water

MDPI

Review

Exploring Herbaceous Plant Biodiversity Design in Chinese Rain Gardens: A Literature Review

Lin Shi [1,2], Sreetheran Maruthaveeran [1,*], Mohd Johari Mohd Yusof [1], Jing Zhao [1] and Ruosha Liu [3,*]

1 Department of Landscape Architecture, Faculty of Design & Architecture, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia
2 Department of Landscape, University of Sheffield, Sheffield S10 2TN, UK
3 School of Architecture & Art, Shijiazhuang Tiedao University, Shijiazhuang 050043, China
* Correspondence: sreetheran@upm.edu.my (S.M.); rsliu_stdu@163.com (R.L.); Tel.: +60-12-3310942 (S.M.)

Abstract: Amidst rapid urbanization and escalating environmental degradation in China's urban areas due to climate change, traditional drainage systems struggle to cope with rainfall, resulting in frequent flood disasters. In response, rain gardens have emerged as ecologically practical stormwater management solutions that integrate urban flood control with landscape design. Leveraging the dual benefits of rainwater purification and aesthetic enhancement provided by vegetation, herbaceous plant-based rain gardens have assumed a pivotal role in green infrastructure. However, dedicated research on the application of herbaceous plants in rain garden design is limited, especially within China's water-stressed context. This study employs a literature review and case analysis to explore this critical issue. Initially, it delineates the concept of the sponge city introduced by the Chinese government. Subsequently, it reviews concepts and methods of plant biodiversity design in urban settings and rain gardens and elucidates the structure and function of rain gardens. Four Chinese rain gardens in different urban environments (old industrial areas, university campuses, urban villages, and urban highway green belts) were selected to examine the selection and arrangement of herbaceous plants while identifying deficiencies in their designs. Finally, feasibility suggestions are provided for the design of herbaceous plant diversity in Chinese rain gardens. This study's findings can provide a reference for the planting design of herbaceous plants in rain gardens for other countries and regions with similar climates and environmental conditions.

Keywords: rain garden; green infrastructure; herbaceous plant; biodiversity; planting design

Citation: Shi, L.; Maruthaveeran, S.; Yusof, M.J.M.; Zhao, J.; Liu, R. Exploring Herbaceous Plant Biodiversity Design in Chinese Rain Gardens: A Literature Review. *Water* **2024**, *16*, 1586. https://doi.org/10.3390/w16111586

Academic Editor: Enedir Ghisi

Received: 3 April 2024
Revised: 20 May 2024
Accepted: 29 May 2024
Published: 31 May 2024

1. Introduction

In contemporary society, rapid advancements in science and technology have led to the exploitation and degradation of the natural environment. This has resulted in water pollution, habitat fragmentation, biodiversity loss, and ecosystem degradation [1,2]. Urbanization has further exacerbated these issues, with urban populations expanding rapidly, leading to sprawling urban land, increased impervious surfaces, and diminished green spaces [3]. Human activities are placing excessive strain on nature, leading to adverse consequences such as global warming and more frequent extreme weather events like floods and droughts [2,4,5]. These challenges pose significant threats to the sustainability of cities. Moreover, conventional urban stormwater management approaches are proving inadequate in coping with the escalating volume of urban runoff and related pollution [6], often failing to recognize stormwater as a valuable resource [7]. Consequently, the urban system has grown increasingly vulnerable. In recent years, urban flooding has become a recurrent occurrence across China, making urban residents despairingly jest about "watching the sea in the city".

Rain gardens are vegetated depressional areas designed to collect, absorb, and infiltrate runoff from impervious surfaces such as rooftops and driveways [8,9]. As ecologically sustainable stormwater control and utilization facilities, rain gardens play a crucial role in effectively infiltrating rainwater and intercepting water pollution sources while also optimizing the utilization of rainwater to conserve water resources and supplement groundwater reservoirs [2,8,10]. Incorporating vegetation, a key component of rain gardens, facilitates transpiration, thereby regulating air humidity and temperature, enhancing the microclimate environment [8], and fostering suitable habitats for local wildlife [2], thereby significantly contributing to biodiversity enhancement [11,12]. Rain gardens are increasingly utilized across various landscapes, encompassing residential zones, road networks, and commercial districts. These innovative features seamlessly integrate natural ecosystems into urban settings, effectively managing stormwater while also providing ecological and aesthetic benefits [13].

The introduction of plant diversity is crucial for the construction of urban ecosystems, offering habitats conducive to diverse organisms' survival and thriving [2]. Despite China's rich plant resources, the prevalent use of a limited range of landscape plant species in urban areas suggests a need for more extensive research and application of diverse species, as seen in the UK and the United States [14]. Enhancing urban plant diversity by incorporating various herbaceous plants can be a compensatory measure in this situation. Utilizing herbaceous plants in rain garden design may foster a vibrant and vertically greened landscape, capitalizing on the diversity of plant species and maximizing their aesthetic value [15]. This approach aids in cost-saving for urban greening initiatives and enhances ecological functions, such as microclimate regulation, urban biodiversity enrichment, and the improvement of urban society's quality of life [2,16–18]. Additionally, herbaceous plants can provide seasonal interest and aesthetic diversity, making rain gardens attractive features in urban settings [2]. Hence, maximizing the use of existing herbaceous plant resources while integrating ecological principles to achieve a low-input, dynamic, diversified, colorful, and ecologically sound urban landscape is crucial for creating vibrant and sustainable urban landscapes.

While rain gardens are not yet commonplace in many Chinese cities, the concept aligns with the Chinese government's broader "sponge city" initiative to improve urban resilience to flooding and enhance environmental sustainability [2,8,10,12]. The sponge city concept, introduced to address urban water issues, advocates using green infrastructure to manage stormwater, mitigate floods, and improve water quality [19–21]. As a critical element of sponge cities, rain gardens represent an innovative solution that can help transform urban water management practices in China. Given the escalating environmental challenges and frequent urban flooding events, there is a pressing need to explore and implement effective stormwater management solutions. Therefore, studying the application and benefits of rain gardens in China is timely and critical for informing future urban planning and development strategies.

This study adopts an integrated approach, combining landscape and ecological perspectives to investigate the selection and arrangement of herbaceous plants in urban rain gardens. The study aims to achieve the following three specific objectives:

(1) Conducting a comprehensive examination of herbaceous species selection in rain gardens across diverse environmental conditions. Emphasis will be placed on meeting local requirements while minimizing maintenance costs, ensuring sustainability, maximizing taxonomic diversity, showcasing seasonal variations, and supporting wildlife.

(2) Optimizing the configuration of herbaceous plants in urban rain gardens to fulfill multiple functional requirements, including flood prevention, aesthetic enhancement, facilitation of ecologically sustainable urban development, and improving urban residents' quality of life.

(3) Identifying shortcomings in the current arrangement of herbaceous plants in Chinese urban rain gardens. This analysis will provide a robust theoretical foundation for future rain garden design in regions with similar climates and environmental conditions.

By addressing these objectives, the study aims to contribute to the development of effective strategies for herbaceous plant selection and design in urban rain gardens, both in China and beyond. The findings from this study will provide valuable insights for urban planners, landscape architects, and environmental scientists working to enhance urban resilience and ecological sustainability.

2. Methods

2.1. Research Structure

This study is motivated by the challenges of stormwater management in China, which have prompted the introduction of the "Sponge City" strategy to respond to urban stormwater issues. Within this strategy, rain gardens represent a significant form of green infrastructure. Herbaceous plants, due to their numerous advantages, are frequently utilized in planting rain gardens and have seen widespread application in landscape design in Western countries. Next, this research provides an overview of rain gardens and the selection and design of herbaceous plants in rain gardens. Four case studies are examined in detail: The Rain Garden at Beijing's 768 Creative Park, the Yuyun Rain Garden at Huazhong University of Science and Technology, the Gongkang Rain Garden in Shanghai, and the Rain Garden along Qinhuang Avenue. These case studies analyze the practical application and effectiveness of herbaceous plants in rain gardens across different Chinese cities. The strengths and weaknesses of herbaceous plant design in Chinese rain gardens are summarized and evaluated. Finally, based on the findings from the literature review and case studies, this study offers insights and recommendations for the planting design of rain gardens in China, aiming to optimize their ecological benefits and landscape performance. The research structure of this study is shown in Figure 1.

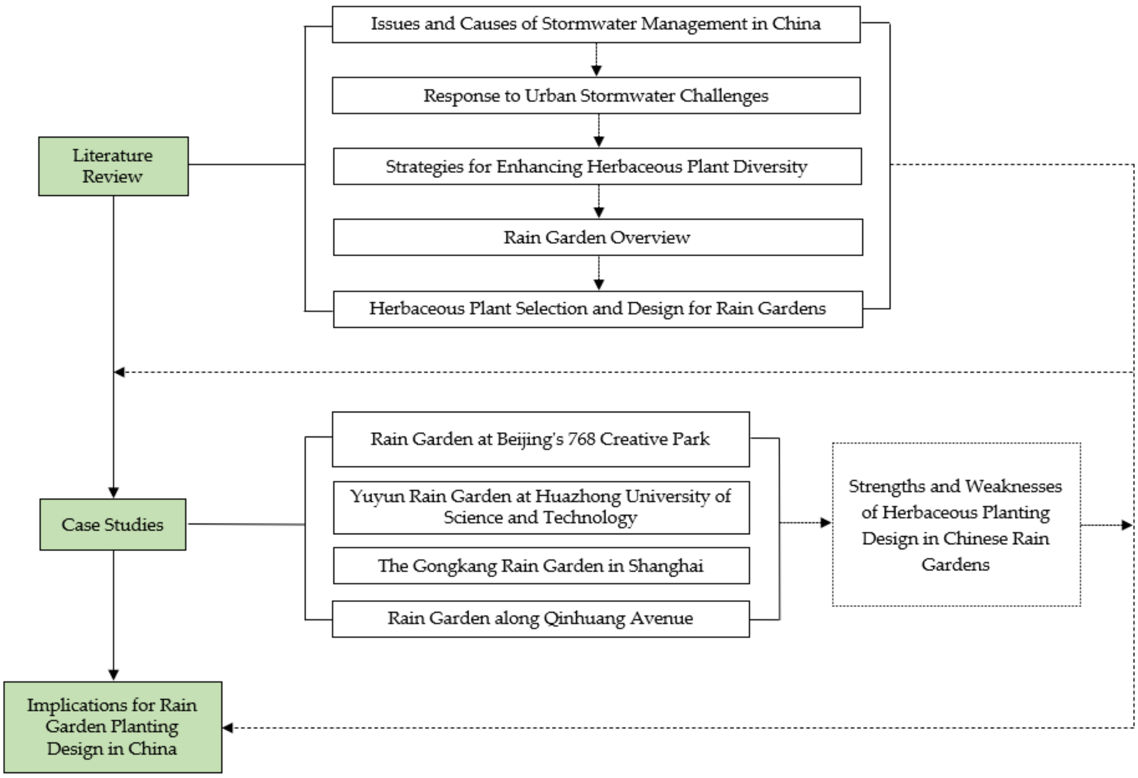


Figure 1. Research Structure of this study.

2.2. Literature Review

This study establishes the scope of research in the field of "herbaceous plant diversity in rain gardens" by searching, selecting, and analyzing the relevant literature. Additionally, it focuses on the literature addressing the issues and causes of stormwater management in China, responses to urban stormwater challenges, and strategies for enhancing herbaceous plant diversity, thus introducing the topics of rain gardens and herbaceous plant selection and design for rain gardens.

A systematic search of the literature on herbaceous plant diversity in rain gardens in the context of China published over the past 20 years (January 2003 to December 2023) was conducted. Four electronic databases, including Scopus, Web of Science, Science Direct, and CNKI, were selected as the primary search sources, with cross-validation performed using Google Scholar. Based on the research theme, keywords such as "rain garden", "sponge city", "green infrastructure", "herbaceous plants", "plant diversity", and "planting design" were combined to retrieve the relevant literature through searching titles, keywords, and abstracts. Two doctoral students independently conducted the searches, and the results were compared to ensure the impartiality of the retrieval process.

Regarding literature screening, selection followed the PRISMA process (Figure 2) to enhance the quality of literature retrieval and ensure the traceability and reproducibility of the screening process. Exclusion criteria included the following: (1) duplicates; (2) non-English or non-Chinese articles; (3) the literature irrelevant to the topic; (4) the literature not published in peer-reviewed journals; and (5) inaccessible full texts. A total of 602 English and Chinese literature items were retrieved. After screening and eliminating the literature that did not meet the criteria, the reference lists of the remaining literature were cross-checked to supplement any potentially overlooked essential studies. Ultimately, 24 literature items meeting the criteria were obtained.

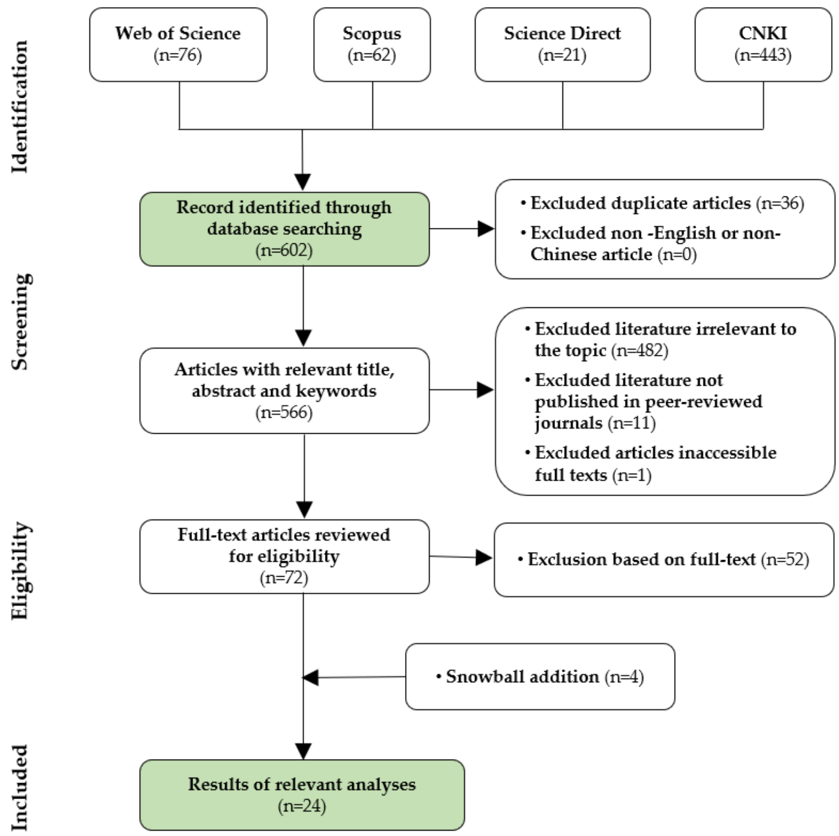


Figure 2. Selection procedure of the articles.

2.3. Case Study Analysis

Focusing on urban rainwater challenges arising from urbanization and climate change, as well as the vital role of vegetation in rain gardens for ecosystem services provision, this section initiates by collating primary research documents concerning urban rain garden design and plant diversity from electronic library journals and online resources. Subsequently, the scope was expanded by including cutting-edge research materials sourced from magazines, scientific research institutions, design firms, academic conferences, and online platforms. These visual examples supplement the peer-reviewed literature by offering insights into current practices and trends in the field. Ultimately, four cases were selected on the design of herbaceous plants within rain gardens in the Chinese context. These cases illustrate herbaceous plants' selection and planting layout in Chinese rain gardens. By comparing successful application experiences of herbaceous plants in rain gardens, particularly concerning rainwater treatment, pollution control, and ecological benefits, this section endeavors to identify extant challenges and proffer practical recommendations.

3. Results and Discussion

3.1. Literature Review

This section will review the literature concerning the challenges and underlying causes of stormwater issues in China. Climate change and rapid urbanization have precipitated what has often been termed the 'urban disease'. Drawing insights from the rainwater management strategies employed in European and American contexts, China has introduced the concept of the sponge city tailored to its unique characteristics, thereby promoting green infrastructure initiatives nationwide. This review will delve into the specifics of urban herbaceous plant diversity, elucidating fundamental concepts and methodologies. It will provide a comprehensive overview of rain gardens, including their conceptual framework and practical applications, as well as the pivotal role vegetation plays within them. Additionally, the section will delve into the selection and arrangement of herbaceous plants in rain garden designs.

3.1.1. Issues and Causes of Stormwater Management in China

Previous studies have shown that building coverage ratio, building congestion level, building density, impervious surface ratio, green space ratio, and population density are the most critical factors contributing to urban waterlogging [22]. Leopold pointed out that the extensive use of impermeable materials across urban areas reduces opportunities for stormwater runoff infiltration and diminishes soil water absorption capacity [23]. This phenomenon not only contributes to the urban heat island effect but also leads to an increase in rainfall in recent years [24,25]. Consequently, drainage infrastructure often becomes overwhelmed, resulting in urban water logging incidents [26]. Rapid urbanization exacerbates the degradation of urban land hydrology. Figure 3 conceptually illustrates the hydrological patterns before and after urban land development. Post-development runoff volume and peak flow are more significant, with shorter peak duration [27]. Meanwhile, stormwater runoff carries a large number of pollutants into rivers or directly infiltrates into the ground, exacerbating river and groundwater pollution as well as the decline in aquatic biodiversity [11,28–30]. Additionally, the rapid expansion of industry in China has led to the widespread over-exploitation of groundwater, resulting in a continuous decline in groundwater levels and severe depletion of water resources [31]. Reports indicate that over 400 cities in China are grappling with water scarcity issues, with 110 cities facing severe water shortages [32].

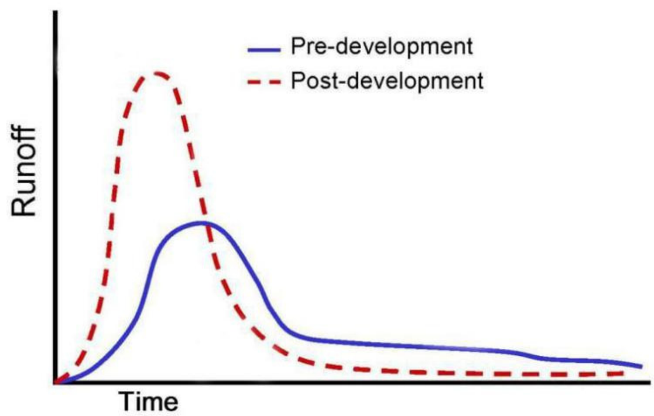


Figure 3. Typical stormwater runoff hydrograph pre- and post-development.

Furthermore, Yuan stated that climate change exacerbates the frequency of floods, presenting a significant environmental challenge dominated by global warming [2]. Many environmental issues we currently confront, including water scarcity, flooding, sea-level rise, loss of biodiversity, and declining air quality, are interconnected with climate change [33–35]. According to the IPCC report, the global average surface temperature increased by 0.6 °C during the twentieth century [36]. The temperature surge exacerbates tropical cyclones, heightening the occurrence and intensity of extreme weather phenomena, thus escalating flood hazard exposure [37]. Studies suggest a probable increase in the frequency of extreme climatic events, including severe typhoons, intense rainfall, heatwaves, and extended droughts. China ranks among the nations hardest hit by global warming [38]. In recent years, China has witnessed substantial flooding almost biennially. For example, following the 2012 Beijing rainstorm, there were subsequent heavy rainstorms in Guangdong in 2014 (Figure 4a), extraordinary rainfall in Beijing in 2016 (Figure 4b), flooding in Shouguang City, Shandong Province in 2018 (Figure 4c), massive rainstorms and debris flows in Sichuan Province in 2019 (Figure 4d), extraordinary rainfall in Zhengzhou City, Henan Province in 2021 (Figure 4e), and in Zhuozhou City in 2023 (Figure 4f).

Figure 4. Flood disaster in China ((**a**) subsequent heavy rain-storms in Guangdong in 2014; (**b**) extraordinary rainfall in Beijing in 2016; (**c**) flooding in Shouguang City, Shandong Province in 2018; (**d**) massive rain-storms and debris flows in Sichuan Province in 2019; (**e**) extraordinary rainfall in Zhengzhou City, Henan Province in 2021; (**f**) extraordinary rainfall in Zhuozhou City in 2023) (source: https://baike.baidu.com/ (accessed on 21 October 2023)).

Compared to developed countries, China's urban drainage infrastructure development began relatively late, with many old urban areas still relying on initial drainage systems characterized by narrow pipes and limited drainage capacity. As urbanization progresses and populations grow, along with increased construction activities and traffic density, the scope for expanding infrastructure becomes progressively constrained, posing critical constraints on urban sustainability [39–41]. Consequently, during periods of heavy rainfall, existing rainwater management facilities become overwhelmed, often unable to meet the demands of contemporary urban drainage systems [42]. For instance, given the early infrastructure development, Beijing's drainage system was designed to handle a 1- to 3-year return period, which equates to managing 36 mm of rainfall per hour. When this threshold is exceeded, the city is highly susceptible to urban flooding [43]. As of 2022, only 21% of Beijing's stormwater drainage pipes meet the standard for handling 45 to 56 mm of rainfall per hour, and 66% of the pipes fail to meet the standard for handling 36 mm per hour. In contrast, New York's drainage system is designed for a 10- to 15-year return period, Tokyo's for a 5- to 10-year return period, and Paris's for a 5-year return period [43].

Traditional Chinese urban drainage system models typically adhere to 'quick removal' and 'end-centralized control' [42]. This approach swiftly channels rainwater through municipal drainage networks and discharges it into nearby rivers or lakes. However, this process results in the wastage of over 80% of precious water resources [42]. Furthermore, it exacerbates flood risks downstream, increasing the vulnerability of these areas to flooding events [20]. Hence, the challenges posed by outdated urban drainage infrastructure underscore the urgent need for innovative solutions to meet the evolving needs of modern urban environments. As cities grapple with increasingly frequent and severe rainfall events, strategies to enhance drainage capacity, improve water resource utilization, and mitigate flood risks become imperative. Collaborative efforts between policymakers, urban planners, engineers, and environmental scientists are essential to develop sustainable and resilient urban drainage systems capable of effectively managing stormwater, safeguarding water resources, and enhancing overall urban resilience.

3.1.2. Response to Urban Stormwater Challenges

In 2013, China launched the 'Sponge City' initiative, a sustainable stormwater management strategy tailored to the nation's unique geographical and climatic conditions. This initiative, inspired by advanced Western stormwater management techniques, aims to absorb and utilize 70% of China's stormwater onsite [21]. Subsequently, the State Council of China issued the Guiding Opinions on Promoting the Construction of Sponge Cities, which emphasizes the implementation of various measures such as infiltration, retention, storage, purification, utilization, and drainage [42]. Termed internationally as 'low-impact development rainwater system construction', a Sponge City operates as an urban underground water system akin to a sponge, absorbing, storing, filtrating, and purifying rainwater [44]. During droughts or water shortages, stored water can be released to alleviate urban water scarcity, facilitating a more natural water flow within the city and promoting a return to the natural hydrological cycle (Figure 5) [42]. The 'sponge' concept embodies a landscape-oriented ecological infrastructure, diverging from traditional rigid grey infrastructure. It offers a comprehensive, systematic, and sustainable approach to water management, encompassing rainwater purification, rainwater storage, groundwater replenishment, water source protection, habitat restoration, and soil enhancement [19,45,46].

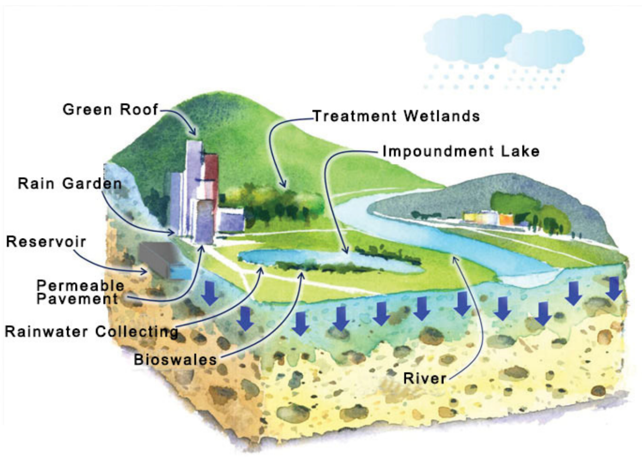


Figure 5. Sponge city concept illustration (source: https://www.dsd.gov.hk/Documents/SustainabilityReports/1617/tc/sponge_city.html (accessed on 26 November 2023)).

The rapid urbanization and economic growth in China have significantly altered land-use patterns, which, in turn, have intensified the demand for improved urban drainage infrastructure [47]. The expansion of urban areas, coupled with increased industrial and construction activities, has led to a substantial rise in impervious surfaces, exacerbating urban flooding and water scarcity issues [23,31]. This shift has placed enormous pressure on existing drainage systems, which are often outdated and inadequate for current demands. Consequently, developing innovative infrastructure systems to manage stormwater effectively and sustainably has become imperative. The economic impetus behind these developments is also evident, as improved stormwater management infrastructure can enhance urban resilience, reduce flood-related damages, and promote sustainable urban growth [48]. By integrating economic considerations with sustainable land use planning, the Sponge City initiative represents a strategic approach to modern urban challenges, ensuring long-term economic and environmental sustainability. This initiative addresses the dual pressures of rapid land-use changes and economic growth, aiming to create resilient urban environments capable of handling the complexities of contemporary urbanization.

Green Stormwater Infrastructure (GSI) functions as the city's green sponge, acting as an urban ecological rainwater regulation and storage system [44]. It transforms the traditional drainage model, shifting from direct rainwater runoff to on-site flood retention and storage [49,50]. Integrating landscape features for rainwater dispersion and storage gradually purifies, absorbs, and restores the water cycle process, resembling natural processes [51]. This approach reduces pressure on municipal rainwater networks and nearby river channels while optimizing rainwater utilization as a resource [44,52]. In this way, it mitigates urban water scarcity and diminishes reliance on finite surface water and groundwater [2]. Furthermore, the reasonable utilization of rainwater resources yields various ecological benefits, including water quality control, urban environment enhancement, and wildlife habitat provision [26,53]. Currently, various types of GSI, such as concave green spaces, permeable paving, shallow vegetation ditches, green roofs, rain gardens, rainwater ponds, bioswales, ecological banks, and bioretention areas, are widely implemented across different countries, showcasing mature design practices (Figure 6).

Figure 6. Green stormwater infrastructure ((**a**) concave green space; (**b**) permeable paving; (**c**) shallow vegetation ditches; (**d**) green roof; (**e**) rain garden; (**f**) rainwater pond; (**g**) bioswales; (**h**) ecological banks; (**i**) bioretention area).

As urban areas expand, natural landscapes are increasingly replaced by impervious surfaces such as concrete and asphalt [10]. This limits rainwater infiltration into the soil, exacerbates flooding and erosion, and reduces green spaces vital for biodiversity and human well-being [54–57]. In this context, rain gardens emerge as an eco-efficient solution, integrating rainwater management with landscape aesthetics. Rain gardens collect rainwater from impervious surfaces like rooftops, roads, and parking lots, redirecting it into planted soil through vegetation and sand layers [58]. This passive management system effectively handles runoff from surrounding areas, filtering and retaining water in the soil and slowly releasing it into groundwater, urban streets, and drainage systems [59,60]. Rain gardens capture and retain rainwater, reducing runoff volume and peak flow rates and mitigating urban flooding risks by slowing runoff velocity [10,59,61]. By intercepting, filtering, and absorbing rainwater, rain gardens alleviate the burden on traditional drainage systems, prevent water pollution, and minimize the negative environmental impacts of rapid urban expansion and climate change [44]. For instance, a study by Chen on rain garden retrofitting in a residential area demonstrated that rain gardens could manage 70% of the annual net rainwater runoff and absorb 26.8 mm of precipitation [62]. Additionally, rain gardens contribute to urban ecosystem restoration by providing habitats for various plant and animal species, enhancing urban aesthetics, and improving community resilience to climate change impacts [10,61]. Given the urgent need for green infrastructure in urban planning, incorporating rain gardens into landscape design is increasingly essential for fostering sustainable and resilient cities.

3.1.3. Strategies for Enhancing Herbaceous Plant Diversity

Over centuries of development, herbaceous plants have gained widespread application throughout Europe. In recent years, numerous designers have synthesized diverse concepts for herbaceous plant design, drawing from their extensive project experience. Notable figures in this realm include Piet Oudolf, a distinguished horticulturist from the Netherlands, and James Hitchmough, a professor at the University of Sheffield's Department of Landscape in the UK.

Landscape architects, exemplified by Piet Oudolf, champion the use of wild plants, perennials, grasses, bulbs, and other flora to create garden landscapes. They aim to seamlessly blend gardens with natural elements, employing artistic techniques rooted in botanical knowledge. Through meticulous arrangement, a harmonious integration of nature, art, and time is achieved [63,64]. This strategy not only reduces maintenance costs but also promotes biodiversity by considering the seasonal life cycles of plants. The plant design adopted in New York's High Line Park, under Oudolf's guidance, vividly exemplifies this design concept [63].

In designing The High Line (Figures 7 and 8), Piet Oudolf carefully curated a selection of 210 species of perennial herbs, flowers, shrubs, and trees chosen for their diverse textures, colors, cold resistance, and durability, as well as their adaptability and low-maintenance requirements. Notably, by incorporating a blend of native and non-native species in a wildflower meadow community, the park achieves a continuous bloom of flowers year-round, infusing it with perpetual vitality [63]. The diverse array of herbs fosters ideal habitats for insects and birds, enriching the park's ecological tapestry [65]. Employing a curtain-like planting approach, Oudolf seamlessly intertwines the virtual and real, crafting a landscape teeming with wildness and dynamism. Moreover, Oudolf acknowledges the natural decline in plant diversity over time and advocates for regularly monitoring species' adaptability to the environment [63]. Those found unsuitable are replaced with more resilient herbaceous varieties, fostering the gradual development of more stable ecological communities [63].

(a) (b)

Figure 7. The High Line (**a**) herbal plants in the High Line 1; (**b**) herbal plants in the High Line 2 (source: https://zhuanlan.zhihu.com/p/406040804 (accessed on 12 January 2024)).

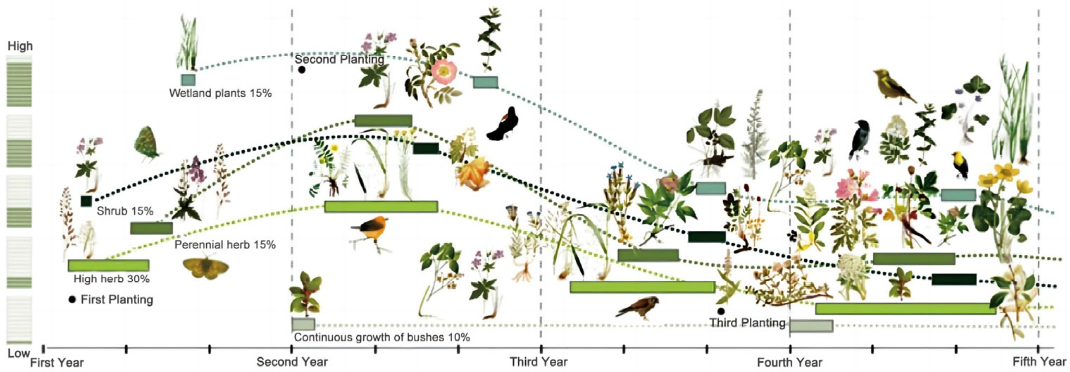


Figure 8. Succession of ecological community in High Line (Adapted from Ref. [63]. 2016, Oudolf, P.; Kingsbury, N.).

James Hitchmough's planting design philosophy is similar to Oudolf's approach. He advances a naturalistic planting concept that integrates cultural and ecological theories, promoting on-site planting and strategically allocating diverse seed mixes before planting to establish expansive vegetation. This herbaceous plant community, cultivated through seeding, boasts a wealth of species, dense populations, and robust growth. Moreover, its management is as straightforward as safeguarding native flora, facilitating the creation of captivating landscape aesthetics with minimal economic investment and carbon footprint [65].

The herbaceous plant diversity designs championed by Piet Oudolf and James Hitchmough represent a burgeoning trend in urban plant design. While their approaches differ—Oudolf favors seedling transplantation, while Hitchmough advocates seeding—both prioritize selecting highly adaptable plants based on site-specific climatic conditions and emphasize the use of native species whenever feasible [63,65]. Moreover, in landscape construction, they both advocate for creating diverse herbaceous plant communities rather than singular landscapes, aiming to generate a range of visual and morphological structures that provide striking scenery throughout the year [63,65]. Additionally, they concur on the importance of integrating natural habitats into urban areas and strategically assembling plant species to enhance diversity, ultimately fostering a stable urban plant community [63,65,66]. By designing temporally and artistically inspired urban ecological environments, they aim to mitigate maintenance and management costs [63,65,66].

When James Hitchmough and Nigel Dunnett designed the London Olympic Park (Figure 9), they aimed to imbue the urban landscape with cultural significance while integrating principles of aesthetics and ecology into plant community design [67,68]. They adeptly utilized seed ratios, sowing well-balanced seed mixes in situ to establish expansive vegetation areas [67]. In plant selection, they incorporated indigenous species and introduced exotic herbs suited to the local climate, fostering diverse plant communities [67,68]. Compared to alternative approaches, this cost-effective conservation method enhances a city's provision of ecosystem services. Its balanced ecological structure fosters stability and sustainability within plant communities on a large scale [65,67,68]. Table 1 presents the herb species utilized in the design of the Olympic North Park, emphasizing biodiversity by employing native herbs to establish natural plant communities, minimizing lawn coverage, increasing the prevalence of flowering and long-blooming herbs, and crafting visually striking grass–flower combinations [67,68].

(**a**) (**b**)

Figure 9. London Olympic Park (**a**) London Olympic Park; (**b**) London Olympic Park planting design (source: https://mp.weixin.qq.com/s/5wl55q00Cr5R_6kN9AIGuA (accessed on 15 December 2023)).

Table 1. Mixed seeds for SUDS drainage basin (Adapted from Ref. [67]. 2012, Hitchmough, J.; Dunnett, N.).

	Species	Number of Target Plants (Plants/m^2)	The Number of Seed Needed (g/m^2)
Mixed seeds on low land slope	*Betonica officinalis*	10	0.29
	Centaurea nigra	10	0.13
	Geranium sylvaticum	10	0.67
	Leucanthemum vulgare	40	0.07
	Lychnis flos-cuculi	40	0.04
	Cardamine pratensis	50	0.19
Mixed seeds at bottom of basin	*Geranium sylvaticum*	5	0.33
	Eupatorium cannabinum	5	0.02
	Lythrum salicaria	5	0.00
	Valeriana officinalis	5	0.02
	Mentha aquatica	30	0.02
	Juncus effusus	30	0.00
	Lychnis flos-cuculi	40	0.04
	Cardamine pratensis	40	0.15

3.1.4. Rain Garden Overview

Rain gardens are shallow depressions seamlessly integrated into the landscape [8]. They serve as collection points for rainwater, whether from roofs or the ground, undergoing filtration and purification processes facilitated by soil and plants. Many researchers have demonstrated that this process can effectively eliminate suspended solids, heavy metal ions, bacteria, and other harmful substances before gradually percolating into the soil [26,69,70]. Owing to their significant landscape and ecological advantages, rain gardens have gained popularity across diverse settings, such as residential areas, roads, and commercial districts [2,11].

It has been proved that rain gardens imitate natural ecological processes, playing a pivotal role in restoring the natural water cycle and ensuring the vitality of urban ecosystems [71–73]. Malaviya et al. pointed out that rain gardens, as a stormwater management tool, can effectively mitigate stormwater flow rates and volumes by capturing rainwater from impervious surfaces, such as rooftops and pavements, allowing for enhanced infiltration into the soil and the recharging of underground aquifers [74,75]. The research results of Morash et al. showed that the collected rainwater undergoes natural filtration processes within rain gardens, resulting from the interaction between vegetation and soil, thereby removing contaminants like oil, grease, heavy metals, and other pollutants from runoff and safeguarding the purity of nearby water bodies, including streams, lakes, and bays [76]. Moreover, purified rainwater collected in rain gardens can serve various urban public water needs, such as firefighting, the irrigation of green spaces, and toilet flushing [77], thereby contributing to water conservation and resource optimization. Furthermore, the presence of vegetation and the natural evaporation and transpiration processes within rain gardens play a crucial role in regulating air temperature and humidity levels. This helps mitigate the urban heat island effect, fostering a more comfortable and sustainable urban environment [26]. Additionally, rain gardens provide vital habitats for diverse species of birds, insects, and other wildlife, enhancing urban biodiversity and promoting ecological balance [11,12,76]. The creation and maintenance of rain gardens contribute to creating aesthetically pleasing green spaces that seamlessly integrate with the urban landscape, offering both ecological benefits and enhancing the overall visual appeal of urban areas [12,13]. In summary, rain gardens represent a multifaceted solution to urban environmental challenges, offering ecological, aesthetic, and functional benefits that contribute to sustainable urban development.

Rain gardens are structured with multiple layers, encompassing gravel, sand, planting soil, mulch, and an aquifer layer, arranged from innermost to outermost [2,78]. Moreover, they feature a perforated pipe for rainwater collection and an overflow pipe to regulate water levels when they surpass the designated storage capacity [12] (Figure 10). Steiner and Domm have verified that the combination of rain gardens with surface drainage or culvert systems ensures complete drainage within 24 to 96 h, thereby reducing the likelihood of localized flooding [12]. As a result, they serve as efficient filters for urban runoff [2].

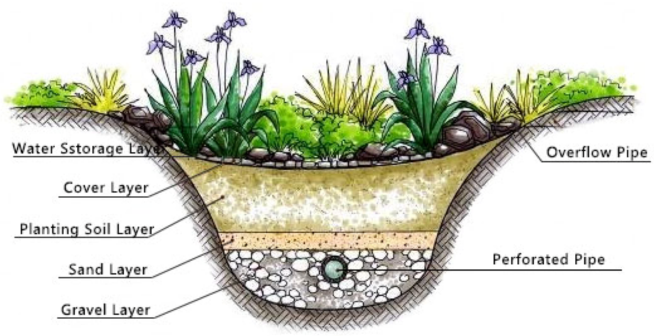


Figure 10. Anatomy of a rain garden (source: https://baike.baidu.com/item/%E9%9B%A8%E6%B0%B4%E8%8A%B1%E5%9B%AD/7656249 (accessed on 12 October 2023)).

Researchers have pointed out that the primary objective of rain garden planning is to expedite the infiltration of precipitation into the soil [75]. To achieve this, the rainwater must follow a slope during runoff, with a short distance to travel. Hence, positioning the rain garden close to the runoff source is essential [2]. Yuan emphasized that maintaining a safe distance from surrounding buildings is essential when selecting a location to prevent changes in the foundation's moisture content due to precipitation infiltration. Song highlighted that rain gardens should be at least 3 m from low-rise buildings and recommends even greater distances for high-rise buildings [46]. Additionally, Yuan also noted that the ideal location for rain gardens should avoid low-lying areas prone to water accumulation, sites with high groundwater levels, and areas close to drinking water sources, as runoff may carry pollutants that can seep into the soil and rainwater [2]. While rain gardens are not wetlands or ponds and can only retain water for short periods, they should possess relatively porous soil or be linked to urban drainage systems for complete dehydration within 24 to 96 h [12]. Many practices have proved that sandy soil and sandy loam are preferred for constructing rain gardens [79–83].

The size and configuration of rain gardens are contingent upon their intended purpose and design. Typically, rain gardens are constructed within the confines of available urban space rather than systematically sized for effective rainwater management [2,84]. The literature on the methodology for determining the appropriate dimensions of rain gardens is scarce.

Herbaceous plants are a crucial component of rain gardens, serving as both the substance and conduit for urban landscape and ecological values [2,75,85]. Studies have verified that herbaceous plants are pivotal in retaining rainwater, replenishing groundwater, effectively managing surface runoff, and enhancing soil stability and erosion resistance [86,87] (Figure 11). The experimental results of Lewis et al. demonstrated that a broader herbaceous plant coverage correlates with a more significant reduction in rainwater runoff [88]. These plants are generally more adaptable to varying moisture conditions, which is essential for rain gardens experiencing intermittent flooding and dry periods [2,12]. Additionally, some studies have shown that the fibrous root systems of herbaceous plants are highly effective at stabilizing soil and enhancing infiltration, thereby reducing natural flood risk and improving water quality [89–91]. For example, the research by Morash et al. and Biswal et al. concluded that herbaceous plant roots absorb essential organic elements like nitrogen and phosphorus from rainwater for growth while mitigating rainwater pollution by absorbing various heavy metal pollutants [76,92]. Furthermore, plants provide habitats for diverse organisms such as birds and insects [93]. Several studies also proved that the alternating wet and dry conditions within rain gardens support the survival of underground bacteria and algae, thereby enhancing biodiversity to a certain degree [11,12,76]. Moreover, Siwiec et al. concluded that vegetation's capacity to absorb CO_2 and release O_2 improves thermal comfort during hot weather and increases air humidity, mitigating the urban heat island effect [26]. Designers can leverage the diverse characteristics of herbaceous plants—including form, line, color, texture, and proportion—to artistically combine different plant species, creating unique landscape effects and providing people with varied visual enjoyment [63,94].

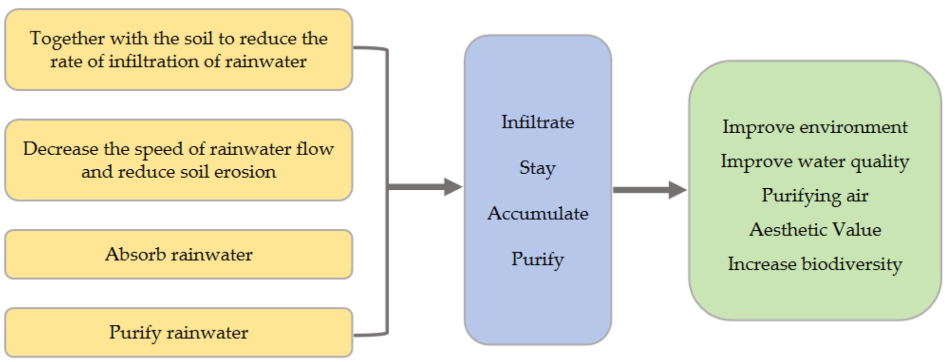


Figure 11. Herbaceous plants' function schematic in rain gardens.

3.1.5. Herbaceous Plant Selection and Design for Chinese Rain Gardens

In recent years, within the context of China's "sponge city" initiative, scholars have conducted a series of studies focusing on the selection and arrangement of plants in rain gardens. These studies involve investigations and assessments of rain gardens in different regions to determine plant species suitable for local environments [95–97]. For instance, Yang et al. conducted a study on plant selection in rain gardens in the Guanzhong region, emphasizing the importance of considering local environmental characteristics when choosing plants [95]. Similarly, Han et al. conducted field surveys of herbaceous plants in rain gardens in the pilot built-up areas of Beijing's sponge city initiative, noting that dominant families primarily include Compositae, Gramineae, Liliaceae, and Crassulaceae [96]. Furthermore, some studies have employed experimental and comprehensive evaluation methods to identify critical factors in plant selection for rain gardens, such as drought resistance, flood tolerance, greening and beautification characteristics, and pollution mitigation capabilities [98–101]. For example, Ma et al. combined field surveys with data analysis to evaluate the effectiveness of plant arrangements in the understory of rain gardens in Shanghai's Gongkang area, focusing on plant climate adaptability using the Analytic Hierarchy Process [98]. Through environmental stress tests, Liu et al. 's research highlighted the adaptability of perennials like flax, buttercup, and chive under comprehensive stress conditions [99]. Xu et al. compared the flood tolerance of 15 rain garden plant species in southern Anhui [100]. At the same time, Yang and Chen utilized the Analytic Hierarchy Process to determine that the capacity to intercept rainwater, resilience, flowering period and color, and water purification ability are the most influential factors in plant selection for rain gardens [101].

Numerous factors must be considered when selecting herbaceous plants for rain gardens. Rain garden water levels fluctuate with rainfall, resulting in alternating high- and low-water periods. Therefore, Casanova and Brock highlighted that it is essential to prioritize herbs with solid roots, practical purification abilities, and resilience to water pollution, short-term flooding, drought, and soil instability [102]. Native herbaceous species should be favored due to their robust adaptability to local climatic and soil conditions [102]. While introducing exotic herbs can enhance biodiversity and ecosystem stability to a certain extent [65], caution is warranted to prevent the introduction of invasive species that could threaten native plant survival [103]. Additionally, attention should be paid to the varied tolerances of herbs under different conditions, such as shade, water availability, humidity, temperature, and pH levels [26]. From a functional perspective, various herbaceous vegetation types exhibit distinct capacities for canopy rainwater retention and the absorption and degradation of pollutants during floods. Depending on the flood, rain garden planting areas can be categorized into water basins, slopes, and margins [2,11] (see Figure 12). Marginal areas lack water storage capacity and require drought-tolerant plant species, while slope areas necessitate moisture-tolerant plants to accommodate rainfall and resist rain erosion [2]. Water basins must handle substantial rainfall, thus requiring plants with high flood control, purification, and pollution resistance capacities [2].

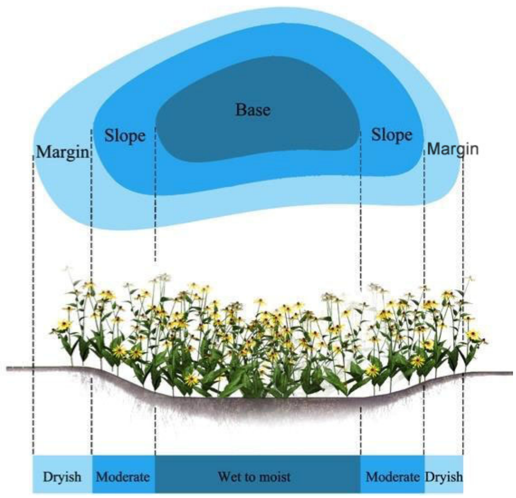


Figure 12. Schematic of rain garden water storage zoning.

3.2. Case Studies

3.2.1. Rain Garden at Beijing's 768 Creative Park: An Urban Sustainability Project

UP+S is a design institute known for its innovative solutions, and the UP+S Rain Garden exemplifies one of its projects aimed at mitigating flooding resulting from extensive impervious surfaces. Situated in the Beijing 768 Creative Park, a former industrial site with historical significance, the UP+S Rain Garden covers a modest area of 140 m^2 (Figure 13). Central to the garden's design is the prominent role of vegetation, strategically integrated into the landscape to rejuvenate rainwater management systems and establish an aesthetically pleasing 'rainwater bank' [104].

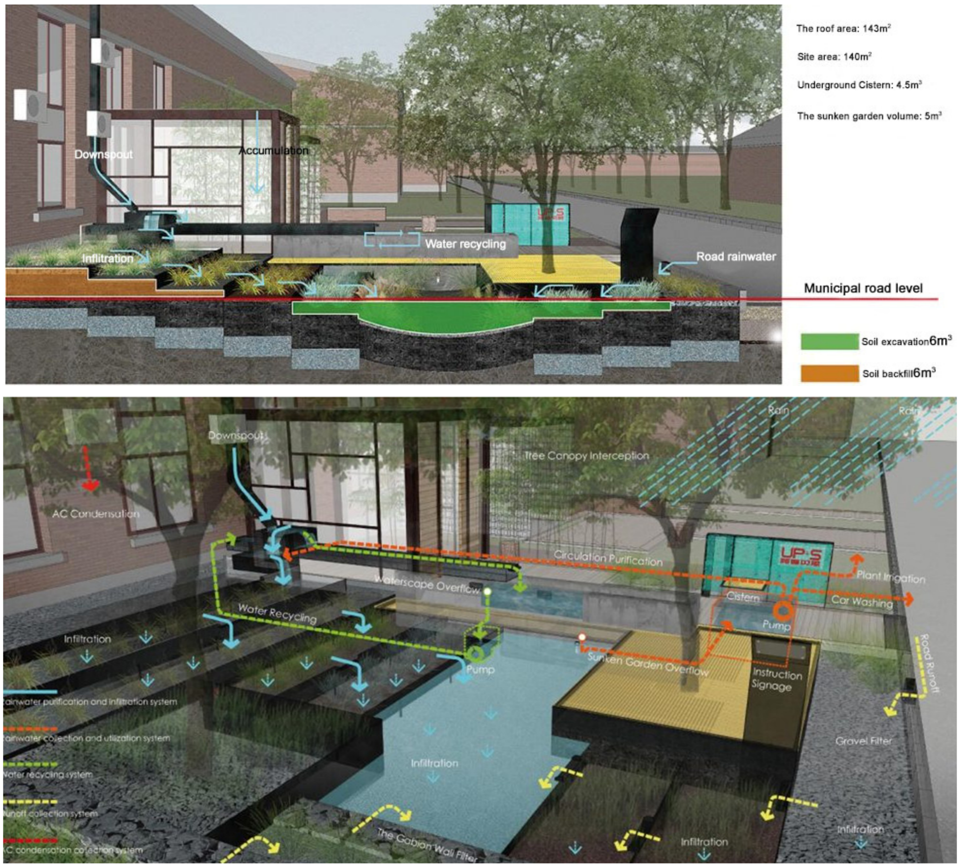


Figure 13. UP+S Rain Garden's rainwater analysis chart (source: https://www.gooood.cn/rain-garden-ups.htm (accessed on 14 September 2023)).

The UP+S Rainwater Garden stands out for its three distinctive features: low-maintenance plants, energy-saving materials, and vibrant colors [105]. Built upon the concept of a 'sustainable landscape', the project capitalizes on Beijing's significant rainfall variability and intense rainstorm patterns to identify suitable plant species for rain gardens [104,105]. Introducing a diverse range of plant species (Table 2), the design aims for both functional efficacy and aesthetic appeal, showcasing the beauty of rainwater while fulfilling practical requirements.

Preserving existing vegetation on-site was a priority, and native herb species were meticulously chosen to thrive without additional irrigation, resulting in a lush green space within a single growing season. Rainwater collected is utilized to nourish these native herbs within the sunken garden while also replenishing groundwater through specialized bioretention soil media [104]. Moreover, the garden boasts high ornamental value, with abundant herbs providing vibrant colors and vitality throughout the seasons (Figure 14). Evergreen varieties ensure the garden remains visually appealing year-round, avoiding any sense of dormancy.

Table 2. Herb species utilized in the UP+S Rain Garden.

Types	Species	Native or Non-Native	Height (cm)	Flowers' Color	Flowering Time (Month)
Perennial herbs	*Hosta plantaginea (Lam.) Aschers.*	Native	30~40	White or purple	8~9
	Iris tectorum Maxim.		30~50	Blue-purple or yellow	4~6
	Clematis heracleifolia DC		30~70	Blue-purple	8~9
	Potentilla chinensis Ser.		20~70	Yellow	4~6
	Ranunculus japonicus Thunb.		≤70	Yellow	4~6
	Lythrum salicaria L.		30~100	Magenta or lavender	7~8
	Gaura lindheimeri Engelm. et Gray		≤100	Light blue-purple or white	8~10
	Aster novi-belgii		60~100	White or light pink	5~8
	Dianthus deltoids L.	Non-native	15~40	White, light yellow, pink, or red	5~6
	Sedum hybridum 'Immergrunchett'		15~20	White, fuchsia, or rose red	6~10
	Allium		40	White, pink, purple, or yellow	4~5
	Achillea millefolium		40~100	White, pink, or lavender	7~9
	Physostegia virginiana		60~120	Light blue, fuchsia, or pink	7~9
Ornamental grasses	*Carex giraldiana*	Non-native	16~30		
	Pennisetum alopecuroides (L.) *Spreng*		30~120		
	Calamagrostis epigeios (L.) *Roth*		45~100		
	Pennisetum setaceum 'Rubrum'		60~90		
	Miscanthus sinensis cv.		100~200		
	Panicum virgatum		100~200		
	Miscanthus sinensis Andress 'Zebrinus'		120		
	Cortaderia selloana		200~300		
	Arundo donax		300~600		
Aquatic herbs	*Eichhornia crassipes (Mart.) Solms*	Native	30~60	Blue-purple	7~10
	Iris pseudacorus L.	Non-native	60~100	Yellow	5

(**a**) (**b**)

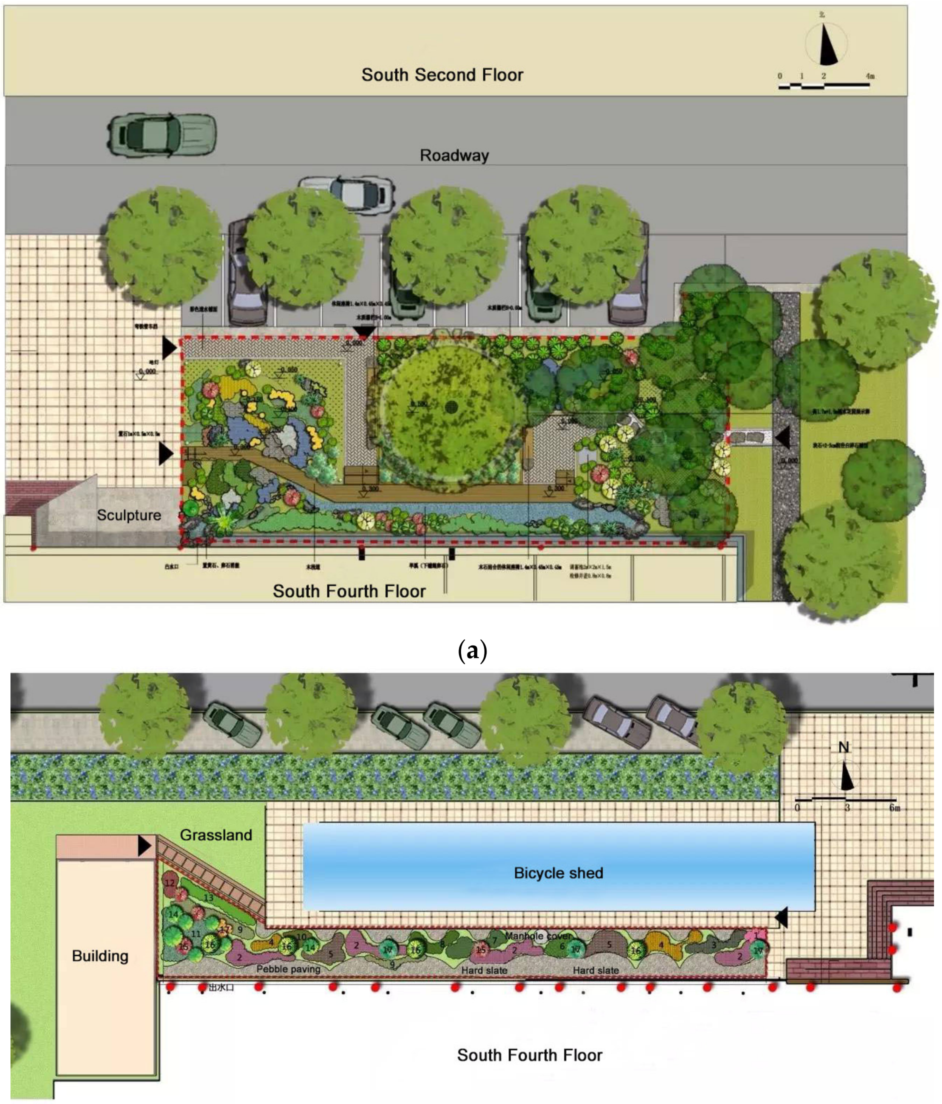
(**c**) (**d**)

Figure 14. UP+S Rain Garden in different seasons (**a**) spring; (**b**) summer; (**c**) autumn; (**d**) winter (source: https://www.gooood.cn/rain-garden-ups.htm (accessed on 16 December 2021)).

Characterized by low-impact, low-cost, and low-maintenance landscapes, the garden effectively manages rainwater, serving as a veritable stormwater bank for the building roof and surrounding areas [105]. Through its capacity to infiltrate, retain, purify, accumulate, utilize, and discharge rainwater, the UP+S Rain Garden exemplifies an innovative approach to sustainable stormwater management.

3.2.2. Rain Garden at Huazhong University of Science and Technology: Project Yuyun

The Yuyun Rain Garden, located within the Huazhong University of Science and Technology campus in Wuhan, China, exemplifies sustainable urban design initiatives led by Yin LiHua, a faculty member at the university. Described as 'a small pore in the sponge city' [106], this project ingeniously transforms idle vacant land into a vital component of urban stormwater management. Comprising two distinct sections, the rain garden occupies the east and west areas of the south fourth-floor entrance. The east segment spans a modest 202 m^2 green space nestled in the northeast corner of the main entrance, while the west section extends as a narrow strip between the bicycle shed and the north elevation of the same floor, covering an area of 100 m^2 (Figure 15).

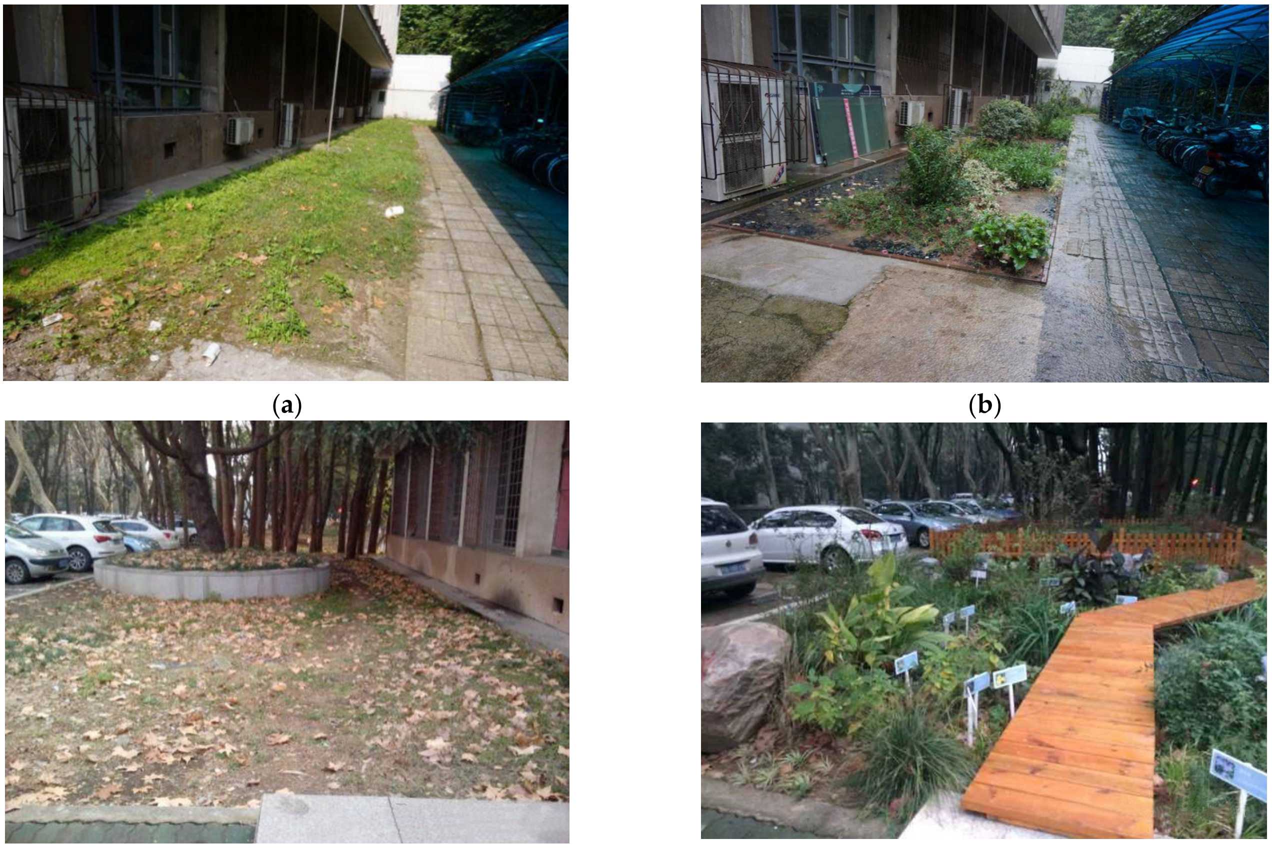


(a)

(b)

Figure 15. Floor plan of the Yuyun Rain Garden (**a**) floor plan 1; (**b**) floor plan 2 (source: https://mp.weixin.qq.com/s/uUxHvAgTuYwyxYpZnhZbOA (accessed on 12 June 2020)).

In light of the dense shading environment created by the ten camphor trees on the east side of the planting area, the preference leans towards selecting shade-tolerant understory herbs [106]. Yin Lihua, in her herb plant design, demonstrates a profound respect for the site's original conditions and resources (Figure 16), adhering to principles of science, aesthetics, simplicity, and ecology to enhance the quality of the green landscape. She meticulously arranges plants based on a comprehensive understanding of their growth characteristics, encompassing seasonal variation, ecological preferences, physiological attributes, and aesthetic appeal. While considering factors such as color, form, and cultural significance, she also integrates principles related to color harmony, flowering patterns, fruiting cycles, fragrance, and sensory elements, including touch and sound (Table 3) [106,107].



(**a**) (**b**) (**c**) (**d**)

Figure 16. Yuyun Rain Garden ((**a**,**c**) before construction; (**b**,**d**) after construction). (source: https://mp.weixin.qq.com/s/iA0t-sTvtOvOVlu_r_GGBA (accessed on 20 January 2020)).

Nevertheless, a drawback in the design is the issue of mosquito breeding induced by the high humidity in the east area. Despite the rain garden's potential to serve as a habitat for flying birds and insects, it is imperative to manage the mosquito problem within acceptable limits, particularly in areas frequently traversed by many students or teachers [107]. To address this concern, it is advisable to incorporate mosquito and insect-repellent plants into the rain garden—species such as *Pelargonium citrosum Voigt ex Breit.*, *Plectranthus 'Cerveza n Lime'*, and *Artemisia argyi Lev. Et. Van* can be strategically planted for this purpose.

Table 3. Herbaceous species utilized in the Yuyun Rain Garden.

Types	Species	Native or Non-Native	Height (cm)	Flowers' Color	Flowering Time (Month)	Quantity
Perennial herbs	*Gaura lindheimeri 'Crimson Bunny'*	Native	90~130	Pink	5~11	120
	Coreopsis grandiflora 'Hogg'		20~100	Yellow	5~9	48
	Hydrangea macrophlla		100~400	Pink, light blue, or white	6~8	5
	Trachelospernuim jasminoides 'Flame'		20~50	White or light pink	5~8	50
	Hemerocallis fuava 'Baltimore Oriole'	Non-native	40~50	Red	7~8	5
	Hylotelephium erythrostictum		30~50	White, fuchsia, rose red	7~10	100
	gm hybrida 'Vbss'		10~50	White, red, blue, snow green, or pink	5~11	90
Ornamental grasses	*Miscanthus sinensis*	Native	100~200			18
	Carer 'Evergold'	Non-native	20			30

3.2.3. The Gongkang Rain Garden in Shanghai

Located in Zhabei District, Shanghai, the Gongkang Rainwater Garden covers an expanse of 13,000 m^2. The garden is ingeniously designed as a depression approximately 50 cm below ground level to capture stormwater runoff from roads, communities, and rooftops [108]. The planting areas are categorized based on water levels into three types: the marginal zone, the buffer area, and water storage (Figure 17) [98]. Notably, the water storage area experiences significant fluctuations in water levels due to precipitation, necessitating plants with high waterlogging tolerance and drought resistance. Plants in the buffer zone require a moderate level of waterlogging tolerance, whereas those in the marginal area adapt to the surrounding environmental conditions, providing flexibility in vegetation selection.

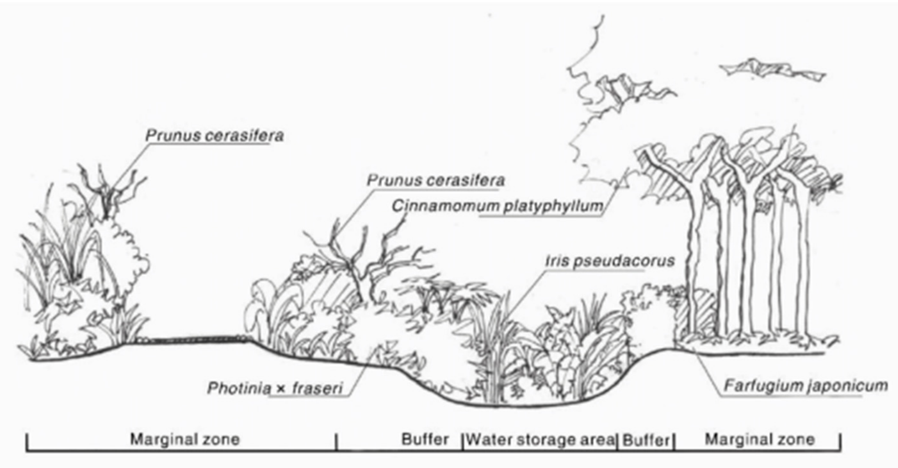


Figure 17. Elevation of Gongkang Rain Garden.

Compared to tall trees, the arrangement of ground cover herbaceous plants in rain gardens offers a better portrayal of species diversity, ornamental value, landscape coherence, and integration with the underlying environment, thus reflecting rich and diverse characteristics with significant research potential. Carefully selected by designers based on their growth attributes such as color, height, and habit, these plants ensure a harmonious blend of science and artistry, enriching the multi-layered structure of the plant community (Table 4) (Figure 18) [98]. Among the understory herbaceous vegetation, *Iris tectorum Maxim.*, *Lythrum salicaria* L., *Juncus setchuensis*, *Iris pseudacorus* L., *Thalia dealbata*, and *Arundo donax 'Versicolor'* dominate the larger areas, while *Hemerocallis fulva*, *Nassella tenuissima*, *Cordyline fruticosa*, and *Cyperus alternifolius* are employed for decorative purposes, albeit in smaller quantities. *Koch* var. *sinensis (Tobl.) Rehd*, *Reineckea carnea*, and *Hedera nepalensis K*, preferring humid conditions, are clustered beneath trees and shrubs. *Ophiopogon bodinieri*, capable of thriving in sunlight and shade, is strategically placed at the green space's edge. Alongside the pool, *Wisteria sinensis* and Digitalis purpurea group plantings complement the lower layers. Moreover, the water-purifying function of herb plants is also taken into account. Post-stormwater collection, pollutants are absorbed or diminished by these plants. For instance, *Canna indica* tubers excel at absorbing heavy metals, while *Iris pseudacorus* L. readily absorbs nitrogen oxides, addressing water quality deterioration. The Gongkang Rain Garden boasts six ground-cover herbaceous plant modes [98,108]:

Table 4. Herbaceous species utilized in the Shanghai Gongkang Rain Garden.

Types	Species	Native or Non-Native	Height (cm)	Flowers' Color	Flowering Time (Month)
Perennial herbaceous flowers	*Hemerocallis fulva*	Native	30~60	Orange	5~8
	Ophiopogon bodinieri		10~30	White or slightly purple	6~8
	Canna indica		≤150	Red and yellow	5~10
	Euryops pectinatus		30~50	Yellow	5~7
	Iris germanica		30~50	Lavender, blue-purple, deep purple, or white	4~5
	Lythrum salicaria L.		30~100	Magenta or lavender	7~8
	Iris tectorum Maxim.		30~50	Blue-purple or yellow	4~6
	Cordyline fruticosa	Non-native	100~300	Light red; blue-purple to yellow	11~3
	Digitalis purpurea		60~120	Fuchsia	5~6
	Reineckea carnea		20	Lavender	8~9
	Sedum lineare		10~20	Yellow	4~5
Ornamental grasses	*Juncus setchuensis*	Native	≤90	Brown	6~9
	Cyperus alternifolius		30~150	White	3
	Phalaris arundinacea	Non-native	60~140	Violet	5~9
	Nassella tenuissima		30~50	Yellow	5
	Arundo donax 'Versicolor'		300~600	Blue-purple	7~10
Aquatic herbs	*Sagittaria sagittifolia*	Native	60~100		
	Ceratophyllum demersum		40~150		
	Typha orientalis Presl		130–200		
	Gladiolus gandavensis		30~60		
	Phragmites australi		100~300		
	Vallisneria natans		20~200		
	Typha angustifolia		≤300		
	Lemna minor		3~4		
	Nymphaea tetragona		80~150		
	Iris pseudacorus L.	Non-native	60~100	Pink or white	7~10
	Nuphar pumila		40~50		
	Thalia dealbata		100~250	Yellow	5~7

(**a**) (**b**)

Figure 18. Shanghai Gongkang Rain Garden (**a**) site 1 of Shanghai Gongkang Rain Garden; (**b**) site 2 of Shanghai Gongkang Rain Garden (source: https://mp.weixin.qq.com/s/J5Mg-KK6bRT5HYEi490Erg (accessed on 21 January 2020)).

Mode 1: *Cordyline fruticosa* + *Juncus setchuensis* + *Lythrum salicaria* L. + *Gladiolus* × *gandavensis* + *Iris tectorum Maxim.* + *Thalia dealbata* + *Cyperus alterni-folius*;

Mode 2: *Typha orientalis Presl* + *Hemerocallis fulva* + *Phalaris arundinacea* + *Arundo donax 'Versicolor'* + *Cordyline fruticosa*;

Mode 3: *Thalia dealbata* + *Cyperus alternifolius* + *Iris pseudacorus* L. + *Lythrum salicaria* L.;

Mode 4: *Cordyline fruticosa* + *Arundo donax 'Versicolor'* + *Miscanthus sinensis cv.* + *Typha angustifolia* + *Hemerocallis fulva* + *Cordyline fruticosa;*

Mode 5: *Iris pseudacorus* L. + *Hemerocallis fulva* + *Cordyline fruticosa* + *Iris tectorum Maxim.* + *Cyperus alternifolius* + *Thalia dealbata* + *Iris germanica;*

Mode 6: *Iris germanica* + *Thalia dealbata* + *Phalaris arundinacea* + *Lythrum salicaria* L. + *ypha orientalis Presl* + *Iris pseudacorus* L.

3.2.4. Rain Garden along Qinhuang Avenue

Qinhuang Avenue serves as a key north–south urban thoroughfare within Xi'an Fengxi New District, a leading city in China's sponge city initiative. Spanning an 80 m wide corridor, the road features expansive 35 m wide green belts on either side. The road's landscape design adopts a four-board and five-belt configuration (Figure 19). Integrated within the green buffer zone, rain gardens alongside other Low-Impact Development (LID) facilities like transmission grass ditches and retention grass ditches are strategically positioned between motor and non-motor vehicle lanes. Their purpose is to absorb, purify, retain, and discharge stormwater, as illustrated in Figure 20 [109].

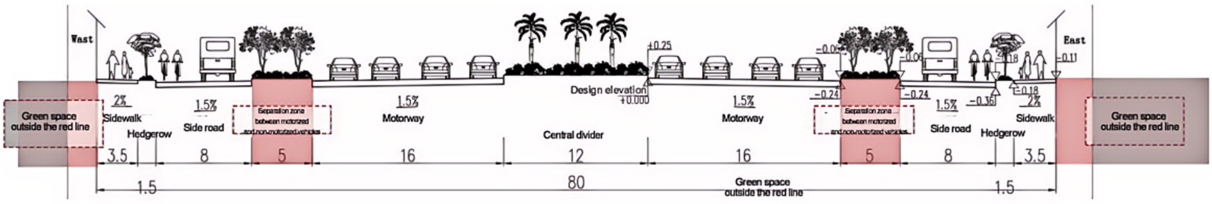


Figure 19. Elevation of Qinhuang Avenue (Adapted from Ref. [110]. 2016, Xia, Y.).

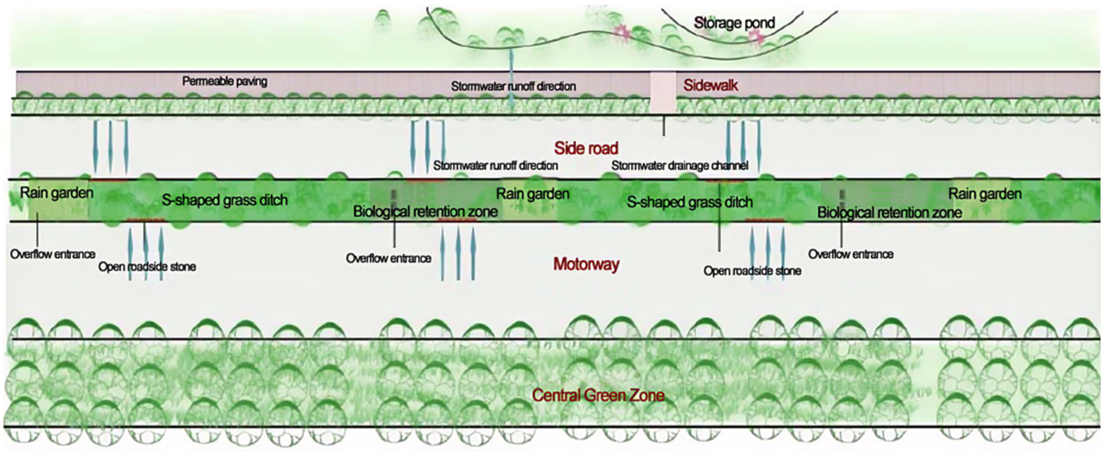


Figure 20. Plan for LID facilities at Qinhuang Avenue (Adapted from Ref. [109]. 2018, Dong, Y.Y.).

In selecting herbaceous vegetation, the designer meticulously assessed the habitat conditions of the site (Table 5). Variations in water levels within the rain garden dictated the choice of plant species. Moisture-tolerant herbs were deployed in the water storage area, while those resistant to short-term flooding and long-term drought were situated in the buffer zone. Drought-tolerant plants were preferred for the edge area [110]. Emphasis was placed on native species, known for their superior adaptability to the local environment. Since rain gardens are typically positioned at road intersections, their visual cues were factored into the herb selection process [110].

Table 5. Primary herbaceous species utilized in the Qinhuang Avenue Rain Garden (Adapted from Ref. [109]. 2018, Dong, Y.Y.).

Types	Species	Native or Non-Native	Height (cm)	Flowers' Color	Flowering Time (Month)
Perennial herbaceous flowers	*Lythrum salicaria* L.	Native	30~100	Magenta or lavender	7~8
	Iris tectorum Maxim.		30~50	Blue-purple or yellow	4~6
	Orychophragmus violaceus (L.) *O. E. Schulz*		50	Purple	4~5
	Ophiopogon japonicus (Linn. f.) *Ker-Gawl.*		20~50	White or lavender	5~8
	Echinacea purpurea (Linn.) *Moench*		50~150	White	6~8
	Rosmarinus officinalis	Non-native	200	Blue-purple	11
Ornamental grasses	*Reineckea carnea* var. *varigata*	Native	20		
	Juncus setchuensis		≤90		
	Pennisetum alopecuroides (L.) *Spreng*		30~120		
	Miscanthus sinensis cv.		100~200		
Aquatic herbs	*Iris pseudacorus* L.	Non-native	60~100	Yellow	5

The design of rain gardens exhibits a degree of spontaneity in terms of form, size, and placement, characterized by an interplay of stones and vegetation. Benefitting from favorable hydrological conditions, plants with robust textures and vibrant color variations, such as *Pennisetum alopecuroides* (L.) *Spreng*, *Miscanthus sinensis* cv., and *Iris pseudacorus* L., have been selected. These species demonstrate resilience to short-term flooding and prolonged drought, fostering a cohesive plant community. Additionally, the inclusion of landscape stones and signage accentuates key nodes and underscores the dual objectives of promoting scientific understanding and educational significance [110].

The herbaceous plant design of Qinhuang Avenue integrates the functional and aesthetic aspects of vegetation, aligning with the overall ambiance of the thoroughfare [110]. By employing diverse species, the landscape, biodiversity, stability, and functionality of the rain garden are enhanced. Furthermore, considerations extend to post-maintenance costs, with the utilization of perennials and evergreen plants aimed at reducing upkeep expenses [110]. The varied selection of herbaceous plants ensures a vibrant appearance throughout spring, summer, and autumn, while the presence of dormant herbs during winter maintains visual interest. In this regard, the brown-yellow landscape grass evokes anticipation for the forthcoming spring season (Figure 21) [109].

(**a**) (**b**)

Figure 21. Qinhuang Avenue Rain Garden (**a**) site 1 of Qinhuang Avenue Rain Garden; (**b**) site 2 of Qinhuang Avenue Rain Garden (Adapted from Ref. [109]. 2018, Dong, Y.Y.).

3.2.5. Advantages and Disadvantages of Herbaceous Planting Design in Chinese Rain Gardens

The selection and arrangement of herbaceous plants in Chinese rain gardens, as illustrated by the four cases above, demonstrate careful consideration of plant growth characteristics, ecological functions, and aesthetic effects, reflecting various advantages.

Firstly, the diverse range of plant species covers different ecological types and growth conditions, enhancing the ecological diversity of rain gardens and promoting biodiversity conservation. Secondly, these herbaceous plants are meticulously arranged in the design to ensure their harmonious integration into the landscape, adding unique beauty and visual appeal to the rain gardens. Additionally, the selection and arrangement of herbaceous plants consider their growth height, root characteristics, and water requirements, contributing to improving hydrological effects and water purification functions in rain gardens. In summary, the selection and arrangement of herbaceous plants in Chinese rain gardens demonstrate the scientific and artistic aspects of design and fully leverage the ecological functions of plants in rain gardens, thereby positively contributing to the improvement of urban ecological environments and the enhancement of urban landscapes.

Research on rain gardens abroad primarily focuses on hydrological process simulation, soil infiltration effects, water purification capabilities, substrate layer design, the impact of different planting methods on hydrological processes, construction methods, and maintenance. However, in China, rain garden design is still in its early stages, with research primarily concentrated on the history of Chinese rain gardens, their functions and construction principles, construction techniques, and case studies of typical rain gardens. There is limited attention to plant diversity, particularly herbaceous plants, from an ecological perspective. Although the application of herbaceous plants in urban landscapes has increased in recent years, they are mainly used for decorative purposes. Given the significant differences in native plant species across different climatic regions, selecting suitable plants for rain gardens is particularly crucial. However, research in this area in China is still limited. Moreover, commonly used herbaceous plants mainly flower in spring and summer, leading to a withered appearance in winter and the need for frequent replacement, thus increasing maintenance costs and contradicting the concept of sustainability. Furthermore, a trend towards a single application mode result in a need for more landscape diversity. More attention should be paid to the functional role of herbaceous plants in stormwater retention and pollutant purification, overlooking their varying capabilities in these aspects. Additionally, there needs to be a stronger ecological consciousness, with plant selection prioritizing flowering periods rather than considering natural habitat simulation and the creation of dynamic landscapes through plant life cycle succession. Therefore, a comprehensive exploration of herbaceous plant diversity design in Chinese rain gardens is needed, focusing on enhancing biodiversity, diversifying plant application forms, enriching seasonal landscapes, and reducing protection and management costs.

3.3. Integrating Ecological Principles in Herbaceous Planting Design for Chinese Rain Gardens

The literature review emphasizes the crucial integration of ecological principles, functionality, and aesthetics in the arrangement of herbaceous plants within rain gardens. In 2003, Nigel Dunnett and James Hitchmough, scholars from the University of Sheffield in the UK, pioneered the naturalistic herbaceous landscape concept. This concept emphasizes the selection of herbaceous plants that adapt to site-specific environmental conditions and can coexist with various biological and non-biological elements. This approach enhances system stability and resilience against urban flooding disasters and pests while ensuring rich seasonal changes in plant landscapes by establishing a community biodiversity and symbiotic structure through mixed herb species. Advocating for mixed seeding technology and functional design, the naturalistic herb landscape harnesses nature to address the shortcomings of conventional urban plant landscapes, offering improved functionality and aesthetic appeal to urban rain garden vegetation design. Employing naturalistic planting design techniques is key to maximizing stability, sustainability, and cost-effectiveness [65–67]. The following guiding principles should be taken into account:

(1) Honor the innate growth patterns of plants and mirror the configuration and composition of natural communities during planting. This approach creates visually appealing natural landscapes, avoiding uniformity and monoculture [63,65].

(2) Carefully contemplate the niche characteristics of species when choosing and organizing herbaceous plants in rain gardens to mitigate adverse effects on their growth caused by excessive competition for space and nutrients among species [111]. The paramount objective should be to enrich the ecological environment, reduce rainwater runoff and pollution, and establish a resilient plant community predominantly comprised of native herbs [67].
(3) From a landscape perspective, the herbaceous plant arrangement in rain gardens should be scientifically and thoughtfully designed, incorporating plants that reflect specific cultural connotations to create visually striking urban landscapes with humanistic characteristics [67]. Factors such as flowering periods, colors, shapes, textures, and seasonal variations of herbaceous plants should be considered. Additionally, planting them alongside woody plants can enhance the vegetation community's structural complexity and aesthetic appeal [63].
(4) Evaluate the economic viability and ease of initial planting as well as ongoing maintenance and management to minimize long-term upkeep expenses and encourage the cultivation of economically sustainable gardens [63,65].

In summary, adopting a holistic approach to rain garden design and management that integrates ecological, functional, aesthetic, and socio-economic considerations is essential for creating resilient, biodiverse, and visually appealing urban green spaces that mitigate stormwater runoff and enhance urban sustainability.

4. Conclusions and Recommendations

In conclusion, this literature review highlights the critical role of herbaceous plant biodiversity design in Chinese rain gardens within the context of addressing climate change and enhancing urban sustainability, including mitigating flooding, purifying stormwater, and improving urban ecological environments. By carefully selecting and arranging herbaceous plants based on their growth characteristics, ecological functions, and aesthetic qualities, Chinese rain gardens can not only enhance biodiversity but also contribute to the creation of visually appealing and resilient urban green spaces. Although herbaceous plants offer numerous benefits, such as increasing ecological diversity and providing habitats for pollinators, challenges like maintenance costs and seasonal variability need to be addressed through careful planning and the selection of plant species.

Moving forward, there are several key suggestions for future research and practice in the field of herbaceous plant biodiversity design in Chinese rain gardens. Firstly, there is a need for further investigation into the ecological adaptability and landscape performance of different herbaceous plant species, particularly in the context of China's diverse climatic conditions. Secondly, efforts should be made to promote the use of native herbaceous plants to enhance ecological resilience and support local biodiversity conservation efforts. Additionally, research should focus on developing innovative planting design techniques that maximize the ecological, aesthetic, and functional potential of herbaceous plant communities in rain gardens.

Overall, the exploration of herbaceous plant biodiversity design in Chinese rain gardens offers valuable insights into the development of sustainable urban green infrastructure and underscores the importance of integrating ecological principles and biodiversity conservation goals into landscape design practices. By continuing to advance our understanding of herbaceous plant ecology and design strategies, we can foster the creation of more resilient, biodiverse, and visually appealing rain gardens that contribute to the long-term sustainability of urban environments in China and beyond.

Author Contributions: Writing—original draft preparation, L.S. and R.L.; formal analysis, investigation, and data curation, L.S.; conceptualization and methodology, L.S., S.M., J.Z. and R.L.; validation, S.M., M.J.M.Y. and J.Z.; writing—review and editing, S.M., M.J.M.Y., J.Z. and R.L.; supervision, S.M. and M.J.M.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: All data supporting the results of this study are included in the manuscript, and data sets are available upon request.

Acknowledgments: We would like to thank all the literature and previous research cited in this study. Their work has provided a solid foundation for our review, enabling us to delve deeper into the issues relevant to this field.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Singh, R.L.; Singh, P.K. Global environmental problems. In *Principles and Applications of Environmental Biotechnology for a Sustainable Future*; Springer: Berlin/Heidelberg, Germany, 2017; pp. 13–41.
2. Yuan, J. Investigating The Planting Potential For Urban Rain Gardens: Plant Selection, Establishment and Performance. Ph.D. Thesis, University of Sheffield, Sheffield, UK, 2016.
3. Grimm, N.B.; Faeth, S.H.; Golubiewski, N.E. Global change and the ecology of cities. *Science* **2008**, *319*, 756–760. [CrossRef] [PubMed]
4. Kumar, P. Climate change and cities: Challenges ahead. *Front. Sustain. Cities* **2021**, *3*, 645613. [CrossRef]
5. Güneralp, B.; Güneralp, İ.; Liu, Y. Changing global patterns of urban exposure to flood and drought hazards. *Glob. Environ. Chang.* **2015**, *31*, 217–225. [CrossRef]
6. Brown, R.R. Impediments to integrated urban stormwater management: The need for institutional reform. *Environ. Manag.* **2005**, *36*, 455–468. [CrossRef] [PubMed]
7. Kenway, S.J.; Lant, P. The influence of water on urban energy use. *Water Sensitive Cities* **2012**, 63–77.
8. Cameron, R.; Hitchmough, J. *Environmental Horticulture Science and Management of Green Landscapes*; Cabi: Wallingford, UK, 2016.
9. Daniels, B.J.; Yeakley, J.A. Catchment-Scale Hydrologic Effectiveness of Residential Rain Gardens: A Case Study in Columbia, Maryland, USA. *Water* **2024**, *16*, 1304. [CrossRef]
10. Doğmuşöz, B.B. Plant selection for rain gardens in temperate climates: The case of Izmir, Turkey. *J. Des. Resil. Archit. Plan.* **2024**, *5*, 18–34. [CrossRef]
11. Dunnett, N.; Clayden, A. *Rain Gardens, Managing Water Sustainably in the Garden and Designed Landscape*; Timber Press: London, UK, 2007.
12. Steiner, L.M.; Domm, R.W. *Rain Gardens: Sustainable Landscaping for a Beautiful Yard and a Healthy World*; Voyageur Press: Minneapolis, MN, USA, 2012.
13. Pickett, S.T.A.; Cadenasso, M.L. Linking ecological and built components of urban mosaics: An open cycle of ecological design. *J. Ecol.* **2008**, *96*, 8–12. [CrossRef]
14. Huang, H. Plant diversity and conservation in China: Planning a strategic bioresource for a sustainable future. *Bot. J. Linn. Soc.* **2011**, *166*, 282–300. [CrossRef]
15. Turner, M.N. Framework for Reconciliation: Adapting an Urban Park to Welcome Little Brown Bats (*Myotis lucifugus*). Ph.D. Thesis, University of Georgia, Athens, GA, USA, 2017.
16. El-Haggar, S.; Samaha, A.; El-Haggar, S.; Samaha, A. Sustainable urban community development guidelines. In *Roadmap for Global Sustainability—Rise of the Green Communities*; Springer: Cham, Switzerland, 2019; pp. 75–102.
17. Preston, S. Examining the Role of Community Engagement in Nature-Based Solutions. Ph.D. Thesis, The University of Liverpool, Liverpool, UK, 2020.
18. Vargas-Hernández, J.G.; Pallagst, K.; Hammer, P. Strategic management innovation of urban green spaces for sustainable community development. *Handb. Engaged Sustain.* **2018**, *2*, 917–944.
19. Yu, K.J. Sponge City—Ideas and Methods. *Constr. Sci. Technol.* **2019**, *377*, 10–11.
20. Mishra, A.; Mukherjee, S.; Merz, B.; Singh, V.P.; Wright, D.B.; Villarini, G.; Paul, S.; Kumar, D.N.; Khedun, C.P.; Niyogi, D.; et al. An overview of flood concepts, challenges, and future directions. *J. Hydrol. Eng.* **2022**, *27*, 03122001. [CrossRef]
21. Griffiths, J.; Chan, F.K.S.; Shao, M.; Zhu, F.; Higgitt, D.L. Interpretation and application of Sponge City guidelines in China. *Philos. Trans. R. Soc. A* **2020**, *378*, 20190222. [CrossRef] [PubMed]
22. Huang, Y.; Lin, J.; He, X.; Lin, Z.; Wu, Z.; Zhang, X. Assessing the scale effect of urban vertical patterns on urban waterlogging: An empirical study in Shenzhen. *Environ. Impact Assess. Rev.* **2024**, *106*, 107486. [CrossRef]
23. Leopold, L.B. *Hydrology for Urban Land Planning: A Guidebook on the Hydrologic Effects of Urban Land Use*; US Geological Survey: Washington, DC, USA, 1968; Volume 3, p. 18.
24. Santamouris, M. Using Cool Pavements as a Mitigation Strategy to Fight Urban Heat Island—A Review of the Actual Developments. *Renew. Sustain. Energy Rev.* **2013**, *26*, 224–240. [CrossRef]
25. Edmondson, J.L.; Stott, I.; Davies, Z.G.; Gaston, K.J.; Leake, J.R. Soil Surface Temperatures Reveal Moderation of the Urban Heat Island Effect by Trees and Shrubs. *Sci. Rep.* **2016**, *6*, 2045–2322. [CrossRef] [PubMed]
26. Siwiec, E.; Erlandsen, A.; Vennemo, H. City greening by rain gardens-costs and benefits, Environmental Protection and Natural Resources. *J. Inst. Environ. Prot. Natl. Res. Inst.* **2018**, *29*, 1–5.
27. Liu, J.; Sample, D.J.; Bell, C.; Guan, Y. Review and research needs of bioretention used for the treatment of urban stormwater. *Water* **2014**, *6*, 1069–1099. [CrossRef]

28. Alberti, M.; Booth, D.; Hill, K.; Coburn, B.; Avolio, C.; Coe, S.; Spirandelli, D. The impact of urban patterns on aquatic ecosystems: An empirical analysis in Puget lowland sub-basins. *Landsc. Urban Plan.* **2007**, *80*, 345–361. [CrossRef]
29. Carey, R.O.; Hochmuth, G.J.; Martinez, C.J.; Boyer, T.H.; Dukes, M.D.; Toor, G.S.; Cisar, J.L. Evaluating nutrient impacts in urban watersheds: Challenges and research opportunities. *Environ. Pollut.* **2013**, *173*, 138–149. [CrossRef]
30. Hatt, B.E.; Steinel, A.; Deletic, A.; Fletcher, T.D. Retention of heavy metals by stormwater filtration systems: Breakthrough analysis. *Water Sci. Technol.* **2011**, *64*, 1913–1919. [CrossRef] [PubMed]
31. Wang, Y.; Zheng, C.; Ma, R. Safe and sustainable groundwater supply in China. *Hydrogeol. J.* **2018**, *26*, 1301–1324. [CrossRef]
32. Browder, J.G.; Xie, S.Q.; Kim, Y.; Gu, L.X.; Fan, M.Y.; Ehrhardt, D. *Stepping up: Improving the Performance of China's Urban Water Utilities*; The World Bank: Washington, DC, USA, 2007.
33. Cramer, W.; Guiot, J.; Fader, M.; Garrabou, J.; Gattuso, J.-P.; Iglesias, A.; Lange, M.A.; Lionello, P.; Llasat, M.C.; Paz, S.; et al. Climate change and interconnected risks to sustainable development in the Mediterranean. *Nat. Clim. Chang.* **2018**, *8*, 972–980. [CrossRef]
34. Kumar, A.; Nagar, S.; Anand, S. Climate change and existential threats. In *Global Climate Change*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 1–31.
35. Watkiss, P.; Downing, T.; Handley, C.; Butterfield, R. *The Impacts and Costs of Climate Change*; European Commission DG Environment: Brussels, Belgium, 2005.
36. Noguer, M.; van der Linden, P.J.; Dai, X.; Maskell, K.; Johnson, C.A. *Climate Change 2001: The Scientific Basis*; Houghton, J.T., Ding, Y.D.J.G., Griggs, D.J., Eds.; Cambridge University Press: Cambridge, UK, 2001.
37. Kabisch, N.; Korn, H.; Stadler, J.; Bonn, A. *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Springer Nature: London, UK, 2017.
38. Lai, E.C. *Climate Change Impacts on China's Environment: Biophysical Impacts*; Woodrow Wilson Center: Washington, DC, USA, 2009.
39. Ahani, S.; Dadashpoor, H. Urban growth containment policies for the guidance and control of peri-urbanization: A review and proposed framework. *Environ. Dev. Sustain.* **2021**, *23*, 14215–14244. [CrossRef]
40. Jiang, P.; Cheng, Q.; Gong, Y.; Wang, L.; Zhang, Y.; Cheng, L.; Li, M.; Lu, J.; Duan, Y.; Huang, Q.; et al. Using urban development boundaries to constrain uncontrolled urban sprawl in China. *Ann. Am. Assoc. Geogr.* **2016**, *106*, 1321–1343. [CrossRef]
41. Wei, G.; He, B.J.; Sun, P.; Liu, Y.; Li, R.; Ouyang, X.; Luo, K.; Li, S. Evolutionary trends of urban expansion and its sustainable development: Evidence from 80 representative cities in the belt and road initiative region. *Cities* **2023**, *138*, 104353. [CrossRef]
42. Yu, K.J.; Li, L. Alleviating waterlogging needs to build a 'sponge city'. *China Econ. Rep.* **2016**, *8*, 52–55.
43. Anonymous. Global Perspectives: Advanced Drainage Systems in Developed Countries. *Urban Manag. Technol.* **2013**.
44. Nguyen, T.T.; Ngo, H.H.; Guo, W.; Wang, X.C.; Ren, N.; Li, G.; Ding, J.; Liang, H. Implementation of a specific urban water management-Sponge City. *Sci. Total Environ.* **2019**, *652*, 147–162. [CrossRef]
45. Qi, Y.; Chan, F.K.S.; Thorne, C.; O'donnell, E.; Quagliolo, C.; Comino, E.; Pezzoli, A.; Li, L.; Griffiths, J.; Sang, Y.; et al. Addressing challenges of urban water management in Chinese sponge cities via nature-based solutions. *Water* **2020**, *12*, 2788. [CrossRef]
46. Song, C. Application of nature-based measures in China's sponge city initiative: Current trends and perspectives. *Nat. Based Solut.* **2022**, *2*, 100010. [CrossRef]
47. Zhou, Q.; Ren, Y.; Xu, M.; Han, N.; Wang, H. Adaptation to urbanization impacts on drainage in the city of Hohhot, China. *Water Sci. Technol.* **2016**, *73*, 167–175. [CrossRef]
48. Elmqvist, T.; Gatzweiler, F.; Lindgren, E.; Liu, J. Resilience management for healthy cities in a changing climate. *Biodivers. Health Face Clim. Chang.* **2019**, 411–424.
49. Nelson, V. *Achieving the Water Commons—The Role of Decentralised Systems*; IWA Publishing: London, UK, 2012; pp. 9–28.
50. Albright, C.M. *Resilience Strategies for Climate, Hydrology, and Urban Green Infrastructure*; Villanova University: Villanova, PA, USA, 2018.
51. Sun, Y.; Deng, L.; Pan, S.Y.; Chiang, P.C.; Sable, S.S.; Shah, K.J. Integration of green and gray infrastructures for sponge city: Water and energy nexus. *Water-Energy Nexus* **2020**, *3*, 29–40. [CrossRef]
52. Chapman, C.M. Green and Grey Drainage Infrastructure: Costs and Benefits of Reducing Surface Water Flood Risk. Ph.D. Thesis, University of Oxford, Oxford, UK, 2023.
53. Jiang, S.C.; Lim, K.Y.; Huang, X.; McCarthy, D.; Hamilton, A.J. Human and environmental health risks and benefits associated with use of urban stormwater. *Wiley Interdiscip. Rev. Water* **2015**, *2*, 683–699. [CrossRef]
54. Arnold, C.L., Jr.; Gibbons, C.J. Impervious surface coverage: The emergence of a key environmental indicator. *J. Am. Plan. Assoc.* **1996**, *62*, 243–258. [CrossRef]
55. Askarizadeh, A.; Rippy, M.A.; Fletcher, T.D.; Feldman, D.L.; Peng, J.; Bowler, P.; Jiang, S.C. From rain tanks to catchments: Use of low-impact development to address hydrologic symptoms of the urban stream syndrome. *Environ. Sci. Technol.* **2015**, *49*, 11264–11280. [CrossRef] [PubMed]
56. Miles, B.; Band, L.E. Green infrastructure stormwater management at the watershed scale: Urban variable source area and watershed capacitance. *Hydrol. Process.* **2015**, *29*, 2268–2274. [CrossRef]
57. Dudrick, R.; Hoffman, M.; Antoine, J.; Austin, K.; Bedoya, L.; Clark, S.; Gotsch, S.G. Do plants matter?: Determining what drives variation in urban rain garden performance. *Ecol. Eng.* **2024**, *201*, 107208. [CrossRef]
58. Bąk, J.; Barjenbruch, M. Benefits, inconveniences, and facilities of the application of rain gardens in urban spaces from the perspective of climate change—A review. *Water* **2022**, *14*, 1153. [CrossRef]

59. Dussaillant, A.R.; Wu, C.H.; Potter, K.W. Richards equation model of a rain garden. *J. Hydrol. Eng.* **2004**, *9*, 219–225. [CrossRef]
60. Jia, Z.; Tang, S.; Luo, W.; Li, S.; Zhou, M. Small scale green infrastructure design to meet different urban hydrological criteria. *J. Environ. Manag.* **2016**, *171*, 92–100. [CrossRef] [PubMed]
61. Han, J.W. Comprehensive evaluation of plant materials in Ya'an rainwater garden based on sponge city. *J. Cent. South Univ. For. Technol.* **2018**, *39*, 131–135.
62. Chen, W. Selection and application of plants in rain gardens for Sponge City construction in Xiamen. *Henan Build. Mater.* **2018**, 449–451.
63. Oudolf, P.; Kingsbury, N. *Planting: A New Perspective*; Timber Press: London, UK, 2016.
64. Burlando, P.; Vagge, I. The 'Green'as Element of Regional Identity. *ATTI* **2020**, 263–272.
65. Hitchmough, J.; Dunnett, N. *The Dynamic Landscape: Ecology, Design and Management of Urban Naturalistic Vegetation*; Spon Press: London, UK, 2003.
66. Hitchmough, J.; Wagner, M. The dynamics of designed plant communities of rosette forming forbs for use in supra urban drainage swales. *Landsc. Urban Plan.* **2013**, *117*, 122–134. [CrossRef]
67. Hitchmough, J.; Dunnett, N. Landscaping in Sport Complex; Ecologically Based Planting Design at the 2012 London Olympics. *MANZAR Sci. J. Landsc.* **2012**, *4*, 14–19.
68. Hitchmough, J.; Dunnett, N. Design and Planting Strategy in the Olympic Park, London. Flowering meadows around the Olympic sports facilities. *Topos Eur. Landsc. Mag.* **2013**, *83*.
69. Kumar, A. Experimental Study of a Rain Garden. Ph.D. Thesis, National Institutes of Technology, Ajitgarh, India, 2019.
70. Robinson, T.; Schulte-Herbrüggen, H.; Mácsik, J.; Andersson, J. *Raingardens for Stormwater Management: Potential of Raingardens in a Nordic Climate*; Swedish National Road and Transport Research Institute (VTI): Stockholm, Sweden, 2019.
71. Caparrós-Martínez, J.L.; Milán-García, J.; Rueda-López, N.; de Pablo-Valenciano, J. Green infrastructure and water: An analysis of global research. *Water* **2020**, *12*, 1760. [CrossRef]
72. Novotny, V. Sustainable urban water management. In *Water and Urban Development Paradigms*; CRC Press: Boca Raton, FL, USA, 2008; pp. 37–50.
73. Kasprzyk, M.; Szpakowski, W.; Poznańska, E.; Boogaard, F.C.; Bobkowska, K.; Gajewska, M. Technical solutions and benefits of introducing rain gardens–Gdańsk case study. *Sci. Total Environ.* **2022**, *835*, 155487. [CrossRef]
74. Malaviya, P.; Sharma, R.; Sharma, P.K. Rain gardens as stormwater management tool. In *Sustainable Green Technologies for Environmental Management*; Springer: Singapore, 2019; pp. 141–166.
75. Sharma, R.; Malaviya, P. Management of stormwater pollution using green infrastructure: The role of rain gardens. *Wiley Interdiscip. Rev. Water* **2021**, *8*, e1507. [CrossRef]
76. Morash, J.; Wright, A.; LeBleu, C.; Meder, A.; Kessler, R.; Brantley, E.; Howe, J. Increasing sustainability of residential areas using rain gardens to improve pollutant capture, biodiversity and ecosystem resilience. *Sustainability* **2019**, *11*, 3269. [CrossRef]
77. Philp, M.; McMahon, J.; Heyenga, S.; Marinoni, O.; Jenkins, G.; Maheepala, S.; Greenway, M. Review of stormwater harvesting practices. In *Urban Water Security Research Alliance Technical Report*; 2008. Available online: https://www.researchgate.net/profile/Oswald-Marinoni/publication/268435696_Review_of_Stormwater_Harvesting_Practices/links/54bda4020cf218da9391b541/Review-of-Stormwater-Harvesting-Practices.pdf (accessed on 12 March 2024).
78. Syafriana, A.; Arifin, H.S. Rain garden model for stormwater management in Sentul City, Bogor, Indonesia. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2020; p. 01203147.
79. Carpenter, D.D.; Hallam, L. Influence of planting soil mix characteristics on bioretention cell design and performance. *J. Hydrol. Eng.* **2010**, *15*, 404–416. [CrossRef]
80. DelVecchio, T.; Welker, A.; Wadzuk, B.M. Exploration of volume reduction via infiltration and evapotranspiration for different soil types in rain garden lysimeters. *J. Sustain. Water Built Environ.* **2020**, *6*, 04019008. [CrossRef]
81. Funai, J.T.; Kupec, P. Evaluation of three soil blends to improve ornamental plant performance and maintain engineering metrics in bioremediating rain gardens. *Water Air Soil Pollut.* **2019**, *230*, 3. [CrossRef]
82. Virahsawmy, H.K.; Stewardson, M.J.; Vietz, G.; Fletcher, T.D. Factors that affect the hydraulic performance of raingardens: Implications for design and maintenance. *Water Sci. Technol.* **2014**, *69*, 982–988. [CrossRef] [PubMed]
83. Yuan, J.; Dunnett, N. Plant selection for rain gardens: Response to simulated cyclical flooding of 15 perennial species. *Urban For. Urban Green.* **2018**, *35*, 57–65. [CrossRef]
84. Campbell, C.; Johnston, C.; Lee, D.; Zabil, D.; Morgan, L.; Pour, S. Top ten design considerations for rain gardens. *Proc. Water Environ. Fed.* **2013**, *2013*, 1501–1511. [CrossRef]
85. Liao, K.H.; Deng, S.; Tan, P.Y. Blue-green infrastructure: New frontier for sustainable urban stormwater management. In *Greening Cities: Forms and Functions*; Springer: Singapore, 2017; pp. 203–226.
86. Shi, L.; Dai, C.; Maruthaveeran, S. Application of Perennial Sweet Pea in Soil and Water Conservation. *Appl. Sci.* **2023**, *13*, 11075. [CrossRef]
87. Zuazo, V.H.D.; Pleguezuelo, C.R.R. Soil-erosion and runoff prevention by plant covers: A review. *Sustain. Agric.* **2009**, *28*, 785–811.
88. Lewis, J.F.; Hatt, B.E.; Deletic, A.; Fletcher, T.D. The impact of vegetation on the hydraulic conductivity of stormwater biofiltration systems. In Proceedings of the 11th International Conference on Urban Drainage, Edinburgh, UK, 1 August–5 September 2008.
89. Löbmann, M.T.; Geitner, C.; Wellstein, C.; Zerbe, S. The influence of herbaceous vegetation on slope stability—A review. *Earth-Sci. Rev.* **2020**, *209*, 103328. [CrossRef]

90. Boldrin, D.; Knappett, J.A.; Leung, A.K.; Brown, J.L.; Loades, K.W.; Bengough, A.G. Modifying soil properties with herbaceous plants for natural flood risk-reduction. *Ecol. Eng.* **2022**, *180*, 106668. [CrossRef]
91. Wang, J.F.; Yang, Y.F.; Liu, G.B.; Wang, B.; Zhang, F.B.; Fang, N.F. Investigating the effects of herbaceous root systems on the soil detachment process at the species level. *Sci. Total Environ.* **2023**, *859*, 160196. [CrossRef]
92. Biswal, B.K.; Bolan, N.; Zhu, Y.G.; Balasubramanian, R. Nature-based Systems (NbS) for mitigation of stormwater and air pollution in urban areas: A review. *Resour. Conserv. Recycl.* **2022**, *186*, 106578. [CrossRef]
93. Fernández Cañero, R.; González Redondo, P. Green roofs as a habitat for birds: A review. *J. Anim. Vet. Adv.* **2010**, *9*, 2041–2052.
94. Taylor, J.R.; Lovell, S.T. Designing multifunctional urban agroforestry with people in mind. *Urban Agric. Reg. Food Syst.* **2021**, *6*, e20016. [CrossRef]
95. Yang, Y. Plant selection for green stormwater infrastructure in Guanzhong Area. *Shaanxi For. Sci. Technol.* **2020**, *48*, 72–80.
96. Han, Y.; Liu, L.; Yao, Y.Z. Ecological adaptability and application of rain water garden plants in sponge city pilot area of Beijing City. *Bull. Soil Water Conserv.* **2023**, *43*, 186–194.
97. Wu, W.T.; Wang, Y.M.; Qin, X.Z.; Sui, Y.; Ren, L. Application status and optimization strategy of bamboo resources in rain gardens in Hangzhou, China. *Acta Agric. Zhejiangensis* **2023**, *35*, 1338–1348.
98. Ma, X.Y.; Shu, Y.; Shi, Y.; Bao, Z.Y. Analysis of plant selection and landscaping design for rain garden: A case study of Gongkang Rainwater Garden in Shanghai. *Acta Agric. Zhejiangensis* **2018**, *30*, 1526–1533.
99. Liu, J.J.; Guo, H.C.; Bai, W.L.; Gao, Y.K.; Zhang, Q.X. Selection of Rain Garden Plants in Northern Regions. *North. Hortic.* **2016**, *10*, 82–87.
100. Xu, H.W.; Yu, D.G.; Zhou, X.W. Comparative Study on Flood Tolerance of 15 Rain Garden Plants in Southern Anhui. *J. Guiyang Univ. Nat. Sci. Q.* **2022**, *17*, 58–64.
101. Yang, Y.; Chen, D. Rain Garden Plants in the Semi-arid and Semi-humid Region of Northwest China: Application and Suitability Evaluation. *Chin. Agric. Sci. Bull.* **2021**, *37*, 54–60.
102. Casanova, M.T.; Brock, M.A. How do depth, duration and frequency of flooding influence the establishment of wetland plant communities? *Plant Ecol.* **2000**, *147*, 237–250. [CrossRef]
103. Taguchi, V.J.; Weiss, P.T.; Gulliver, J.S.; Klein, M.R.; Hozalski, R.M.; Baker, L.A.; Finlay, J.C.; Keeler, B.L.; Nieber, J.L. It is not easy being green: Recognizing unintended consequences of green stormwater infrastructure. *Water* **2020**, *12*, 522. [CrossRef]
104. UP+S Rain Garden, Beijing 768 Creative Park/UP+S. UP+S Rain Garden. Available online: https://www.gooood.cn/rain-garden-ups.htm (accessed on 4 September 2020).
105. Zou, Y.B.; Meng, X.Y. Sponge city landing-UP+S rain garden practice. *Constr. Technol.* **2016**, 39–41.
106. Yin, L.H. *Theories and Practices of Urban Rain Garden*; Huazhong University of Science and Technology Press: Wuhan, China, 2018.
107. Sun, C.; Zhao, Y.; Zou, Y.C.; Zhang, M.; Fu, X.Y. Exploring the application of rainwater garden in campus—Taking the Yuyun Garden of Huazhong University of Science and Technology as an example. *Chin. Hortic. Abstr.* **2017**, 119–121.
108. Plant Configuration in Rain Garden. Available online: https://zhuanlan.zhihu.com/p/99521261 (accessed on 10 August 2020).
109. Dong, Y.Y. Research on Road Landscape Design of Spong City in Xixian New District. Master's Thesis, Northwest Agriculture and Forestry Technology, Xianyang, China, 2018.
110. Xia, Y. Habitat-Side Design Method in the Street Green Space of Citiies in North-Western China Based on LID Strategies—Take Fengxi New City as Example. Master's Thesis, Xi'an University of Architecture and Technology, Xi'an, China, 2016.
111. Brickell, C. *RHS Encyclopedia of Gardening*; Dorling Kindersley Ltd.: London, UK, 2012.