Discussion on the Ecological Design Path of Street Corner Park Landscape Based on the Concept of Sponge City

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Abstract. Based on the context of urban ecological restoration and spatial renewal, the sponge city concept has established an ecological technology framework system for the landscape design of the corner park. This study focuses on the design dimension and comprehensively explores the landscape creation path of the corner park under the guidance of the sponge city. By tapping into the technical key of "natural accumulation, infiltration and purification", It is integrated into a design element system with vegetation ecological configuration, rainwater management system integration, and humanized facility design as the core. Based on typical cases at home and abroad, we have summarized key technical methods such as the construction of native plant communities, the application of permeable materials, and the collaborative design of rain gardens and micro-terrain, and verified their practical effectiveness in runoff control, ecological purification and microclimate regulation. The research aims to provide feasible solutions for the ecological design of small-scale public Spaces in high-density cities. Promote the precise implementation of the sponge city concept landscape design.

Keywords: Sponge city; Corner park; Landscape design; Low-impact development; Rainwater management.

1 Introduction

As global climate change exacerbates urban flooding and the heat island effect, sponge cities, as a nature-based solution, adopt a technical system of "infiltration, retention, storage, purification, utilization and drainage" to establish a flexible rainwater and flood management system. Compared with large urban parks, corner parks can be regarded as green paths in the urban fabric, which not only complement the functions of large parks but also meet People's Daily contact with nature to a certain extent [1]. As the kind of micro-green space in the city, the landscape design of corner parks has special value in achieving the goal of sponge cities. The integration of ecological technologies through small-scale Spaces can not only exert the node efficiency of rainwater management, but also improve the level of ecological services in high-density urban areas. The research focuses on the design itself. Explore the key points of the combination of the sponge city concept and the spatial characteristics of the corner park, with the aim of

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creating a landscape design approach that combines ecological benefits and functional use.

China's sponge city construction, driven by policy, has shifted its focus from "scale orientation" to "quality evaluation" (targeting 80% coverage by 2030). The central government has promoted differentiated exploration through 30 national pilot projects, but localized implementation suffers from fragmentation issues. Technological innovation emphasizes system integration and smart solutions, exemplified by Shenzhen's three-dimensional sponge system (wind-powered water circulation with daily rainwater reuse of $665m^3$) and Beijing's IoT-based pipeline monitoring. However, bottlenecks remain prominent, including a 40% reduction in permeable material lifespan due to freeze-thaw cycles and less than 50% peak reduction rate during extreme rainstorms. The performance evaluation forms a dual-track system (monitored areas adopt fuzzy evaluation methods, e.g., Beijing's Xicheng District achieves a 60% compliance rate; non-monitored areas combine remote sensing simulation), but lacks assessment methods for extreme scenarios. In socio-ecological synergy, Chongqing's wetland ponds increased carbon sequestration by 30%, and Shenzhen's projects enhanced community belongingness, yet reliance on PPP funding models and disjoined cross-scale planning (e.g., Shanghai's Suzhou Creek case) hinder sustainability. Moving forward, the focus will center on "Sponge City 3.0," leveraging AI for optimized stormwater management and blockchain for water quality traceability, while exploring carbon emission accounting integration into evaluation systems (e.g., Liu'an's plan) and establishing tropical region technology alliances (modeled after Shenzhen-Singapore cooperation). Yu Kongjian's "Nature-Based Solutions" are expanding from technical to institutional dimensions, driving the globalization of "blue-green infrastructure."

2 The Connection between the Design of Sponge Cities and Corner Parks

2.1 Conceptual Analysis

The Sponge City initiative draws on the Low Impact Development (LID) and green infrastructure in the United States and Canada, the sustainable drainage system (SusDrain) in the United Kingdom and other European countries, and the water-Sensitive Urban Design (WSUD) concept in Australia and New Zealand [2]. Guided by the principle of ecological priority, sponge cities build resilient systems by simulating the natural hydrological cycle. The core technologies are mainly low-impact development (LID) facilities such as permeable pavement, rain gardens, and grass swales. The goal is to control the source and multiple uses of rainwater, according to data surveys. Mature sponge facilities can reduce peak surface runoff by 30%-70%, remove pollutants by more than 50%, and increase carbon sink capacity to 1.5-2.5 tons per year.

The corner park is a small green space located at the intersection of urban roads and the edge of the community. It is designed to break free from the constraints of traditional recreational functions and integrate rainwater management, microclimate regulation and community service functions as a micro-node in the "urban sponge". It is designed with sunken green space, permeable pavement (porosity ≥25%) and rainwater chain system. It can reduce runoff by 65%-80%, purify pollutants by 50%-70%, and reduce surface temperature in summer by 2-4 ° C through the rational configuration of native vegetation.

2.2 Synergistic Design Logic

The combination of sponge cities and corner parks is essentially a synergy of ecological technology and spatial function: by arranging rainwater management facilities in the open space of the corner park, it becomes a processing unit at the front end of the urban stormwater network; The use of ecological landscape design to enhance the quality of the space and achieve the dual goals of "landscape effect of rainwater management facilities and ecological characteristics of landscape space", as evidenced by the practice of Shenzhen Shenwan Street Park, the use of stepped rain garden design can reduce runoff by up to 65%, and the use of seasonal plant design can increase landscape satisfaction to 85%. This synergistic design is proven to be feasible.

3 Sponge-Oriented Corner Park Design Element System

3.1 Ecological Design Strategies for Vegetation Communities

3.1.1 Functional Configuration of Native Plants.
The vegetation design takes native species as the core to form a multi-level ecosystem structure, as evidenced by the case in North China: The tree layer uses deep-rooted Sophora japonica and salix willows, which can help increase rainwater infiltration efficiency by 40%-60%, and each tree can evaporate 200-300 liters of water per day; The shrub layer is equipped with drought-tolerant and flood-tolerant locust trees and tamarisks, whose dense root systems can reduce surface runoff by 30% to 50%. The herbaceous layer was planted with foxtail grass and iris, creating a surface cover layer that could remove 60 percent of suspended solids (SS).

3.1.2 Vegetation Adaptation Design for Functional Zones.
Different vegetation strategies are adopted for different functional zones: The rain garden area combines flood-tolerant calamus, iris and submerged plant Myriophyllum to build a three-stage purification system of "emergent - floating leaf - submerged", which can remove 80% of total phosphorus; In the area of grass swales, anti-erosion herbs such as foxtail grass are selected. With the "grass swales - gravel layer - soil" structure, the runoff flow rate is reduced by 50%-70%, and more than 70% of the suspended matter is filtered out. The leisure area uses high-shade plants such as plane trees and ginkgo trees, along with fragrant plants like mint and lavender, to create a pleasant environment where the perceived temperature drops by 3-5 ° C in summer.

3.1.3 Integrated Design of Landscape Aesthetics and Ecology.

In landscape design, the integration of aesthetics and ecology is an important strategy for improving environmental quality. First, by combining seasonal plants such as forsythia in spring and Huanglu in autumn, the visual layers and seasonal variations of the landscape can be enhanced, giving the park unique beauty in different seasons. Secondly, the three-layered vegetation structure of "tree-shrub-ground cover" not only enriches biodiversity but also provides habitat for a variety of species and enhances the stability of the ecosystem. In addition, integrating regional cultural identifiers, such as planting local plants like bamboo and lotus in the Jiangnan region, can enhance the sense of identity and cultural belonging of the site and avoid the problem of landscape monotypization due to the lack of regional characteristics in ecological design. [3].

3.2 Technical Integration of the Rainwater Management System

3.2.1 System Design for Permeable Pavement.

As an effective means of rainwater management, the system design of permeable pavement is of vital importance. Using resin-bonded gravel with a porosity of 35% to 40% for paving and forming a series pattern with grass swales and seepage Wells to achieve "slow drainage and slow release" of rainwater, this design not only improves the infiltration efficiency of rainwater but also significantly reduces surface runoff. The case of Shenzhen's central park shows that the combination of permeable pavement and sunken green space can increase rainwater permeability to over 90 percent, effectively reducing the risk of urban flooding and improving the quality of surface water.

3.2.2 Synergistic Rain Gardens with Micro-Terrain.

Design stepped rain gardens in combination with the site's micro-terrain, guide rainwater runoff through terrain elevation differences, and lay gravel layers, sand layers and planting soil layers at the bottom to form a natural filtration system . The practice at Bishan Park in Singapore shows that such designs can achieve a total phosphorus removal rate of 75% and a suspended solids removal rate of 69%.

3.2.3 Embedding of Intelligent Monitoring Systems.

Integrate Internet of Things sensors in rainwater management facilities to monitor soil moisture, water quality indicators and water level changes in real time, providing data support for facility operation and maintenance. Through the intelligent monitoring system, precise management of the facilities can be achieved, ensuring the efficient operation of the rainwater management system while providing a scientific basis for the sustainable use of urban water resources.

3.3 Ecological Design of Humanized Facilities

3.3.1 All-Age Spatial Layout.

All-age spatial layout is an important part of environmentally friendly design and an embodiment of the humanization of the sponge city concept. In terms of specific design, the children's activity area can use non-slip and environmentally friendly rubber floor MATS and wooden play facilities, with shade trees planted around it; For the elderly recreation area, a combination of covered seats can be set up, a comfortable environment can be created by planting fragrant plants, and the intervals between various facilities should comply with barrier-free design specifications; The blind path system should be coherent and reasonable, and Braille should be engraved at the human-machine height of the signage.

3.3.2 Application of Sustainable Materials.

Within the framework of efficient material design, local, recyclable, climate-friendly and economical materials should be chosen. The use of efficient materials also promotes the efficient use of energy and water [4]. Prioritize the use of recyclable materials such as recycled wood and eco-friendly concrete, process garden ornaments with local stone to reduce carbon emissions during transportation, and use solar-powered LED lighting systems to meet nighttime activities and reduce energy consumption.

3.3.3 Coordination of Safety and Landscape.

The walkways are paved with anti-slip permeable pavement, and ecological gabion retaining walls are set at the height differences; Low shrubs are planted around the children's area to create a safe boundary with clear visibility, and a clear signage system is set up to balance safety requirements and landscape effects.

4 Design Analysis of Typical Cases

4.1 Renovation of Bishan Hongmao Bridge Park in Singapore

The project transformed a 2.7-kilometer-long concrete drainage channel into a natural river course, with core designs including: optimizing the channel morphology by widening it to 10-30 meters and adjusting the slope to 1:10 to 1:1, thereby increasing rainwater retention capacity for a 10-year rainfall event to 10,000 cubic meters; establishing a 1.2-hectare mangrove wetland to create intertidal ecology, increasing bird species from 32 to 68. Concurrently, a permeable system integration project was implemented, utilizing resin-bonded gravel paving and grass swales to achieve a total phosphorus removal rate of 75%, suspended solids removal rate of 69%, and annual groundwater recharge of 5,000 cubic meters. The microclimate regulation project reduced summer surface temperatures by 3-4°C [5].

The Bishan-Ang Mo Kio Park project in Singapore focused on renovating an aging concrete drainage channel (prone to flooding, ecologically fragmented, and hindering rainwater infiltration) to address riverbank stability during tropical storms, soil pollution remediation, and balancing ecological and community acceptance. A groundbreaking "natural river course transformation" approach was adopted: demolishing the channel and widening it into a 100-meter meandering waterway, employing 11 soil bioengineering techniques for bank stabilization, constructing a three-tiered rainwater purification wetland system, and utilizing recycled waste materials for facilities, combined with smart flood warning and flexible floodplain design. Long-term outcomes were significant: ecologically, species diversity increased by 30% (attracting otters and bird habitats), with a daily water purification capacity of 860,000 liters; socially, annual visitor numbers reached 6 million, enhancing community belonging; flood resilience improved while saving 15% in costs compared to traditional solutions. It has become a global exemplar of blue-green infrastructure and sponge city principles, demonstrating the value of nature-based solutions in urban ecological restoration.

4.2 Design of Shenzhen Shenwan Street Park

Shenzhen Shenwan Neighborhood Park has achieved a significant transformation in the construction of a sponge city. Originally, stormwater runoff in this area was directly discharged into municipal pipelines, leading to frequent waterlogging and poor biodiversity. Now, through the combination of terraced rain gardens and permeable paving, a three-tiered terrace landscape has been constructed, planted with flood-tolerant species such as irises, reducing stormwater runoff by 65% while providing habitats for birds and insects. Permeable concrete and grass pavers enable on-site rainwater infiltration, replenishing groundwater and reducing surface runoff. Wooden pergolas paired with plants like camphor trees enhance aesthetic appeal, significantly improving resident satisfaction and establishing the park as a model for sponge city development.

The project design addresses spatial integration challenges in a 1.16-hectare high-density urban area, tackling issues such as the disconnect between the coastal boulevard and the sea ("near the sea but not close to it") and poor soil permeability. The solution—"three-dimensional sponge system + functional integration"—features a layered stormwater management structure combined with windmill-powered water circulation, achieving daily rainwater reuse of 665m³. Vertical spatial folding connects urban and coastal slow-traffic systems, while the innovative "Sponge Five Senses" framework transforms technology into artistic landscapes. Long-term benefits are substantial: ecologically, runoff control exceeds 95%, non-point source pollution is reduced by 67%, and surface temperatures are lowered by 3-5°C. Socially, the park attracts thousands of daily visitors, resolving spatial imbalance issues. Recognized with national awards, the project embodies the "Ecology as a Service" concept, creating a replicable "Shenzhen Model" that demonstrates the value of technological innovation and human-centered design in reshaping urban public spaces.

5 Integration and Optimization of Design Techniques

5.1 Climate-Adaptive Design Framework

Develop technical adaptation schemes for different climate zones. In temperate regions, the significance of rainwater infiltration and carbon sink functions is highlighted, and communities of Sophora japonica and Sophora japonica are mainly constructed to achieve an annual carbon absorption of 1.8 tons per hectare; In the subtropical regions, emphasis is placed on heavy metal adsorption and cooling, using camphor and vetiver grass to reduce PM2.5 by 15% to 20%. In the cold regions, winter snow retention is further strengthened, with spruce and reed communities achieving a snow retention effect of 50-80 ㎡/ha.

5.2 Benefit Analysis of Technology Integration

Combined with the data from the integrated case, it can be seen that sponge corner parks can achieve multiple benefits. Hydrology-related benefits include reduction of runoff by 65% to 80% and removal of pollutants by 50% to 70%; The second is the ecological formation benefit, with a 133% increase in carbon sink and a 40%-60% increase in species. Finally, there are practical benefits. Due to the improvement of the microclimate in summer, the perceived temperature has decreased by 2-5 ° C, and the frequency of community activities has increased significantly.

6 Conclusions

The study explored the landscape design strategies of corner parks guided by the sponge city concept, demonstrating that the scientific allocation of native vegetation, the technical integration of rainwater management systems, and the collaborative design of humanized facilities can achieve the alignment of ecological functions and use values in small-scale Spaces. The practices of Bishan Park in Singapore and Community parks in Shenzhen show that The integrated design of "ecological technology + landscape aesthetics" can effectively enhance the efficiency of rain and flood management, improve the microclimate and invigorate the community. Future design needs to further increase the application of intelligent technology, optimize the implementation approaches in different climate zones, promote the precise implementation of the sponge city concept in urban renewal, and provide a reference design solution for building a resilient and livable urban ecosystem.

References

1. Nordh, H., & Østby, K. (2013). Pocket parks for people–A study of park design and use. Urban forestry & urban greening, 12(1), 12-17.
2. Li, H., Ding, L., Ren, M., Li, C., & Wang, H. (2017). Sponge city construction in China: A survey of the challenges and opportunities. Water, 9(9), 594.
3. Wang, D. (2021). Seasonal color matching method of ornamental plants in urban landscape construction. Open Geosciences, 13(1), 594-605.
4. Ak, B. (2024). Principles and Applications of Ecological Landscape Design. Türkiye Peyzaj Araştırmaları Dergisi, 7(2), 2013-229.
5. Wang, X., & Li, H. (2024). Enhancing Public Education of Water Resource Conservation Through Urban Landscape: A Case Study of Bishan-Ang Mo Kio Park in Singapore. Communications in Humanities Research, 45, 25-31.