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Comprehensive Case Study on the Ecologically Sustainable Design of Urban Parks Based on the Sponge City Concept in the Yangtze River Delta Region of China

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Abstract: Owing to widespread urbanization, previously elastic and permeable ecological foundations are being continuously hardened, sealed, and channelized, leading to problems such as intensified urban convergence, water pollution, seasonal rain, and flood disasters. Urban parks and large green spaces, as rare large, cavernous bodies in cities, can effectively address the abovementioned urbanization problems. This study holistically analyzed and discussed the current developments in the sponge city concept using several case studies of recent ecologically sustainable designs for urban parks in the Yangtze River Delta region of China. Under basic conditions of the same hydrological characteristics and considering the differences in other external conditions and the environment, sponge city construction aims to address the actual characteristics and needs of specific projects, develop applicable goal-oriented sponge city constructions, and ensure design practices around a goal-oriented method. Practical problems associated with identifying specific design features, priorities, and measures were then identified according to the project location, goals, and characteristics. Thus, this study details various goal-oriented sponge city designs and their application methods to inform future design efforts.

Keywords: sponge city; stormwater management; goal orientation; design practice

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1. Introduction

1.1. Sponge City Concept

In 2014, China's "2014 Work Highlights of the Urban Construction Department of the Ministry of Housing and Urban-Rural Development" clearly stated: "Improve the level of urban drainage and waterlogging prevention, vigorously promote the low-impact development (LID) and construction model, and speed up research on policies and measures for the construction of sponge cities" [1]. Thus, the "sponge city" concept has gained increasing public attention. The term "sponge city" refers to a city with sponge-like characteristics for rainwater. Urban construction based on this concept exhibits elasticity and adsorption functions, thus abandoning the traditional drainage mode of rapid discharge and moving toward the six-pronged strategy of "seepage, stagnation, storage, purification, use, and drainage" for urban rainwater management. The Chinese sponge city concept focuses on urban stormwater management, urban water environment, and water resource utilization to develop urban areas that respond flexibly to environmental changes to avoid natural disasters caused by rainwater [2]. Similarly, several stormwater management philosophies have been developed internationally, including the LID [3] and stormwater control measure (SCM) systems in the United States, sustainable urban drainage systems (SUDSs) in the United Kingdom [4], and the water-sensitive urban design (WSUD) approach in Australia [5]. As relevant research in these countries began in the 1970s, a comprehensive theoretical system has been established after accumulating decades of theoretical and practical evidence. Moreover, several representative design projects have emerged, such as the High Point community in Seattle and the Lynbrook Estate demonstration project in

Melbourne. As the Chinese sponge city theory is lagging in development, a comprehensive analysis of the concepts and practical applications of LID, SCMs, SUDSs, and WSUDs can help promote the theory and practice of Chinese sponge cities [6].

1.2. Development of the Sponge City Concept

Following the release of the national sponge city construction Technical Guide in November 2014, most major cities in China have issued local technical guides, which address region-specific considerations because sponge city construction should consider regional watershed characteristics [7]. For example, the Shanghai Sponge City Construction Technical Guidelines (Trial) were issued in November 2015, the Hangzhou Sponge City Construction Low Impact Development of Rainwater System Technical Guidelines (Trial) were published in May 2016, and the Jiangsu Province Sponge City Special Planning Preparation Guidelines (Trial) were promulgated in August 2016. Subsequently, other regions have published technical specifications and atlases that fit their respective local requirements. Simultaneously, pilot projects demonstrating the construction of sponge city construction were undertaken in batches at both national and local levels, as varied landscape and municipal engineering designs were necessary to effectively incorporate the unique requirements for sponge city design [8]. Indeed, the relevant theories for stormwater management have been improved and optimized via continued theoretical and practical development [9,10]. Moreover, sponge city pilot projects have been implemented via various distinctive technical routes and measures to establish a versatile sponge city construction system by accumulating abundant replicable empirical experience to inform future sponge city construction projects [2,11–13]. Numerous practical problems related to project selection, goal orientation, project timing, labor division and cooperation, red line boundaries, measure applicability, and utilization of an evaluation system in the later stages of design implementation in sponge city construction have also gradually emerged.

1.3. "Failing" Sponge City Construction

Various degrees of urban flooding have occurred in several pilot sponge cities throughout China owing to combined pressure from urban rainstorms and upstream lateral inflow. Thus, it appears unlikely that these sponge city designs have improved stormwater management. This indicates that the pilot work aiming to implement sponge city construction concepts has failed. Theoretically, sponge cities should play a key role in alleviating urban flooding, delaying flood peaks, and reducing flood losses [14]. The reasons underlying these observed "failures" can be summarized by considering two main aspects. First, a sponge city is a systematic and cross-regional project. Although a few micro-scale pilot projects can regulate stormwater at the catchment-zone level, their effects are negligible considering 50- or even 20-year flood periods affecting an entire urban region [15]. Indeed, pilot projects only represent the beginning of sponge city development, and the effects of sponge city design should gradually become evident in the future. The second aspect is the exaggerated role that sponge cities are expected to play in stormwater regulation. There are two primary approaches for resolving stormwater-related problems: The traditional stormwater management system, represented by "stormwater pipe networks," i.e., the "gray" system [2], and the "green" system, which addresses the core concepts of "ecosystems and low impacts," represented by sponge cities [11]. In modern urban development, both gray and green systems play essential roles in regulating urban stormwater [2]. The gray system is more efficient, requires less land, entails lower costs, requires only basic technology, and is easily maintainable. Thus, to some extent, sponge city construction is intended to ecologically supplement conventional stormwater regulation construction [16]. This is especially true for established urban areas where sponge city construction faces site constraints and requires high costs. Therefore, future urban stormwater management systems should be tailored to the characteristics of the targeted urban areas: Established urban areas should improve existing conventional "gray" stormwater systems while effectively integrating these systems with ecologically supplemental "green" stormwater systems

(i.e., sponge city construction). Conversely, urban areas under new development should increase the proportion of sponge city construction to build an organically integrated "gray and green" system at the planning level [17].

Therefore, this study holistically analyzes and discusses the present development status of several case studies representing ecologically sustainable designs for urban parks in the Yangtze River Delta region of China using the basic sponge city principles and construction approaches of "planning guidance, ecological priority, safety first, adapting measures to local conditions, and overall construction." As these case studies are highly representative and typical of many potential sponge city applications, they can inspire other WSUDs and sponge city construction.

2. Methods

2.1. Analysis of the Main Hydrological Characteristics of the Yangtze River Delta Region

2.1.1. Uneven Rainfall

Controlled by the southeast and southwest monsoons, the annual precipitation in the Yangtze River Delta region is 1000–1500 mm, with extreme seasonal fluctuations. Precipitation is primarily concentrated from May–August, when 60–80% of the annual precipitation occurs. These large seasonal variations in rainfall, as well as the uncertainty associated with ongoing climate change, have imposed frequent flash flood risks and increased the flood peak, making this region flood-prone in summer.

2.1.2. High Groundwater Level

The data for November 2021 from the Department of Hydrology of the Ministry of Water Resources show that the average groundwater depth in the Yangtze River Delta plain and in the plains along the east coast of Zhejiang Province is 2.5 and 1.6 m, respectively, indicating that this region has the shallowest average groundwater depth in China. Owing to the high groundwater level and low soil infiltration rate, most rainwater cannot percolate downwards, causing it to flow as runoff.

2.1.3. Low and Flat Terrain with Dense Distribution of Rivers and Lakes

The altitude of the Yangtze River Delta is mostly <10 m above the mean sea level. Furthermore, this region has several lakes and is characterized by the highest river network density in China, with an average channel length of 4.8–6.7 km. This waterlogged, low-lying terrain is a major factor contributing to severe flooding in the region (Table 1).

Table 1. Main hydrological features and strategies in the Yangtze River Delta Region.

Influence Type	Influencing Factor	Key Factor Identification	Sponge City Construction Strategy and Technical Construction Recommendations
Climatic Conditions	Climate type	Subtropical monsoon climate, four distinct seasons, mild and humid climate	The primary goal is stormwater management, with an emphasis on "storage and drainage" Adapt measures to local conditions and consider other sponge city goals of "net and use" Select suitable infiltration construction according to the actual situation Focus on the coupled "gray and green" infrastructure system Adopt ecological sponge construction, such as grass-planting ditches, wet ponds, rain gardens, and ecological floating islands.
	Rainfall	The annual precipitation is 1000–1500 mm, and the precipitation is primarily concentrated in May to August	
Hydrogeology	Topography and drainage	Primarily plain, local hills, numerous lakes, the highest density of river networks in China, low-lying terrain, rich water resources	
	Underground water level and soil	High water table, low soil permeability	
	Water quality	The population density is high, the amount of pollution is large, and the urban water body is more black and smelly	
Others	Natural disasters	High flood risks in summer; relatively few droughts and other geological disasters	

2.2. Analysis Methodology

2.2.1. Multi-Objective Approach to Stormwater Management

Owing to the major hydrological characteristics of the Yangtze River Delta, some researchers consider that the sponge city approach is unsuitable for this region [6]. However, this conclusion is drawn from an insufficient understanding of the diverse goals underlying sponge city initiatives. For example, the protection of water ecosystems, security, environments, resources, and culture are all goals of sponge city construction [18]. When carrying out these projects in the Yangtze River Delta region, the local fundamental hydrological characteristics must first be considered. Therefore, according to the hydrological characteristics of the Yangtze River Delta region, stormwater management and water security should be among the core goals of any sponge city project. The key to solving the stormwater problem lies in the "container" used to retain water. Indeed, because an urban area itself can be considered a large water container, the form of water can be changed by designing proper water containers within [19]. Multiple factors, such as hardening of the underlying surface of the urban water container, channelization of rivers, fragmentation of water bodies, and destruction of vegetation, can lead to the hardening and confinement of the original open container governing the ecological texture, elasticity, infiltration, and filtering functions. Urbanization destroys the ecological balance of the original container structure, with river channels being constantly compressed and confined even though the water intake remains unchanged; this mismatch is a major cause of accelerated confluence and stormwater disasters [20]. Furthermore, in established urban areas with existing gray infrastructure, improving the regional gray system and using new green systems as ecological supplements for effectively managing stormwater is more practical and cost-effective [17,21]. Identifying the real problems and difficulties associated with specific projects and clarifying these core issues are necessary to determine suitable goals, and thus develop applicable sponge city construction methods and nuanced solutions [9]. Although the Yangtze River Delta should clearly consider rainwater and flood management as well as water security as the core design goals, reasonable consideration should be given to other potential goals of sponge city construction, such as rainwater recycling, water purification, and wetland habitat restoration.

2.2.2. Data Acquisition and Analysis

After determining the stormwater management objectives, the local storm intensity formula, rainfall data, and other relevant hydrological parameters should be collected to estimate the total amount of stormwater management construction required for regulation and storage. The sum of designed regulation and storage volumes of all LID construction in the plot is taken as the total storage volume. After determining the total volume of flood management construction, the type and scale of the sponge construction can be appropriately determined to plan the overall construction layout. Owing to recent technological developments, quantitative analysis is commonly applied in green urban design to provide a scientific and rational analytical basis for supporting design decisions. The application of digital technology methods such as GIS, DEM, urban physical environment simulations, and water environment simulations such as the SWMM, can provide designers with improved quantitative analysis and decision-making references based on powerful data analysis and simulation capabilities.

2.2.3. Organically Combined "Gray–Green" System

As noted previously, the "gray" traditional rain and flood system [17] and the "green" low-impact, ecologically integrated system (e.g., sponge city construction) [21] are the two main approaches to managing rain and floods in urban environments. In modern urban construction, both gray and green systems play critical roles in regulating urban rainwater. Owing to rapid urbanization in the Yangtze River Delta region, numerous projects involve the renovation of old urban areas. In old cities, considering that their gray system is a fait accompli, the regional gray system could be improved to enhance the overall rainwater

management system. The green system can be used as a beneficial ecological complement in synergy with the gray system. Considering the land costs associated with renovating old cities, the gray system has the advantages of relatively high efficiency, a small footprint, low relative cost, and ease of maintenance. Development of urban regions also includes yet-to-be-developed open areas. Therefore, this space is available to construct "green" stormwater construction; thus, sponge city development can (and should) be synchronized with the planning of new city construction [22]. Suitable hydrological models can be used to simulate the influence of urban development plans on the hydrological characteristics of a given region while prioritizing urban stormwater management and ecosystem health [23]. The demand for stormwater management construction can be quantitatively determined to increase the proportion of green construction in the stormwater system and mitigate the adverse ecological impact of urban development using natural and sustainable measures [24].

2.2.4. Habitat and Biodiversity

Micro fields, water collection, water delivery, and water catchment landscapes do not support sponge city construction owing to their individual functions. Commonly used sponge city measures, such as grass-planting ditches, sunken green spaces, dry streams, and wetlands, constitute a closely linked system [25,26]. The system habitat and biodiversity must be considered to ensure the sustainable operation of a sponge city, such as increasing surface roughness, selecting surface materials to reduce flow rates, adjusting the soil permeability coefficient, and selecting effective vegetation [19]. A good habitat can enhance the self-purification ability of water, promote plant growth and biodiversity, and lay the foundation for sponge city construction and sustainable urban development. Simultaneously, designing habitats and promoting biodiversity according to local conditions can enable the landscape to maintain ecological SCMs [25,26]. Integrating stormwater measures and the urban landscape improves the implementability and popularization of stormwater management measures in urban spaces and helps couple and link the urban green and gray stormwater management construction [7]. This is of great value for efforts to construct urban ecological environments, prevent and manage disasters, and balance water supply and demand.

2.2.5. Sponge Construction Selection and Landscaping Treatment

While meeting the established functions of sponge cities such as stormwater management, factors such as ecological sustainability, low cost, and easy maintenance of sponge construction should be considered as much as possible. For example, if space conditions permit, grass-planting ditches, wet ponds, and ecological floating islands should be prioritized. sponge city construction should also be organically combined with the landscape design to create a pleasant landscape pattern according to local conditions. Doing this will provide an environmental foundation for creating various recreational spaces and ecological environments, such as landscaped rain gardens, unique dry creeks, and ornamental planting areas.

3. Results and Discussion

In this study, the external conditions of six sponge city pilot projects (Figure 1), namely the urban location, urban structure, current situation of water resources, flood distribution during flood season, infrastructure status, water pollution, and other target environmental differences, were analyzed. It is important to recognize the locale-specific problems that affect each project, clarify the core issues, and determine appropriate goals to ensure the effective development of ecologically sustainable designs for urban parks in the Yangtze River Delta region of China.



Figure 1. (**a**) Project location in the Yangtze River Delta region. (**b**) Geographical location of the Yangtze River Delta region in China.

3.1. Huzhou Olympic Park

The Huzhou Olympic Park (Figure 2) is located in Huzhou City, Zhejiang Province. When the landscape of Huzhou Olympic Park was designed, the surrounding roads and drainage systems were already present. This development sequence, wherein municipal construction is constructed first followed by the introduction of green spaces, has been followed in most established urban areas and has been a typical mode in Chinese traditional design prior to 2015. In this case, traditional urban construction followed a problematic order of development and involved completely independent design boundaries and management systems for parks and green areas compared to those for the surrounding roads and other municipal construction. By cutting across boundaries and professional barriers, green space design should not only address the local sponge city planning indicators but also examine the surrounding area and its rainwater levels and redefine the site catchment boundary via surveys and calculations [27]. Thus, in the design of Huzhou Olympic Park, the surface runoff from surrounding existing municipal roads is channeled into the green spaces of the park, which then overflows into a retention pond through a sedimentation pond before finally merging with the main water body. The design guidelines typically state "local absorption and utilization of 70–80% of rainwater" as the target. However, the basis for this utilization rate (70%) is not clearly stated. Evidently, the green space of parks should absorb rainfall and manage runoff from the hard surfaces of surrounding urban areas. The specific approaches and quantity of absorption largely depend on the boundaries of the target site and the delineation of the associated catchment zone.

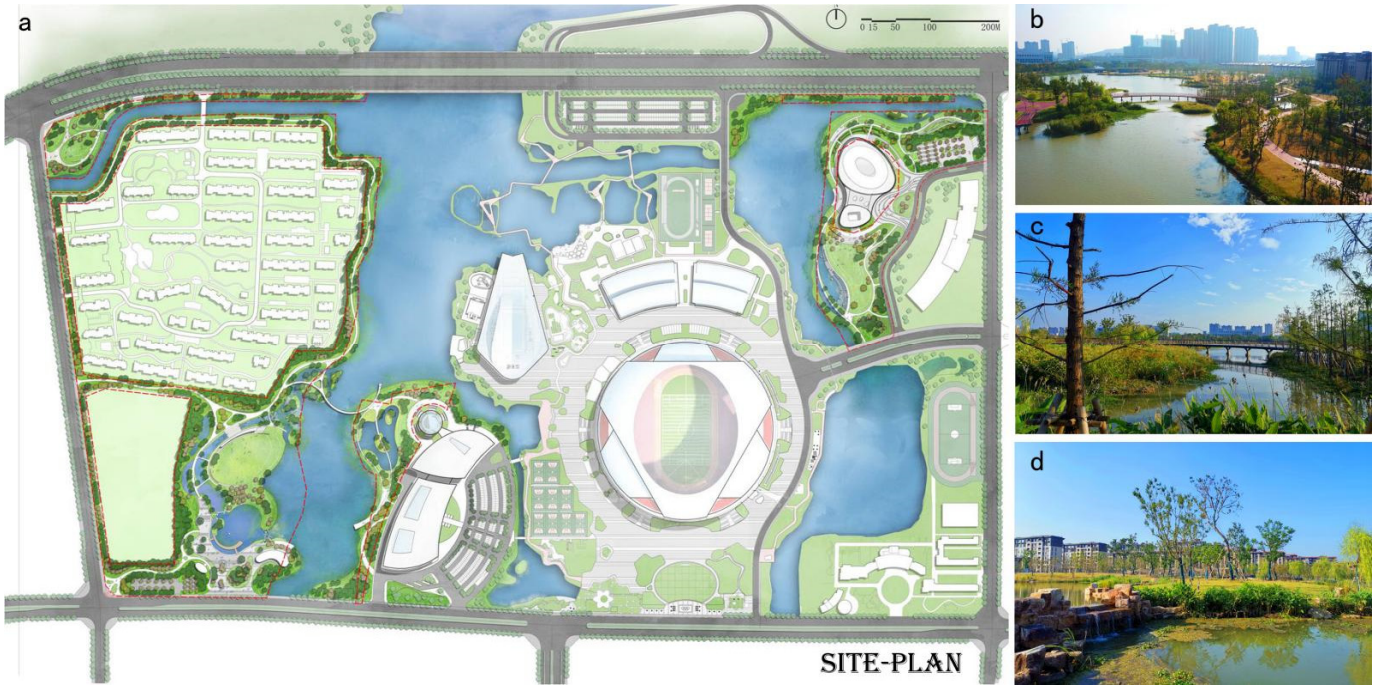

Figure 2. (**a**) Master plan and (**b**–**d**) photographs of Huzhou Olympic Park.

3.2. Siyang, Changdong District, Huzhou

Compared with the sponge city construction in the old urban areas, the new city area included undeveloped land, which allows more space for developing "green" stormwater construction. A sponge city was synchronized with the planning of the new city and a relevant hydrological model was used to simulate the impact of urban development on regional hydrology, urban stormwater, and ecosystems before and after urban planning. The total demand for stormwater construction was quantitatively analyzed, the proportion of green systems in the stormwater system was maximized, and the most natural and sustainable method was adopted to alleviate the non-ecological impacts of urban development. The landscape planning of Siyang in the Changdong area of Huzhou (Figure 3), with a total area of approximately 140 hectares, is a relatively large design case on the microscopic scale. The design has considered different levels of flood control requirements and strengthened the regulation and storage functions of regional rainwater storage by connecting the existing water systems in the area, earthwork allocation, and treatment of vertical space. While meeting the requirements of flood control, it has broken existing canalized embankments and reconstructed a natural water bank with self-purification ability. The project attempted to maximize the utilization of natural methods to weaken the impact of urban development on the site's ecosystem. Notably, future urban development should fully consider the characteristics of urban agglomeration, and the role of sponge systems in urban stormwater regulation should not be amplified infinitely even in newly built urban areas. A coordinated gray–green system is critical for supporting urban rainwater control and the total amount of stormwater construction should be appropriately increased when evaluating the uncertainties associated with urban planning.



Figure 3. Master plan of Siyang, Changdong District.

3.3. Yongkang Three Rivers and Six Banks Park

The Three Rivers and Six Banks project (Figure 4) is located in Yongkang City, Zhejiang Province. As the river runs through the whole city and serves as its main rain and flood channel, early urban planning led to river channelization, continuous compression of the flood discharge section, and prolonging of seasonal flood disasters. Therefore, the core objective of this project was "rainwater and flood regulation and storage," including the establishment of a safe drainage guarantee mechanism, reducing rainstorm runoff, and increasing the capacity of water system regulation, storage, and rainwater discharge. While considering the function of "rain and flood regulation," developed schemes should address the use function of the park to the greatest extent. These designs particularly focus on the core issues of sites, avoiding "big and comprehensive" design ideas and simplifying complexity to strengthen project executability. The main design techniques used in such parks include appropriately extending the flooding section; softening flood control levees by using "hidden" and "receding" levees to control different flood levels; organically integrating flood control functions into the landscape; connecting the water systems and expanding local sites to form a "lake" surface thereby strengthening the regional stormwater storage capacity; effectively coordinating the drainage systems of municipal roads and parks to ensure appropriate intake and discharge of seasonal floods; and selecting suitable and easy-to-maintain sponge city construction. Considering the flood control requirements at different levels, such designs strengthen the rainwater regulation and flood storage function of an area by connecting the existing water system with earthwork allocation and

vertical space treatment. The intended purpose of such designs is to break the existing river channel and riverbank and restore their self-cleaning capacity.

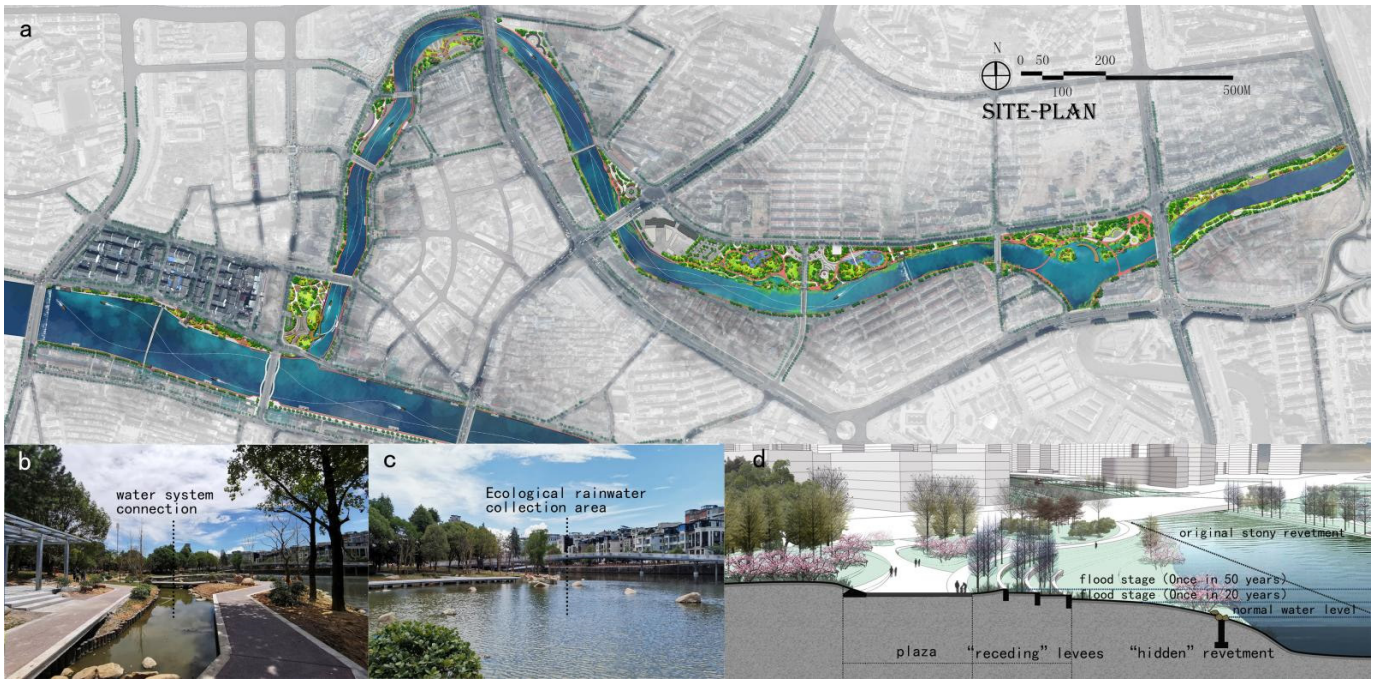

Figure 4. (**a**) Master plan and (**b**,**c**) scene photographs of the Three Rivers and Six Banks Park in Yongkang City. (**d**) Cross sections.

3.4. Yongkang Tower Hill Park

Across the Yangtze River Delta region, site-specific problems should be analyzed while considering the core goal of stormwater regulation. The plan for the Yongkang Tower Hill Park design project (Figure 5) considered the present landscape pattern of the site. Yongkang Tower Hill Park is located in Yongkang City, Zhejiang Province. The project base has a good landscape pattern. However, because of the high terrain of the site and the extended dry period of the Yangguan Reservoir, the landscape has negatively influenced the site. Therefore, the core goal of this sponge city project was to maximize water retention for stormwater utilization and water purification. Thus, the plan has adopted appropriate filling and excavation technologies to balance the earth on site and improve the rain-collection capacity of the terrain. When the small catchment unit reaches the maximum storage capacity, the water is transported to the next catchment unit with greater storage capacity through the water conveyance landscape. To fully utilize the functions of rainwater collection and purification at the source and reduce rainwater runoff and pollutant accumulation downstream, pre-treatment should be carried out before rainwater enters the main water body, and waste flow, sedimentation, and filtration construction should be established to ensure that only treated rainwater enters the Yangguan Reservoir. A small portion of rainwater from the mountain can penetrate and conserve the groundwater via the sponge design, with most of the non-infiltrated rainwater flowing as natural runoff. Using green rainwater construction, such as dry creek landscapes, grassed ditches, and ecological retention ponds, rainwater runoff is introduced to the Yangguan Reservoir to the greatest extent possible. Moreover, the plan has also considered the diversion of water from Yongkang River to replenish and exchange the water in Yangguan Reservoir. The water diversion first enters the forebay of the reservoir and then enters the main water body of the reservoir after multistage sedimentation. Excessive rainwater can be discharged outward via an overflow pipe network and pumping stations to return it to Yongkang River, thereby forming a dynamic water cycle model primarily regulated by natural systems with supplementary human-made water conservation construction.



Figure 5. (**a**) Master plan and (**b**–**e**) scene photographs of Tower Hill Park in Yongkang City.

3.5. Taicang Qiputang Ecological Park

The Qiputang Ecological Park project in Taicang (Figure 6) is located at the confluence of the Qiputang and Yangtze rivers. Considering the wild characteristics of the site, the project sought to preserve existing site characteristics, and the sponge city construction goals were defined as stormwater regulation and storage in addition to ecological conservation. The water systems were connected via local topographic modifications. Proper filling and excavation techniques were used to ensure in situ balancing of earthwork and vertical space creation for rain-collection sites. A design approach requiring minimal intervention with low-cost, low-technology, and low-maintenance sponge construction was applied. For example, the project employed low-cost natural revetments, gravel pavements, rain gardens, and wild vegetation communities prone to natural succession to limit the construction of costly permeable and stone pavements. This approach created diverse biological habitats, providing an ecological foundation for long-term development goals to be determined at a later date. In addition to the abovementioned goals for the Qiputang Ecological Park, multiple core goals corresponding to the specific characteristics of different projects and external conditions, including groundwater level restoration, microclimate regulation, water cultural services, and water cultural heritage protection, can be considered in the future; the site-specific parameters were thus developed accordingly.



Figure 6. (**a**) Master plan and (**b**–**d**) scene photographs of Qiputang Ecological Park in Taicang.

This design focused on habitat and water purification while considering the scale, water capacity, flow rate, and water purification capacity of the wetland park. The water retention time of wetlands can be increased, and the ecological treatment capacity of wetlands can be improved via various waterfront spatial organization measures such as constructed wetlands, underwater forests, ecological berms, ecological green islands, green trenches, and permeable pavements. Placing aeration devices at the edges and corners, where the water body is vulnerable to pollution and eutrophication, can help maintain the dynamic characteristics of the water body and enhance the self-purification capacity of the entire water system. Notably, because of a hydraulic load of subsurface flow wetland, the difficulty of bed filling, and later maintenance, the cost is relatively high, and considering the large area of the project, the scheme discussed here abandons the expensive and intensively maintained subsurface flow wetland design and focuses on more natural, ecological, and horizontal flow wetlands.

3.6. Suzhou Baiyang Lake Wetland Park Project

The Wusong River Sewage Treatment Plant lies on the east side of the Suzhou Baiyang Lake Wetland Park Project site (Figure 7). This project focuses on wetland restoration and water purification. The plan has considered the scale of the wetland park, water body capacity, flow rate, and the corresponding relationship between water purification capabilities, and it diverts and purifies part of the water discharge from the sewage treatment plant. The design has utilized water environment and hydrodynamic simulation software to quantitatively simulate and analyze lake hydrodynamics, flow velocity and direction, and the spatial distribution of pollutants, among other factors. Through the diverse organizations of waterfronts, artificial wetlands, underwater forests, ecological revetments, ecological green islands, and floating islands, the water retention time and ecological treatment capacity of these wetlands have been improved. Aeration devices arranged in corner spaces, focusing on areas prone to pollution and eutrophication, help maintain the dynamic characteristics of the water body and strengthen the self-purification ability of the entire water system. The project has abandoned the high-cost and high-maintenance subsurface flow wetland scheme and focused on more natural and ecological, multi-level horizontal flow wetlands.

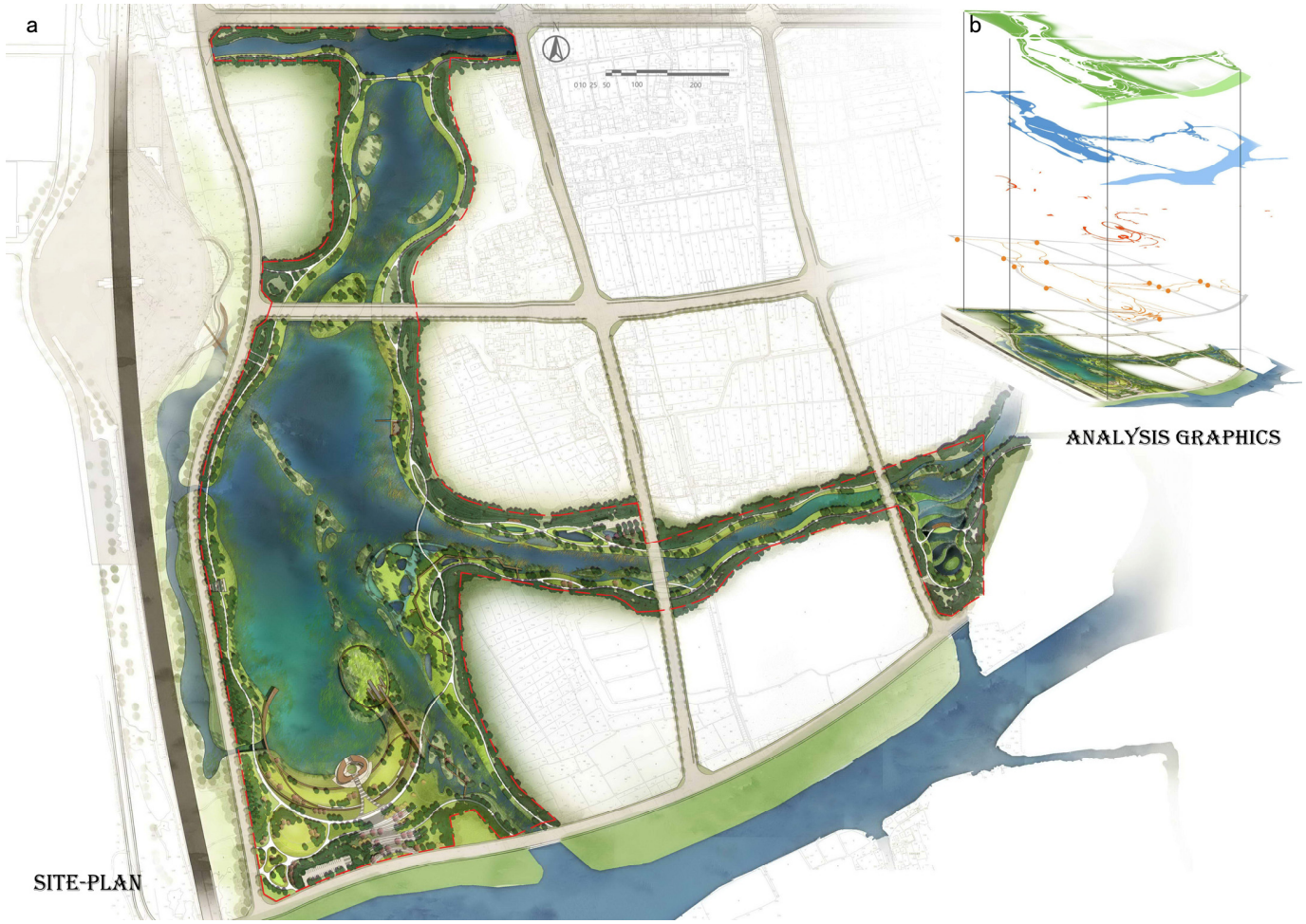

Figure 7. (**a**) Master plan and (**b**) analysis scheme of Suzhou Baiyang Lake Wetland Park Project.

Six design cases of sponge cities located in the Yangtze River Delta region were analyzed in detail. Although they are all based on similar hydrological conditions, each project has formulated more applicable goal planning, goal priorities, design, and practice methods based on its own actual characteristics and needs and has thus obtained different practical results that are more in line with its actual needs. Huzhou Olympic Park focuses on the combination of a sponge city and the "transformation of a traditional old city." Yongkang Sanjiang Liu'an Park Project is the main rainwater and flood channel in the city. However, the current river is channelized, the flood section is constantly compressed by the city, and the seasonal flood disaster is serious. Therefore, the project is more concerned with "rainwater and flood regulation and storage". The main contradiction of Yongkang Tashan Park is that the main water body, Yangguan Reservoir, has a long dry season and a poor landscape effect. Therefore, its core goal is "rainwater reuse and rainwater recycling." Owing to the relatively remote location of Taicang Qiputang Ecological Park and its nature, the project aims to primarily choose sponge city design methods and measures with "low cost, low technology, and low maintenance." The main problem of the Suzhou Baiyang Lake Wetland Park Project is the reclaimed water treatment of the Wusong River Sewage Treatment Plant; therefore, the plan takes "habitat restoration and water purification" as the main entry point. As this project is located in a new urban area, it is virgin land yet to be developed. Thus, compared with an old urban area, more space is available in new urban areas for modification. The design proposal for this project is to better coordinate the relationship between the "gray and green" system and maximize the proportion of the

"green" system in the rain and flood management system under the premise of permissible conditions.

4. Conclusions

The sponge city concept represents a sustainable urban construction model that emphasizes stormwater management. Sponge cities should be constructed on an ecological and sustainable foundation. This study expounds on the sponge city concept, discusses the current state of related development, evaluates the "failures" of Chinese sponge cities at this stage, and emphasizes the iterative characteristics of the theories and practices underlying sponge city projects. In conjunction with analyzing the main hydrological characteristics of the Yangtze River Delta, this study discusses the sponge city design method based on similar hydrological characteristics. Finally, combined with the practical experience of six projects and sponge cities, the construction of sponge cities by considering locale-specific characteristics is discussed to ensure the most appropriate design by taking the design and practice of some park sponge cities in the Yangtze River Delta as examples. Overall, this study provides a reference for the construction of sponge cities in other regions with similar hydrological characteristics. However, owing to practical limitations, we primarily studied the objectives and practical measures of sponge city projects in specific areas, primarily large parks and green spaces. Subsequent relevant studies are expected to further expand the research directions in the context of city squares and roof buildings, among others.

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