilience of Humanistic Elements

The design of Bishan-Ang Mo Kio Park tackles environmental and flood management challenges while simultaneously promoting community engagement and environmental education. In particular, it serves as an educational space for children, promoting water conservation and encouraging active participation in environmental stewardship. Besides, children contribute to river health monitoring, highlighting its role in instilling a sense of responsibility towards nature in the community [7]. In terms of structural transformation, the park replaced concrete drainage channels, which lacked flood control measures, with a natural river system. Traditional hard revetments were substituted with soft landscape strategies such as planting, gentle slopes, and shoals, thus enhancing the park's ecological function. In contrast to traditional designs that use guardrails to keep people away from the water, Bishan-Ang Mo Kio Park encourages a more intimate and inclusive connection between people and water, offering an open and accessible riverside experience.

3.7 Adaptation to the Resilience of Economic Factors

The original Bishan Park was a conventional urban park with no ecological value. Built on a former landfill, it faced significant issues with rainwater and sewage drainage. On the south side of Bishan Park, there is an artificial water channel built with concrete - Kallang River. Before the planning, there was no resilient design and no flood prevention measures in the area near the Kallang River. As such, the park faced flood risks every rainy season. Flooding was a persistent issue, marked by the severe floods in 1964 and December 1978, causing an estimated \$3 million in damage [8].

Under the traditional urban management model, different departments usually perform their own duties. For example, parks are generally managed by the National Parks Service, whereas drainage channels fall under the

authority of the Water Authority (PUB). While this fragmented management approach is clear, it proves to be limited when addressing the complex water challenges in urban areas. After the introduction of an integrated water management system in cities, the functional boundaries among various institutions have become blurred, and the scope of responsibilities needs to be redefined. This means that the originally independently operating departments need to break down barriers and carry out collaboration in areas such as water resource planning, infrastructure construction, and ecological environment protection. Thus, through the resilient design of cities and cross-departmental cooperation, cities can maximize overall benefits. The project has increased the river channel's flood discharge capacity by 40% and added about 6.2 hectares of new park space, improving the local ecology and residents' quality of life, as shown in Figure 2 [9].

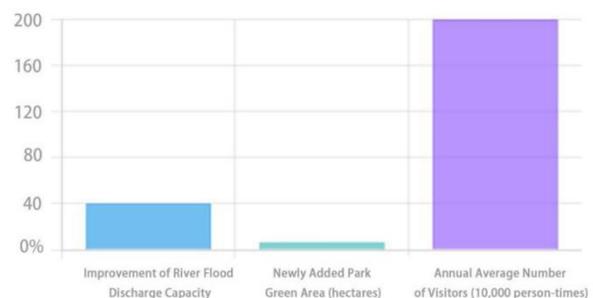


Figure 2: The Revenue Increase from the Bishan-Ang Mo Kio Park Renovation Project [9]

4. Pathways for Ecological and Social Resilience Design in Coastal Parks

4.1 Ecological and Social Resilience-Oriented Design

The resilient landscape design of coastal parks emphasizes rebuilding the system's self-restoration, self-adaptation, and continuous renewal capabilities through a combination of ecological restoration and artificial intervention, based on ecosystems that have been disturbed and degraded. The design strategy enhances ecological resilience through plant diversity, water restoration, and landscape optimization, while also boosting social resilience through community participation, education, and multifunctional facilities. By considering the interactive relationship between ecological and social elements, this approach is practice-oriented to achieve the sustainable and healthy development of natural systems within a limited space,

while fostering residents' awareness and responsibility for the environment. This method offers a strategic framework for coastal parks, enhancing ecological functions while meeting social needs and public interests.

4.2 Approaches to Optimizing Ecological Mechanisms

4.2.1 Reconstruction and Restoration of Plant Communities

The reconstruction and restoration of plant communities aim to enhance the ecological function and plant diversity of coastal parks through ecological assessments, the removal of invasive species, and the optimized arrangement of native plants. First, the plant communities in the coastal

park are assessed for health, with invasive and harmful species identified and removed. Besides, an ecological survey identifies weak points within the park, followed by zoned restoration. Particular attention is given to increasing the use of native tree species, optimizing plant combinations based on growth and aesthetic value, as shown in Table 1. Color coordination and seasonal variations are key considerations to ensure that the plant landscape offers rich layering throughout the year. The design prioritizes native plants resistant to tides and tolerant of salt and alkalinity, thus enhancing plant diversity and supporting a healthy ecological cycle. Additionally, the combination of large trees, small trees, shrubs, and ground cover plants is considered to enrich the spatial layers and visual effects in the upper, middle, and lower levels of the landscape.

Table 1: Classification Table of Native plants [10]

Category	Scientific Name
Foliage Plants	Euonymuskiautschovicus, Ostrya liana, Berberis thunbergii, Atropurpurea, Machilus thunbergii, Pistacia chinensis
Flowering Plants	Elaeagnus macrophylla, Lilium tsingtauense, Rhododendron spp, Corylopsis spicata, Camellia japonica
Fruiting Plants	Maclura tricuspidata, Meliosma spp

4.2.2 Water Body Environmental Protection and Regulation

Due to the significant ecological pressures on coastal water bodies, protection measures must be adapted to local conditions and focus on practical solutions. Firstly, water quality protection should target industrial and agricultural pollution. By enforcing strict emission monitoring and promoting environmentally friendly agricultural practices, we can effectively reduce pollutants entering water bodies. Besides, the construction of rainwater collection systems and wetland purification areas can enhance the self-purification ability of water bodies and reduce the impact of stormwater runoff on water quality. In terms of wetland and shoreline vegetation restoration, priority should be given to protecting and restoring local wetland ecosystems and increasing the density of shoreline vegetation to reduce soil erosion. The roots of wetland plants filter pollutants, enhancing water quality and ecological functions. Moreover, the surrounding green belts and aquatic plants can provide habitats for local wildlife, increasing biodiversity. The functions of water bodies should not be limited to flood control and water storage, but should provide recreational and educational spaces for citizens. By planning pedestrian paths, landscape belts, and other water-accessible areas, citizens can better connect with

nature and raise environmental awareness. Besides, water-based activity areas can be tailored to local features, enhancing functions and increasing community involvement. And water body protection needs multi-party cooperation. Local governments, environmental protection, and urban planning must work together on water policies, with community involvement in monitoring and cleaning boosting awareness and responsibility. These measures can improve water body health, enhance water quality, and promote coastal sustainability [11].

4.3 Strategies for Enhancing Social Adaptation

4.3.1 Social Management and Coordination Mechanism

In practice, multi-departmental collaboration depends on effective communication and cooperation mechanisms. Thus, the government, community, and environmental organizations can collaborate via a platform and regular meetings. The technical platform serves as a shared tool for information exchange and coordination. Through the platform, policies and management updates can be shared in real time., feedback on residents' needs and concerns can be submitted by the community, and ecological data and expert advice can be provided by environmental organizations. The use of this platform ensures that all parties

can respond to each other's needs based on transparent information. Meanwhile, regular meetings offer a chance for direct communication between departments. These meetings help address specific issues during implementation and allow for progress evaluation to ensure all parties are aligned. In these meetings, the government leads by providing policy support and coordinating resources, community members contribute residents' input to improve plans, and environmental groups provide specialized advice on ecological conservation to ensure management aligns with sustainability objectives. By integrating the technical platform with regular meetings, effective collaboration can be achieved in areas like information exchange, issue resolution, and resource coordination, supporting the collaborative and sustainable management of coastal parks.

4.3.2 Community Participation and Public Education

In daily maintenance, public awareness and participation are key to enhancing social resilience. The long-term development of the project is secured via joint design, ecological monitoring, and popular science education. In terms of joint design, both residents and schools can participate in the design and construction of facilities. The project team actively invites local residents and school staff and students to get involved. For example, students are encouraged to create colorful murals and designs for the children's playground in the park. In ecological monitoring, volunteers and students can engage in water quality monitoring and the observation of plants and animals. Meanwhile, students are encouraged to participate in river monitoring activities, regularly observe water quality and aquatic life, and become "river guardians" [12]. Moreover, popular science education is crucial for ideological education. Knowledge can be disseminated through educational paths, science boards, interactive installations, and other means. Involving the community, especially young people, not only strengthens residents' sense of identity and belonging but also subtly raises public awareness of water environmental protection. Through education and community involvement, cultivating the public's awareness of water conservation helps ensure the sustainable use of water resources. Even if water prices rise due to scarcity, the public will use it more responsibly [13].

5. Conclusion

This study examines urban resilience in coastal park design, establishing a comprehensive framework to enhance sustainability, adaptability, and public value. By shifting from a traditional resistance-based method to a dynamic approach that embraces environmental change, it provides

a forward-looking perspective on waterfront development and urban resource management. The analysis underscores that a resilient coastal park is not merely a green space but a complex socio-ecological system capable of self-organization, adaptation, and learning in the face of disturbances, while generating social and economic benefits for the community. The case study of Qingdao's coastal parks highlights the importance of integrating resilience principles into urban planning to address rising environmental pressures and evolving leisure demands. The findings suggest that moving beyond static design to a more integrated and adaptive management approach can optimize public spaces, maximize social and ecological returns, and ensure their long-term viability and value as essential urban assets.

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