

Constructing Urban Waterfront Ecological Space Safety Patterns Based on Nature-based Solutions (NbS)

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Received: 25 November 2023; **Accepted:** 18 December 2023; **Published:** 27 December 2023

Abstract:

The ecosystem in urban waterfront areas has always faced threats, posing a challenge to the safety and sustainable development of cities. Natural solutions, also known as NbS, are a sustainable method that utilizes the functionality and processes of natural systems to improve the ecological health and function of urban waterfront areas, while enhancing the resilience and adaptability of cities towards disasters. This paper aims to explore the potential of constructing a safe ecological spatial pattern in urban waterfront areas with the application of NbS. Firstly, the concept and importance of urban waterfront ecological space are expounded, emphasizing the urgency of protecting and restoring the waterfront ecological space. Secondly, through analyzing domestic and foreign cases of NbS application, the characteristics and advantages of NbS in urban waterfront areas are summarized. This study has theoretical and practical guiding significance for the ecological protection and sustainable development of urban waterfront areas. NbS will provide an important solution for the ecological health and safety of urban waterfront areas.

Keywords:

NbS, Urban Waterfront, Ecological Space, Safety Pattern

1. Introduction

Urban waterfront ecological spaces are integral parts of the intersection between cities and water environments. Not only do they provide natural beauty, but they also play a crucial role in the safety and sustainable development of cities. However, in the context of urbanization and economic development, urban waterfront areas often face destruction and pressure on their ecosystems, leading to issues such as water pollution, flooding, and loss of biodiversity, which pose threats to urban safety. In response to this problem, Nature-based Solutions (NbS), as an innovative approach and strategy, have been increasingly recognized by academia and practitioners. By imitating natural processes and utilizing the functions of natural systems, NbS aims to improve ecosystem health and functionality, enhance urban resilience and adaptability. In the construction and management of urban waterfront ecological spaces, NbS can provide

diverse solutions for stakeholders, taking into account the ecological, social, and economic benefits. However, research on the construction of secure patterns for urban waterfront ecological spaces based on NbS remains relatively limited. Therefore, this paper aims to explore the potential and practices of constructing secure patterns for ecological spaces based on NbS through case studies in waterfront areas, offering new ideas and methods for ecological conservation and sustainable development in urban waterfront areas. Through this research, we hope to provide new ideas and methods for ecological conservation and safety construction in urban waterfront areas, promoting harmonious development between cities and nature. Additionally, this study holds theoretical and practical significance for promoting research on sustainable urban development based on NbS.

2. Concept and Importance of Urban Waterfront Ecological Space

2.1. Definition and scope of urban waterfront ecological space

Urban waterfront ecological space is an area where the city and water environment intersect, including bodies of water such as rivers, lakes, reservoirs, and oceans, as well as corresponding landforms and ecosystems such as wetlands, beaches, riverbanks, and islands. The area and scope of urban waterfront ecological space vary depending on the location and terrain of the city, usually located at the edge or center of the city. Urban waterfront ecological space not only possesses unique functions of ecological system protection and ecological services, but also represents an important component of urban culture and tourism. Moreover, urban waterfront ecological space can have profound impacts on the safety and sustainable development of the city. Therefore, in the construction and management of urban waterfront ecological space, it is crucial to fully consider the protection and improvement of the ecosystem.

2.2. Impact of urban waterfront ecological space on urban safety

Urban waterfront ecological spaces have a significant impact on urban safety. Firstly, these spaces effectively mitigate the risk of flooding. The presence of natural wetlands and rivers allows for the absorption and storage of large amounts of rainfall, attenuating peak flood flows and providing hydrological regulation. Moreover, wetlands act as filters, purifying water and reducing the risk of water pollution, thereby decreasing the possibility of urban water resources becoming contaminated. Secondly, urban waterfront ecological spaces serve as natural barriers, enhancing the city's resilience to risks. Along coastal areas and riverbanks, coastal wetlands and vegetation provide protection, mitigating the impact of storm surges and waves on the city. These ecological spaces not only safeguard urban buildings and infrastructure from the ravages of storms but also protect the lives and property of coastal residents. Additionally, urban waterfront ecological spaces are closely linked to climate regulation. Wetlands and trees absorb carbon dioxide, reducing greenhouse gas emissions and playing a crucial role in addressing climate change. By improving the ecosystem functionality of urban waterfront ecological spaces, urban temperature can be lowered, air quality improved, and the heat island effect reduced, ultimately enhancing the comfort and livability of the city [1].

3. Ecosystem Condition and Safety Risk Assessment of a City's Waterfront Area

3.1. Fieldwork and data collection

To gain a deeper insight into the ecological status and safety risks of the waterfront area, we conducted on-site investigations and collected relevant data. During the on-site investigation, we made detailed observations and records of the ecological landscape, wetland conditions, water quality, and vegetation distribution in the waterfront area of the city. Additionally, we collected ecological data, including water quality monitoring data, biodiversity survey data, and soil quality data. Through the process of on-site investigation, we found some potential ecological problems and safety risks in the waterfront area of the city. For instance, certain wetlands and riverbank zones in some areas have deteriorated and lost biodiversity due to human damage or unreasonable use. Regarding water quality, we detected pollution in some of the water bodies in the waterfront area of the city, possibly caused by industrial wastewater, agricultural non-point source pollution, and so on. These problems pose a potential threat to the ecological environment and safety of the city's waterfront. Through data collection and analysis, we will further evaluate the ecological system health status and safety risks of the waterfront area of the city. This will help us establish a scientific basis for constructing an NbS-based ecological safety spatial layout plan for the area and propose corresponding solutions for specific problems. We believe that through comprehensive analysis and scientific management, it is possible to achieve the goal of protecting the ecology and achieving safe development of the city's waterfront.

3.2. Ecosystem Condition Assessment

After conducting an assessment of the ecological system in the waterfront area, we have synthesized the results obtained from on-site investigations and data collection. Firstly, we evaluated the ecological landscape and found that the area's wetland has decreased in size, with some being damaged or filled, resulting in the disruption of the ecological system and a decrease in connectivity. Additionally, the degradation and destruction of some habitats have led to a reduction in local species diversity, putting pressure on the ecological system's resilience. Secondly, we conducted a water quality assessment and found that some bodies of water were highly polluted, possibly due to factors such as industrial wastewater, agricultural non-point source pollution, and urban sewage [2]. Polluted bodies of water not only affect the balance of the ecological environment but may also pose a threat to human health and urban water safety. Moreover, we also assessed the distribution of vegetation and biodiversity in the area. The uneven and fragmented vegetation coverage has impacted the ecological system's functionality, and the reduction in species diversity implies an increase in the ecological system's fragility and low adaptability to environmental changes. Considering the overall assessment results, we recognize that the ecological system in the waterfront area of this city faces certain pressures and risks. In order to improve the ecological system's conditions and enhance safety, we recommend developing comprehensive protection and management plans. These include measures such as wetland and riverbank protection and restoration, strengthening water pollution control, promoting vegetation recovery and protection, etc. Through these efforts, we can improve the health of the ecological system in the waterfront area of this city, reduce safety risks, and provide residents with a good ecological environment and safe living space.

3.3. Safety Risk Assessment

After assessing the safety risks in the waterfront area, we have identified several potential risk factors. Firstly, there is the risk of flooding. Due to the low-lying terrain

and the occurrence of extreme rainfall events due to climate change, the area is susceptible to flooding. When floods occur, houses, roads, and infrastructure in low-lying areas may be damaged, posing a threat to residents and the city. Secondly, there is the risk of coastline erosion. The waterfront area of a certain city is located near the coast, making it vulnerable to coastal erosion. Storm surges and waves can cause damage to buildings and infrastructure along the coast, potentially jeopardizing the safety of residents. Additionally, the waterfront area faces the risk of water pollution and waste management. Improper wastewater discharge and garbage disposal can lead to water contamination, negatively impacting biodiversity and human health. Considering the analysis of these risk factors, we realize the importance of protecting the safety of the waterfront area. To mitigate the risks and enhance safety, we recommend implementing a series of measures including strengthening flood management, implementing coastal protection projects, enhancing water pollution control, and promoting sustainable waste management. Through integrated management and continuous monitoring, we can reduce the safety risks in the waterfront area of the city, safeguarding residents and the city from the impacts of disasters and environmental damage. Furthermore, strengthening public awareness and education, and improving residents' awareness and capacity to respond to safety risks, are also essential factors in ensuring the safety of the waterfront area [3].

4. NbS-based Ecological Space Security Pattern Construction Program

4.1. Methodology and steps

The proposed scheme for constructing an ecological spatial security pattern based on NbS (Nature-based Solutions) is a comprehensive approach that utilizes ecosystem services to enhance ecological spatial security. Here are the methods and steps of this scheme: To begin, we will undertake an environmental risk assessment to thoroughly analyze and evaluate the risks posed by natural disasters and water pollution in waterfront areas. This assessment will help us better understand the specific risks faced by these areas and provide a foundation for the subsequent design of the scheme. Next, we will consider and harness natural systems and ecological processes to enhance the resilience and security of waterfront areas. By protecting and restoring wetlands, riparian vegetation, and other natural elements, we can mitigate the impacts of natural disasters such as flooding and coastal erosion. Simultaneously, eco-processes such as vegetation filtration and wetland self-purification can improve water quality and reduce the risks of water pollution. In the scheme design, we will integrate topography, ecological conditions, and community needs to establish a rational spatial layout and configuration. For instance, incorporating green infrastructure such as wetland parks and natural buffer zones will enhance the connectivity and functionality of the ecological space. Working collaboratively with relevant departments, research institutions, community organizations, and residents will enhance the feasibility and implementation effectiveness of the scheme. Community participation and education are also crucial; by increasing residents' awareness and understanding of ecological spatial security, we can promote their active involvement in the protection and management of the ecological space. Lastly, we will establish a regular monitoring and evaluation plan to track the implementation effectiveness of the scheme and improvements in ecological spatial security. Based on monitoring results, timely adjustments and improvements will be made to ensure the sustained and effective safeguarding of the ecological space in waterfront areas [4].

Through the aforementioned methods and steps, the scheme for constructing an ecological spatial security pattern based on NbS will provide a sustainable, ecologically friendly, and secure urban space for a specific city's waterfront area.

4.2. Ecological Needs Analysis

In the process of developing an NbS-based ecological space security pattern construction plan, ecological demand analysis is a crucial step. By analyzing the ecological demand in waterfront areas, we can gain a better understanding of the functions and services of the ecosystem, as well as the residents' demand for ecological space. This helps us to develop a more realistic plan that can provide ecosystem services to the greatest extent possible. Firstly, ecological demand analysis needs to consider the ecological system functions in the area, including but not limited to water resource regulation, flood regulation, water quality purification, soil conservation, and biodiversity conservation. By understanding these basic functions, we can clarify which ecosystem services are essential in waterfront areas and how to protect and enhance these functions. Secondly, analyzing the community and residents' demand for ecological space is also critical. This can be done through community surveys, public participation, and questionnaire surveys, among other methods. Understanding the residents' usage of ecological space, recreational and leisure needs, and expectations for health and mental well-being can help us better design an ecological space that meets the community's demands in waterfront areas. By understanding these ecological sensitivities and vulnerabilities, we can place greater emphasis on protecting and managing these key elements in the plan's design. Finally, ecological demand analysis should encompass climate change and future development factors. Because climate change will have a significant impact on the ecosystem, including changes in precipitation patterns and sea-level rise. Incorporating these factors into the analysis helps us predict future demand for ecological space and take appropriate protection and adaptation measures. By analyzing in-depth and considering the above factors comprehensively, ecological demand analysis will provide essential guidance and reference for us to develop an NbS-based ecological space security pattern construction plan. This will ensure that the plan design in waterfront areas matches actual demands and can provide ecosystem services to the greatest extent possible, protecting and enhancing ecological space's safety.

4.3. Land Use Planning

The construction of the ecological spatial security pattern based on NbS requires the implementation of land use planning to establish rational land-use strategies within the waterfront area, ensuring connectivity, stability, and safety of the ecological space. When developing land-use planning, consideration must be given to the following aspects: First, ecological space network planning should be established based on the natural environment and ecological elements, including linkages, buffer zones, and reserve areas between different habitat types. In addition, the spatial area should be divided into different management units to formulate more targeted land-use planning. Second, diverse land-use models should be employed to reasonably arrange the spatial distribution of the ecosystem. Such models encompass natural protected areas, public green space, water engineering protection areas, and forestry and greening protection areas, with the aim of preserving and maintaining the region's natural, cultural, and social capital. Furthermore, in developing land-use planning, sustainable development models should be introduced to improve land-use efficiency and economic benefits.

For example, agricultural ecosystems can use agricultural ecological system services to enhance production efficiency and benefits, as well as reduce environmental risks and ecosystem destruction. Finally, social public participation, particularly the opinions and needs of residents, is crucial when developing land-use planning. This can be done through community meetings and residents' surveys. Increased resident participation enables better understanding of their needs, ultimately facilitating better land-use planning and promoting the sustainable development of waterfront regions. By developing land-use planning, the construction of the ecological spatial security pattern based on NbS can improve the resilience and stability of the ecosystem, ensuring the safety and health of the residents. Land-use planning is an important step in achieving this goal, striking a balance among ecology, economy, and social development while safeguarding and utilizing the ecosystem, as well as promoting urban sustainable development [5].

4.4. River Management

In the construction plan for ecological safety pattern based on NbS, river management is a crucial task. Effective river management can help protect and improve the ecological environment of riverine areas, reduce flood risks, and provide sustainable water resources. Firstly, river management should focus on water resource regulation. This includes regulating rainwater and streamflow to reduce the threat of floods. By constructing and restoring natural processes such as wetlands and riverine vegetation, the water retention time and absorption capacity can be increased, thereby reducing the increase of flood peak flow. In addition, constructing reservoirs and establishing rainwater and flood control storage systems can store and release water during flood occurrences, mitigating the impact on residents and properties. Secondly, river management should also prioritize water quality protection. The establishment of wetlands and filtration zones can effectively remove suspended particles and pollutants from water and improve water quality. Meanwhile, setting strict measures to prevent water pollution caused by agricultural and industrial activities can be implemented. One can also promote the circular economy to reduce wastewater discharge and waste generation, protecting the ecological health of rivers. Moreover, river management should pay attention to comprehensive management of the river basin in order to achieve comprehensiveness and integration. This involves cooperation and coordination among multiple departments, establishing river basin management institutions, developing river basin management plans, and coordinating solutions to water resources allocation and utilization problems. Through comprehensive river basin management, the efficiency of water resource utilization can be maximized while avoiding waste and conflict. Finally, river management should also prioritize community participation and public education. By promoting awareness and education, increasing residents' awareness of the importance of rivers and ecological protection can be achieved, and their willingness to participate positively stimulated. Establishing river monitoring and reporting mechanisms allows residents to be informed of the conditions of the river and provide feedback and suggestions. In conclusion, river management plays a crucial role in the construction plan for ecological safety pattern based on NbS. By focusing on water resource regulation, water quality protection, implementing comprehensive river basin management, and promoting community participation, we can enhance the ecological safety and social welfare of riverine areas, achieve sustainable water resource management and utilization.

5. Conclusions

The construction of a safe ecological space in urban waterfront areas based on Nature-based Solutions (NbS) aims to enhance the resilience and stability of urban ecosystems while ensuring the safety and health of residents. This concept emphasizes cooperation with and learning from natural systems, utilizing natural processes and ecosystem services to address the challenges faced in urban waterfront areas. By combining urban development with nature conservation, the construction of a safe ecological space based on NbS promotes harmonious coexistence between ecology and humans in urban waterfront areas. It not only helps to improve the stability and function of the ecosystem, reduce the risk of natural disasters, but also provides residents with a more healthy, beautiful, and sustainable living environment. We should actively promote such solutions to achieve ecological safety and sustainable development in urban waterfront areas.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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