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Research on the Design Strategy of Adaptive Urban Waterfront Parks Based on Rainwater Resilience

--Taking the Waterfront Space Near Hongdao Street in Qingdao As an Examples

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ABSTRACT

With the acceleration of urbanization and people's pursuit of healthy lifestyles, the development and utilization of urban waterfront space has become more and more important, and ecological parks have also received more and more attention and attention. The research target of this article is the waterfront space located in Hongdao Street, Chengyang District, Qingdao City, Shandong Province, China. Based on the perspective of waterfront park transformation, the concept of "resilient landscape" is introduced to explore the design and implementation of sports ecological parks in urban waterfront spaces. Construction, in order to provide a multi-functional, sustainable public space to meet people's comprehensive fitness and leisure entertainment needs. The core issue is how to realize the comprehensive utilization and ecological restoration of waterfront space through river reconstruction and the design of sports ecological parks, so as to create a healthy and beautiful urban living space for people. It provides a reference for the construction of sponge cities in Qingdao and is of great significance to the construction of sponge cities and ecological civilization.

KEYWORDS

Resilient Landscape; Ecological Restoration; Sports Park; National Fitness.

1. INTRODUCTION

As an important landscape and leisure place in the city, urban waterfront space plays an important role in urban planning and design. However, with the intensification of climate change and urbanization, urban waterfront areas are often affected by natural disasters such as rain and floods, which brings certain challenges to urban development. Therefore, how to consider rain and flood resilience in the planning and design of urban waterfront parks and improve their adaptability is of great practical significance.

Resilient landscape refers to the ability of landscape to quickly restore to its original state or adjust its structure in the face of various internal and external pressures and challenges through reasonable planning, design and management to maintain its basic functions, ecosystem health and social services [2]. The concept of resilient landscape comes from the fields of ecology and urban planning, emphasizing the adaptability and resilience of landscape systems to natural and human interference. Qingdao, as a national coastal open city, is a national historical and cultural city and a scenic tourist and holiday resort. With the continuous development of urbanization and industrialization, coupled with persistent dry conditions, Qingdao has suffered from severe water shortages. At present, the

increasingly prominent water resource problem has led to the industrialization development process of Qingdao, forcing a large number of factories to limit water and production, and even the water use of citizens has been greatly restricted, which has seriously affected the development process of Qingdao as a tourist city and the daily life of residents. Therefore, this study took the waterfront space near Hongdao Street, Chengyang District, Qingdao City, Shandong Province, China as the transformation target for research, combined with the concept of resilient landscape and rainwater management with ecological functions. The application of resilient landscape in Qingdao not only improves the city's disaster resistance and ecological environment quality, but also promotes the sustainable development of social economy.

2. FLOOD RESILIENCE AND WATERFRONT PARK DESIGN

2.1. Resilience thinking and flood resilience

Resilience thinking emphasizes the importance of resilience and recovery, which is closely related to the concept of flood resilience. Cities and communities need to adapt and recover quickly after disasters to reduce losses and resume normal life as soon as possible[1]. Flood resilience refers to the ability of urban infrastructure systems and planning designs to effectively cope with floods and other related disasters caused by extreme rainfall events. The importance of flood resilience lies in the fact that with the impact of climate change, the frequency and intensity of extreme rainfall events may increase, so cities need to take measures to ensure the reliability of infrastructure and the safety of urban residents. Specifically, the concept of flood resilience involves the following aspects:

2.1.1. Flood resistance

Urban infrastructure needs to be designed and built to be able to effectively drain and resist floods. This may include improving drainage systems, building flood walls, developing green infrastructure (such as rain gardens and wetlands), and adopting sustainable urban drainage management strategies.

2.1.2. Resilience

When extreme rainfall events occur, cities need to quickly resume normal operations. This includes repairing damaged infrastructure, providing emergency services and support, and rebuilding affected communities.

In general, flood resilience is a comprehensive concept involving urban planning, infrastructure construction, community preparation and response measures, aiming to ensure that cities can maintain safe, stable and sustainable development in the face of extreme rainfall events.

2.2. Pay attention to the importance of flood resilience

The importance of flood resilience has become increasingly prominent in the context of increasingly frequent extreme weather events and climate change. Resilient landscapes can improve the city's disaster resistance and reduce the impact of natural disasters on the city. For example, the use of flood control green spaces and ecological wetlands in urban design can slow down the flow rate of floods, reduce flood risks, and improve the city's flood resistance. Its importance is mainly reflected in the following aspects:

2.2.1. Ecosystem protection

Resilient landscapes emphasize the protection and restoration of ecosystems. By increasing green space coverage and improving ecological environment quality, they promote biodiversity maintenance and ecological function improvement, and protect and improve natural ecosystems.

2.2.2. Effective use of resources

Resilient landscapes advocate the effective use and recycling of resources. Through measures such as energy conservation, emission reduction, and improved resource utilization efficiency, they achieve sustainable use of urban resources and reduce the city's ecological footprint.

Rainstorm and flood disasters may have serious impacts on urban infrastructure, such as paralyzing traffic, damaging water supply, and power outages. By improving rainstorm and flood resilience, we can reduce the losses caused by floods, reduce the cost of response and recovery, improve the city's disaster resistance, ensure the normal operation of urban infrastructure, and ensure the sustainable development of the city.

2.2.3. Enhance urban climate adaptability

Rainstorm and flood resilience is one of the important means for cities to adapt to climate change. By adjusting urban climate and improving urban environment, we can enhance the city's ability to adapt to climate change, reduce the impact of extreme weather events on cities, and improve the city's climate comfort and livability. As the frequency and intensity of extreme rainfall events caused by climate change increase, improving rainstorm and flood resilience can enhance the city's ability to adapt to climate change and reduce the disaster risks caused by climate change. It helps cities achieve sustainable development goals. Through reasonable planning, scientific design and disaster risk management, we can improve the ecological environment quality, social and economic benefits and quality of life of residents in cities and achieve sustainable development of cities.

3. CURRENTS STATUS AND PROBLEMS

3.1. Geographical location and basic overview of the study area

The research target is located in the waterfront space near Hongdao Street, Chengyang District, Qingdao City. The river flows south into the sea and crosses Yangmaogou Bridge in the south. The site is located in Chengyang District, Qingdao City, Shandong Province, China, and is an important waterfront area. This area is famous for its unique natural scenery and rich ecological resources. The site belongs to warm temperate subhumid monsoon climate. Directly regulated by the marine environment, it has significant marine climate characteristics. The air is humid, the temperature is moderate, and the four seasons are distinct. Affected by the marine climate and temperate monsoon climate, there is more rainfall in July and August.

As one of the main administrative districts of Qingdao City, Chengyang District has been committed to promoting urban sustainable development and ecological environmental protection. In the waterfront space near Hongdao, the Chengyang District Government and relevant departments have realized the importance of developing a sports ecological park. This area has a rich cultural history and ecological system, and the construction of a sports ecological park can provide local residents with a place for leisure, entertainment, fitness and close to nature. The development potential of the waterfront space is huge. The area is endowed with unique natural resources. In addition, Hongdao is relatively close to the center of Qingdao, with convenient transportation, providing residents and tourists with convenient access to and opportunities to enjoy this waterfront space.

3.2. Analysis of strengths and weaknesses of the study area

3.2.1. Strengths:

(1) Rich water resources: The site is surrounded by rich water resources, providing opportunities for landscape design and ecological restoration. The development potential of waterfront space is huge[3]. The area is endowed with unique natural resources.

(2) Strong comprehensive feasibility of the surrounding area: There are many high-tech enterprises and residential areas around the site, which provides a potential population base and cooperation opportunities for park development and operation.

3.2.2. Weaknesses:

(1) Single plant species: The site has a single plant species problem, which may lead to monotonous landscape and fragility of the ecosystem.

(2) Incomplete embankment tour line: The site's embankment tour line is incomplete, which may limit people's waterfront activities and experience.

(3) Excessive garbage and ecological damage: There are problems of excessive garbage and ecological damage, which are not conducive to the environmental quality and sustainable development of the park.

(4) Insufficient development: The development level of the site is relatively insufficient, which may limit the attractiveness and functional diversity of the park.

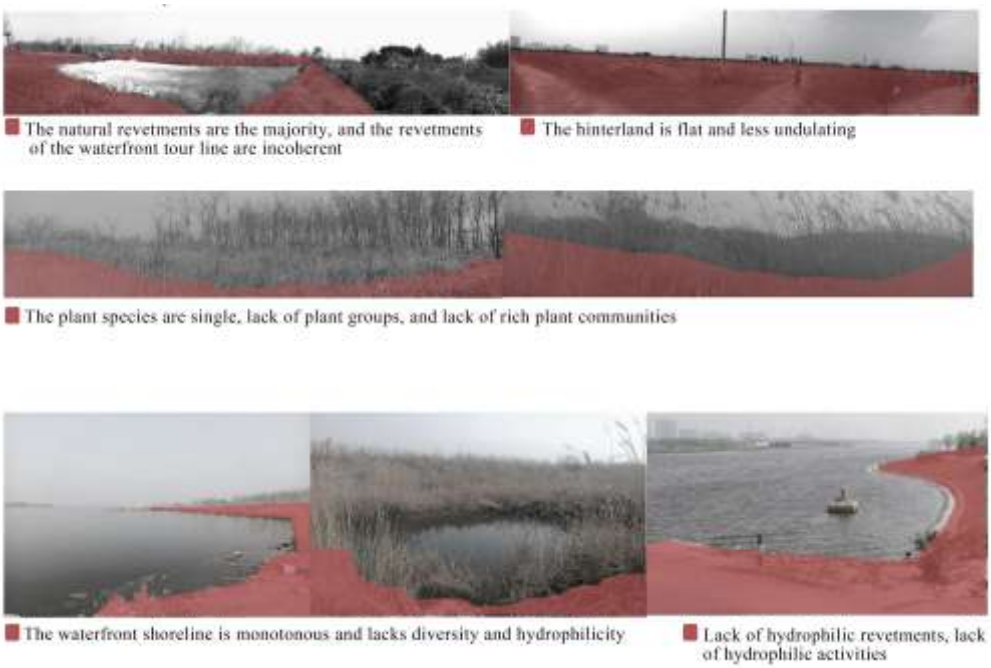

Figure 1. Analysis of current site conditions

3.2.3. Opportunities:

(1) Plant diversification and ecological restoration: By introducing more plant species and carrying out ecological restoration, the landscape quality and ecological function of the base can be improved, and more biodiversity can be attracted.

(2) Improve the revetment tour line: By planning and building a complete revetment tour line, more waterfront activities and leisure space can be provided to increase people's participation and experience value.

3.3. Composition and needs of the surrounding population in the study area

3.3.1. Composition of the surrounding population

The surrounding residential areas are densely populated, and there are many high-tech enterprises. Residents living in the surrounding residential areas will be the main service group of the park. These residents include people of different ages and professional backgrounds, such as families, the elderly, and students. They may want to exercise, relax, engage in outdoor activities, and socialize in the park.

Employees of surrounding high-tech enterprises may be potential service groups. These employees often have high work pressure, and they may need to find ways to relax during the workday or on weekends. The sports ecological park can provide them with a place to relieve stress, exercise, and communicate with colleagues.

Figure 2. Population composition and main life needs

3.3.2. Demand analysis:

(1) Fitness and leisure needs: Residents of residential areas and employees of enterprises may have fitness and leisure needs. They may need well-equipped sports areas, fitness equipment, jogging paths, bicycle paths, etc. to meet their needs for aerobic exercise, strength training and leisure activities[4].

(2) Social and interactive needs: People also want to be able to socialize and interact with others in parks. To meet this need, parks can provide leisure areas, rest seats, outdoor activity venues, etc., to encourage people to make new friends, organize group activities and participate in collective sports.

(3) Environmental quality needs: As a green public space, people hope that ecological parks can provide a beautiful environment and a comfortable experience. This includes clean air, tree-lined landscapes, good lighting and safety facilities. People also pay attention to the sustainability and ecological protection of parks and hope to enjoy activities and leisure in a natural environment.

4. DESIGN STRATEGY UNDER THE GUIDANCE OF STORMWATER RESILIENCE

The transformation concept of the study area should focus on ecological restoration and protection. Measures such as introducing diverse plant species can promote the health and diversity of the ecosystem. Urban parks with flood storage and detention functions integrate ecological protection, science popularization and education, and meet the needs of stormwater management and urban populations[5]. At the same time, they should pursue multifunctionality to meet the needs and activities of different groups of people. Consider designing sports facilities, leisure areas, waterfront squares, etc. to provide people with space for leisure, exercise and social interaction. Cultural elements can be incorporated to enhance the charm and uniqueness of the park. For example, sculptures, art installations, cultural display areas, etc. can showcase local history, culture and creative spirit, bringing people art and cultural enjoyment. The aim is to create an eco-friendly, diverse and sustainable sports ecological park, providing people with an ideal place to interact with nature, exercise their bodies and minds, relax and entertain, and socialize.

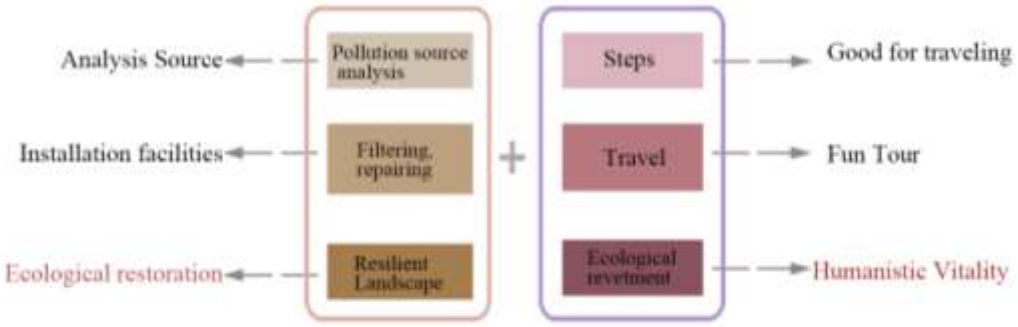

Figure 3. Design concept based on stormwater resilience

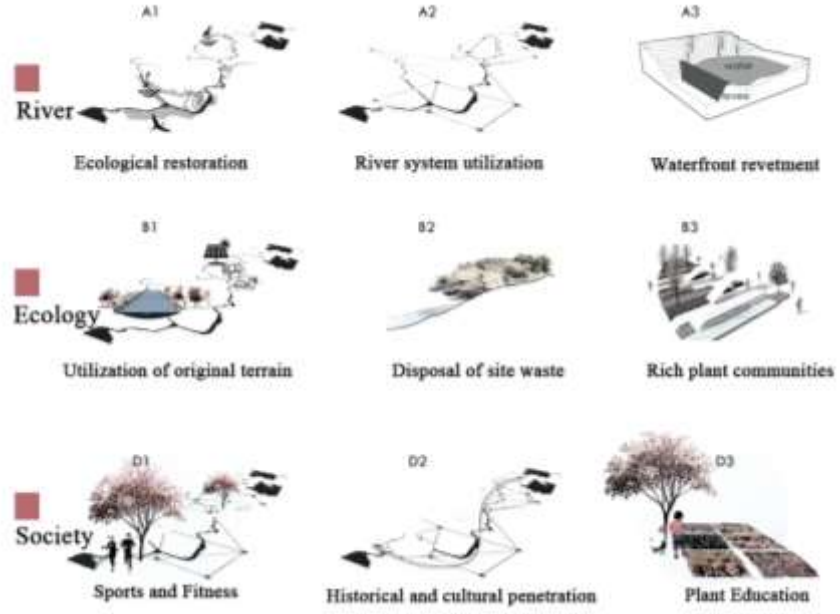

Figure 4. Design strategies guided by stormwater resilience

4.1. Ecological restoration strategy

Consider ecological restoration and vegetation restoration, and introduce local suitable plants to restore and increase biodiversity. Repair the water quality and water environment of water bodies, and use technologies such as biofilters and wetland filtration to effectively increase soil permeability and water storage, slow down the speed of rainwater runoff, and thus reduce the harm of floods to improve the health of the ecosystem. In the construction of plant communities, natural communities are the core, with a stable and balanced ecosystem. In addition, urban wetland parks have a wide variety of habitats, and they are suitable for the habitat and survival of animals and plants[5].

Diverse selection of native plants, including trees, shrubs, flowers and ground cover plants. Consider the growth characteristics, adaptability and seasonal changes of plants to ensure attractive landscapes throughout the year. According to the climatic conditions and soil types of the site, select plants with strong adaptability to ensure that they can grow healthily under the site conditions.

At the same time, select plants with ecological functions and consider introducing wetland plants. Natural hydrophilic plant materials such as grass, reeds, willows, etc. can be used for protection of the bank slope. These plants thrive in a humid environment, protecting the bank slope while creating

a rich natural ecological environment along the coast[7]. At the same time, it is necessary to consider color and layering, and create rich color and layering effects by selecting the flower color, leaf color and texture of the plants. Consider creating attractive landscape changes in different seasons and different areas.

4.2. Use permeable materials

The use of permeable pavement and green roofs can increase the permeable area of the city, reduce rainwater runoff, and reduce the harm of floods. Permeable pavement includes permeable concrete, permeable bricks, permeable lawns, etc., which can allow rainwater to directly penetrate into the groundwater layer or be absorbed by vegetation, reducing surface runoff and playing a role in protecting and absorbing rainwater.

In pavement design, factors such as permeability, skid resistance and durability should be considered to ensure the safety and sustainability of paving materials. Such as permeable bricks, antiseptic wood, granite, etc. On the flat and hard ground of the park, the surface runoff absorption method of the permeable pavement should be fully considered, which can give full play to the advantages of the "sponge" and form a natural ecological regulation cycle[8]. Permeable bricks allow water to penetrate through their surface into the groundwater layer, reducing water runoff and stormwater discharge pressure. Permeable bricks can be used for paving roads, squares and other places to create permeable paving surfaces, which are conducive to water infiltration and rainwater management. The color and shape of permeable bricks can be selected according to design requirements to coordinate with the surrounding environment and landscape. Anticorrosive wood has anti-corrosion and durability, and is suitable for outdoor use. It can be used for paving and construction of places such as trails, water plank roads, bridges, leisure seats and viewing platforms, providing a natural wood texture and warm feeling.

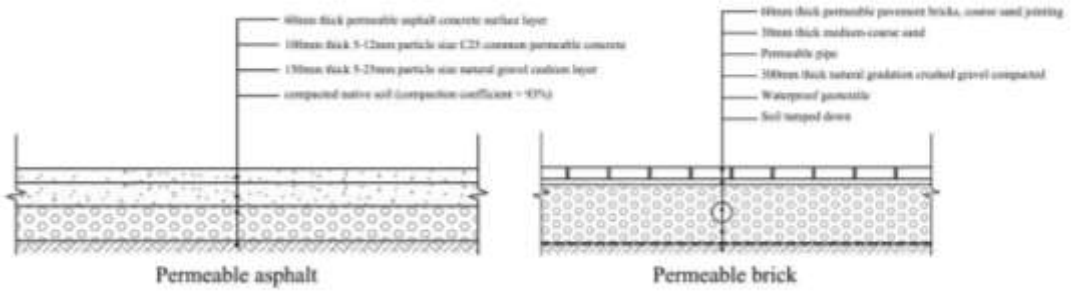

Figure 5. Using permeable materials to reduce surface runoff

4.3. Revetment enrichment strategy

Design a variety of revetment types, including standing ecological hydrophilic space, sightseeing ecological hydrophilic space, and participatory ecological hydrophilic space. Different shoreline designs will produce different ecological hydrophilic spaces, which have a significant impact on tourists and local ecology[1]. Design ecological wetlands in the revetment area of the site, including artificial wetlands, shallow water areas, reed beds, etc., to restore the wetland ecosystem, provide water purification, biological habitats and ornamental value[6]. Combined with topographic and hydrological conditions, design a variety of ecological landscapes, including tidal flats, aquatic vegetation, wetland habitats, etc., to increase the ecological landscape value of the site. At the same time, strengthen the protection and management of the waterfront ecosystem, strictly control development and utilization activities, prevent pollution and ecological damage, and maintain the stability and healthy development of the revetment ecosystem.

4.4. Construction of intelligent drainage system

Design and construction of intelligent drainage system can effectively collect, store and utilize rainwater, reduce the load of urban drainage pipe network, reduce the speed of rainwater discharge, and thus reduce the occurrence of floods[9]. These systems can also be combined with urban landscapes. For example, rainwater collection systems can be designed into landscape pools or rain gardens, which not only play a role in rainwater management, but also improve the quality of the landscape. The advantage of intelligent drainage systems is that they can effectively manage and utilize rainwater, reduce the occurrence of urban floods, and improve the city's flood resistance and resilience. The following are common intelligent drainage measures:

4.4.1. Rainwater Collection System

The intelligent drainage system collects rainwater by setting up rainwater collection facilities, such as rainwater grates and rainwater wells. These collection facilities are usually located in areas such as roads, squares, and roofs, and can effectively collect a large amount of rainwater.

4.4.2. Reservoirs and Water Storage Facilities

The collected rainwater is transported to reservoirs and water storage facilities for temporary storage. Reservoirs are usually set underground or on the bottom floor of buildings. By controlling equipment such as gates and pump stations, the water level in the reservoir can be adjusted to achieve rainwater regulation and storage.

4.4.3. Rainwater Utilization System

Part of the collected rainwater can be used for urban greening, landscape water bodies, road washing, etc. By setting up rainwater utilization facilities, such as rainwater gardens and rainwater wetlands, rainwater can be effectively utilized, reducing the demand for urban tap water and reducing the pressure on urban water supply.

4.5. Ecological river restoration and management

Under the background of resilient landscape, ecological restoration and management of the river in the study area can improve the water conveyance capacity of the river, reduce river siltation and sediment transportation, slow down the speed of rainwater runoff, and reduce the occurrence of floods [10]. To improve the health of the river ecosystem, enhance its natural conservation function, reduce the occurrence of flood disasters, and improve the quality of the urban environment, the following are common ecological river restoration and management measures:

4.5.1. Desilting and dredging

For silted rivers, desilting and dredging are required to remove silt and debris in the river, restore the original water flow of the river, improve the water conveyance capacity of the water body, reduce water flow resistance, slow down the flow rate of floods, and reduce the risk of floods.

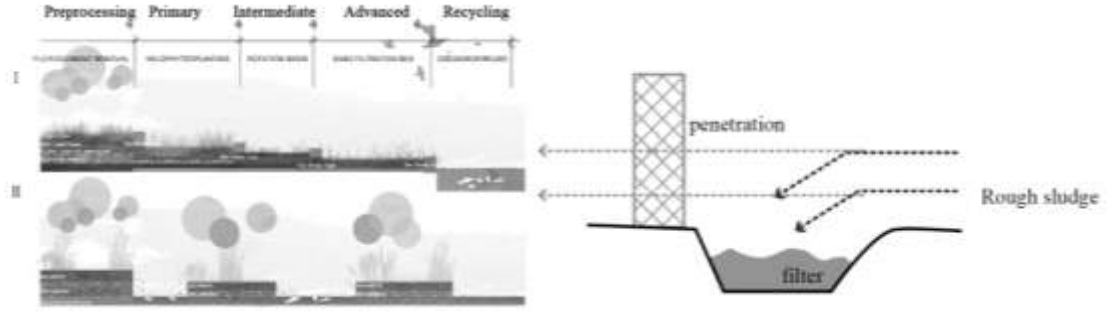

Figure 6. River garbage cleaning, silt removal and dredging

4.5.2. Shoreline greening and vegetation restoration

The greening and vegetation on both sides of the river play an important role in protection and stabilization. They can slow down the flow of river water, reduce the speed of riverbank erosion, and reduce the input of pollutants into the river. Therefore, vegetation restoration and shoreline greening work can be carried out on both sides of the river, and trees, shrubs and herbaceous plants suitable for the local environment can be planted, suitable vegetation can be introduced, the growth and reproduction of vegetation can be promoted, and the ecological function of the ecosystem can be restored[11]. Vegetation restoration can be achieved through artificial planting, natural restoration or the introduction of endangered species to form a stable riverbank ecosystem.

4.5.3. Ecological restoration and wetland construction

Wetland construction and ecological restoration work can be carried out in appropriate areas around the river. Water purification can adopt ecological engineering means such as biological filters, artificial wetlands, and plant filters to improve the transparency and oxygen content of water bodies, promote the growth of plants and microorganisms in water, increase the biodiversity in water bodies, establish a healthy ecosystem, and improve the ecological function of rivers [13]. Increasing wetland area, improving soil water absorption capacity, enhancing water retention and storage capacity, slowing down rainwater runoff, and alleviating floods. Wetland ecosystems can also purify water, improve water quality, and improve the self-purification capacity of water.

In resilient landscapes, ecological restoration usually includes restoring damaged ecosystem structures and functions, promoting vegetation growth and biodiversity, and improving ecosystem stability and anti-interference capabilities. Ecological restoration can be achieved through vegetation restoration, soil restoration, water purification, etc. [12]. Wetland construction can be achieved by artificially constructing wetlands or restoring degraded wetlands to increase the wetland area and function of cities, improve the city's natural water absorption capacity and hydrological regulation capacity, slow down rainwater runoff, and reduce flood risks.

The above can effectively improve the resilience of rivers, reduce the occurrence of floods, create beautiful ecological river landscapes, improve urban environmental quality, and enhance the ecological and landscape quality of cities. In urban planning and design, these measures should be reasonably selected and configured according to the specific geographical environment and river characteristics to improve urban resilience and ensure urban safety and stable development.

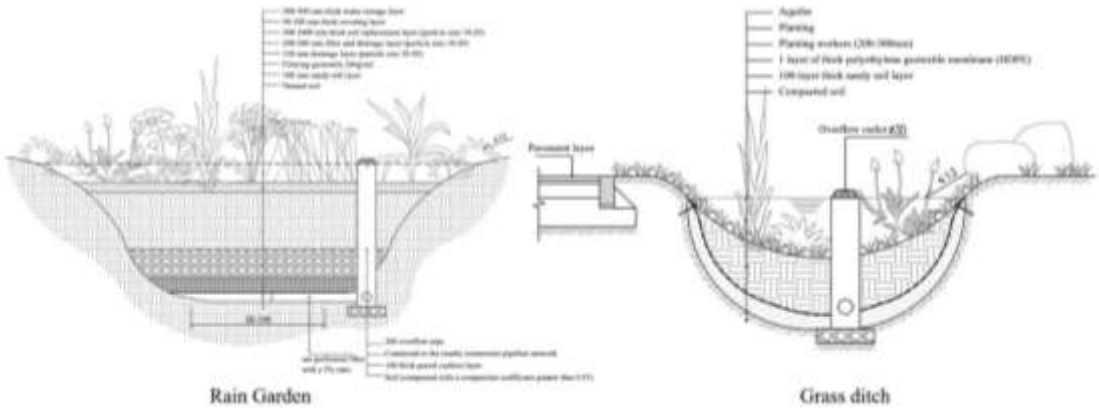

Figure 7. Main measures for stormwater management

4.6. Community participation education

Through community education and participation activities, we can improve residents' awareness of environmental protection and their ability to cope with flood disasters, cultivate residents' conscious compliance with environmental laws and regulations, and promote the overall resilience and sustainable development of the community.

Organize community residents to participate in urban environmental improvement and cleaning work, clean up rivers, streams and other water bodies, clean up urban garbage and weeds, keep the urban drainage system unobstructed and smooth, and reduce the occurrence of urban flood disasters . It can effectively enhance the community's disaster resistance and resilience and reduce the impact of flood disasters on the city. At the same time, these measures also help to strengthen the cohesion and cooperation awareness among community residents and promote the harmonious development and sustainable development of the community.

5. SUMMARY

This paper explores the design strategy of adaptive urban waterfront parks based on stormwater resilience, aiming to cope with the challenges of flood disasters and climate change faced by the city, while enhancing the ecological value and social function of urban waterfront spaces. Through the introduction of the concept of stormwater resilience and the analysis of relevant cases, a series of adaptive design strategies are proposed, and the waterfront space of Hongdao Street in Qingdao City is used as a case study. Through the transformation and design of the waterfront space near Hongdao Street, Chengyang District, Qingdao City, Shandong Province, China, this paper aims to explore the organic combination of waterfront park transformation and sports ecological park to meet people's needs for comprehensive fitness and leisure and entertainment, and promote the coordinated development of urban green space and ecological environment.

First, starting from the concept of resilient landscape, the design principle of learning from nature and giving priority to ecology is emphasized. Secondly, the paper proposes a variety of design strategies including green space and wetland protection, intelligent drainage system construction, ecological river restoration and management, community participation and education. Among them, the construction of intelligent drainage system can effectively reduce the occurrence of urban flood disasters, while the restoration and management of ecological river can improve the ecological quality and landscape quality of urban waterfront space. The goal of these design strategies is to create a multifunctional and sustainable public space that not only meets people's needs for fitness and leisure, but also promotes the restoration and protection of natural ecology.

In summary, the adaptive urban waterfront park design strategy based on rain and flood resilience proposed in this paper has important theoretical and practical significance. Through the transformation and ecological restoration of waterfront parks, the coordinated development of urban green space and ecological environment can be achieved. Contribute to urban development and ecological protection, and create beautiful, healthy and sustainable urban living space. It can not only improve the city's flood resistance and resilience, but also enhance the ecological function and social value of the urban waterfront space, providing important ideas and references for the sustainable development of the city. However, with the continuous advancement of urbanization and the continued impact of climate change, further in-depth research and improvement of relevant design strategies are needed in the future to cope with more complex urban challenges.

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