

Waterfront Landscape Optimization: Integration and Development Trends of Theory and Practice at Home and Abroad

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Abstract In the wave of urbanization, waterfront landscape optimization is very important, but it is faced with ecological deterioration and other problems. By combing the relevant theories and practices at home and abroad and making a comparison and summary, the future direction of waterfront research was analyzed. In theory, foreign research has experienced multi-stage development, covering definition classification, design methods, etc. China started late, and is mainly in the exploration stage of learning from foreign experience and combining with local characteristics. The current research and practice have shortcomings such as ignoring users' needs and lacking quantitative evaluation. In the future, the construction of waterfront should focus on the needs of users, use scientific methods to build an evaluation system, integrate multi-disciplines, excavate regional culture, and establish a monitoring mechanism to achieve sustainable and coordinated development of the ecology, society and economy of waterfront.

Keywords Waterfront, Landscape optimization, Waterfront landscape theory

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In the wave of urbanization, waterfront is of great significance to urban ecology, economy and culture. Global waterfront is faced with ecological deterioration, improper use of space, lack of cultural characteristics and other problems. Based on the analysis of the development of waterfront theories and the successful cases of practice at home and abroad in the past, the effective strategies and methods for future research improvement were explored to improve the comprehensive landscape benefits and users' satisfaction, enrich landscape design and urban planning theories and promote interdisciplinary research, provide guidance for waterfront planning and design, help urban sustainable development, and create high-quality waterfront space.

1 Foreign research on the landscape optimization of waterfront

1.1 Theoretical development context

The research on the renewal and utilization of waterfront space in foreign countries is relatively early, and has gone through several stages of development and changes. Its research ideas are becoming more and more mature, and rich research results have been formed, showing different characteristics and concepts in different periods. With the progress of social economy, the functions of urban waterfront landscape has changed from traditional water conservancy and shipping to the diversified service functions of landscape, experience and cultural tourism. In the *Waterfront Renewal* published in 1988,

Hoyle introduced several practical cases of urban waterfront space for the first time. The *Urban Waterfront Development* (Douglas M.Wren et al., 1983) was the first book to define, categorize and analyze the evolution of urban waterfront^[1]. In the book *Reviving Waterfront: The International Dimension of Waterfront Redevelopment* published in 1988, based on theories and cases, Hoyle summarized the characteristics, renewal motivations and problems of waterfront from multiple perspectives, and included case practices and multidisciplinary expert articles from the United States, Canada, the Netherlands, the United Kingdom and other countries to conduct relevant research on the experience and methods of waterfront redevelopment^[2]. In the *Waterfront: Back to Cities* and *New Waterfront: Worldwide Success Cases* compiled by AimBreen and DickRigby in 1993 and 1994, many excellent waterfront project cases in the world were analyzed, compared and summarized according to functional categories, and construction experiences such as adapting to local conditions and avoiding blind imitation were put forward. Through the study of Hamilton, Wakefield found that ensuring the external accessibility of waterfront landscape is the core of waterfront landscape reconstruction^[3]. In 1995, Japan Civil Engineering Society wrote the *Waterfront Landscape Design*, in which the relationship between waterfront space landscape elements and design methods were discussed. The United States published the *Parks and Site Planning*,

in which domestic waterfront park design projects in the United States were analyzed, and hydrophilicity and vitality were emphasized. With the improvement of people's awareness of heritage protection, many western countries began to try to protect and reuse waterfront historical and industrial sites, and strengthen the connection with waters by reshaping the waterfront landscape form, thereby improving the surrounding and community environment and enhance residents' sense of identity and pride^[4].

1.2 Analysis of cases

At present, foreign scholars have carried out relatively rich theoretical studies on urban waterfront renewal, and gradually carried out related practice on waterfront, which can not only promote urban development, but also continuously improve the good image of cities and demonstrate their charm. Among them, the representative projects include Japanese Daodunjuechuan Waterfront, Amsterdam Canal Belt, Chicago Navy Pier, Buffalo River Promenade, Bishan-Ang Mo Kio Park in Singapore (Table 1).

2 Domestic research on the landscape optimization of waterfront

2.1 Theoretical exploration process

Urban waterfront landscape is an important part of urban ecological environment. There are relatively mature theories and practices in the development and construction of urban

waterfront landscape in foreign countries, while the domestic development is relatively lagging behind, and the treatment and protection of water bodies is only paid attention to at first. In actual waterfront landscape projects, there are some problems such as unreasonable layout of waterfront space, disconnection between cities and rivers, and lack of consideration of users' needs. In order to improve these problems, China began to learn from foreign successful cases, and combined with local development characteristics to explore and innovate the theory and method of waterfront landscape renewal, covering urban planning, urban ecology, landscape architecture and other fields, and certain research results have been achieved.

In terms of waterfront planning and design, Wang Min et al.^[5] conducted an empirical study on the renewal, development and evolution of the Suzhou River and Emscher River in Shanghai, and analyzed the planning characteristics of urban waterfront. Based on the principle of "protection, inheritance and utilization", Wang Weijia et al.^[6] discussed the solutions and construction guidelines for the overall layout of the riverfront landscape belt of cultural heritage, the relationship between the city and river, style control, industrial and cultural heritage utilization, etc. Chen Yuezhong^[7] refined the cultural language of the Beijing-Hangzhou Grand Canal, and applied it to the planning of waterfront public space in Tongzhou District to create a cultural public space with regional characteristics. On the basis of analyzing the status of landscape of Grand Canal National Cultural Park, Tian Lin^[8] put forward methods and strategies of landscape construction. With the concept of "restoring ecology and repairing city", Hou Kelei created a good public leisure environment through landscape and ecological technology means. Taking the waterfront landscape of the Hunhe River in Shenyang as an example, Qin Yibo^[9] put forward suggestions and methods to improve the vitality of waterfront space.

2.2 Results of cases

With the continuous maturity of domestic waterfront space cases, major cities have gradually carried out the renovation and renewal of waterfront, and relatively successful renovation cases have emerged successively. Among them, the more successful and representative cases include spatial renovation of the Qinhuai River in Nanjing, urban public space of Huangpu Riverside in Shanghai, Changbin—"Two Rivers and four banks" in Chongqing, and Baoshan Riverside (phase I) waterfront (Table 2).

3 Comparison of domestic and foreign studies and existing problems

3.1 Comparison of domestic and foreign studies

The study of waterfront landscape optimization in foreign countries started early, and it is mature in the aspects of theoretical system construction and practical experience accumulation. Its research focuses on the integration of multiple disciplines, conducts comprehensive research on waterfront from multiple dimensions such as ecology, society, economy and culture, and has in-depth exploration in ecological restoration, protection and utilization of cultural heritage, public participation and other aspects, forming a relatively complete theoretical and practical system. In practice, the types of foreign cases are rich and diverse, and targeted optimization strategies can be formulated according to the characteristics and needs of different cities, focusing on the long-term sustainable development of projects.

Although domestic research started late, it has developed rapidly. On the basis of learning from foreign experience and closely combining with local conditions, certain progress has been made in the protection and utilization of cultural heritage and the localization application of ecological restoration technology. However, compared with foreign countries, there is still room for improvement in the theoretical depth and systematization of domestic research, and some practical projects have excessive reference to foreign models, failing to fully tap the connotation and regional characteristics of local culture.

3.2 Existing problems

At present, there are some common problems in the research and practice of waterfront landscape optimization at home and abroad. The research focuses too much on the methods and skills of planning and design, and focuses a lot of energy on spatial layout and landscape element design, but ignores the needs and experience of users. For example, the planning of some waterfront did not fully consider the use habits and needs of different groups of people, resulting in a low utilization rate of some landscape facilities.

In terms of evaluation system, there is a lack of quantitative evaluation and analysis of waterfront landscape quality. Presently, it is difficult to measure the ecological, social and economic benefits of waterfront landscape comprehensively and objectively based on the

aesthetic judgment at visual level. As a result, it is impossible to accurately grasp the actual effect of landscape in the process of project evaluation, which is not conducive to scientific optimization and improvement of the project.

In the process of project implementation, there is a lack of effective user participation and feedback mechanism. Public participation is often a mere formality, unable to truly integrate public opinions and suggestions into the renewal and renovation plan of waterfront space, resulting in a gap between the actual use effect of waterfront public space and the expected effect, and low space utilization rate and residents' satisfaction.

4 Research prospects and development direction

4.1 Conducting landscape optimization with users' needs as the core

The future research of waterfront landscape optimization should put users' needs in the first place. By using big data analysis, behavior observation, questionnaire survey and other methods, the functional, aesthetic and emotional needs of people of different ages, occupations and cultural backgrounds on waterfront space are deeply understood. For example, by analyzing mobile phone positioning data and social media information, people's activity tracks and stay hot spots in waterfront can be accurately grasped to optimize the layout of leisure facilities and viewing places. In the planning and design stage of a project, a diversified public participation mechanism should be established to collect public opinions extensively through public hearings, online interactive platforms, field research and other means, so that these opinions can be fully reflected in the design scheme to improve the practicality and attractiveness of waterfront landscape.

4.2 Establishing a scientific waterfront landscape evaluation system

It is very important to establish a scientific and comprehensive waterfront landscape evaluation system. Multi-disciplinary indicators of ecology, sociology and economics should be integrated, such as quantitative indicators of ecosystem service value (including the value of water purification and biodiversity maintenance, etc.), social equity indicators (such as the accessibility of residents in different regions to waterfront and the equality of use opportunities), and economic cost benefit indicators (construction costs, maintenance costs, and driving effects on the surrounding regional economy). Analytic hierarchy process, fuzzy

comprehensive evaluation and other mathematical methods are used to determine the weight of each indicator to achieve the comprehensive quantitative evaluation of waterfront landscape. At the same time, by means of geographic information system (GIS), remote sensing technology (RS) and other spatial analysis methods, the spatial pattern and ecological process of waterfront landscape are dynamically monitored and evaluated to provide scientific and accurate data support for landscape optimization.

4.3 Excavating deeply the connotation of regional culture

Culture is the soul of waterfront landscape, so it is needed to excavate deeply the connotation of regional culture in the future. Through historical literature research, folk culture investigation, oral history collection and other methods, the historical changes, cultural context and folk customs of waterfront are systematically sorted out, and representative cultural elements are extracted. In landscape

design, innovative forms of cultural expression are not limited to the display of traditional cultural symbols, but also allow tourists and residents to personally feel and participate in waterfront culture through immersive cultural experience projects, cultural theme activities planning and other ways. For instance, virtual reality technology is used to reproduce the historical scene of waterfront, and music festivals and art exhibitions with the theme of waterfront culture are held to enhance the cultural vitality and attractiveness of waterfront and achieve the organic combination of cultural inheritance and innovation.

4.4 Establishing a long-term dynamic monitoring mechanism

Waterfront landscape is a dynamic changing system, and is influenced by both natural factors and human activities. Therefore, it is necessary to establish a long-term dynamic monitoring mechanism to continuously track and monitor the ecological environment, social use and economic development impact of waterfront. The Internet of Things technology is used for real-time monitoring of water quality, water level, vegetation growth and other ecological indicators. Through questionnaire survey, people flow statistics and other ways, the social use of waterfront space is understood. With the help of economic data analysis, the driving effect of waterfront on surrounding regional economy is evaluated. According to the monitoring results, landscape management strategies and optimization measures are timely adjusted to ensure that the waterfront landscape is always in a good state and achieve sustainable development.

Table 1 Optimization strategies of foreign waterfront space






Strategy orientation	Project name	Optimization strategy	Case
Urban planning orientation	Japanese Daodunjuechuan Waterfront	Returning roads to rivers to reshape the waterfront shoreline, meeting the diverse space needs of citizens, and conducting humanized design	
	Amsterdam Canal Belt	Protecting the interwoven texture of urban waterways, developing waterways and land development in parallel, and creating unique urban landscape	
Enhancing urban vitality	Chicago Navy Pier	Improving the internal traffic pattern, enriching activity places and spatial levels, establishing a coastal ferris wheel to highlight the new image of the city, and increasing the types of public activities on the waterfront	
	Buffalo River Promenade	Adjusting the distribution of external traffic, improving the habitat of organisms, discovering the city's unique identity, establishing brand culture activities, improving park infrastructure	
Improving urban ecology	Bishan-Ang Mo Kio Park in Singapore	Conducting design and planning based on low impact development concept, changing concrete revetment to natural revetment, reducing the impact of flood disaster and enhancing ecological and natural value, establishing natural hydrophilic space	

Table 2 Optimization and update of domestic waterfront space

Strategy orientation	Project name	Optimization strategy	Case
Preservation of historical sites	Qinhuai River waterfront space in Nanjing	Stabilizing the ecological structure of waterfront, increasing the diversity of waterfront landscape, and optimizing architectural features of waterfront interface to shape urban characteristics	
Shaping of waterfront open space	Urban public space of Huangpu Riverside in Shanghai	Connecting the internal traffic, and creating sightseeing leisure and hydrophilic landscape belt and diversified waterfront space	
Improving riverside ecology, and adapting to dynamic water level	Changbin—"two rivers and four banks" in Chongqing	Conducting toughness design, creating multistage landscape platform spatial to adapt to dynamic changes of water level, building localized landscape space, and organizing a variety of activities	
	Baoshan Riverside (phase I) waterfront	Three level platform connection, ecological waterfront style, fun experience, waterfront leisure interactive experience, and connection with the surrounding community	

5 Conclusions

This study systematically combed the theoretical development and practical achievements of waterfront landscape optimization at home and abroad, compared and analyzed the differences and commonalities between the two, and pointed out the problems existing in current research and practice. The early research and rich practice abroad have provided valuable experience for the domestic research. Combining with local characteristics, domestic exploration on the basis of reference has also made some achievements. However, the existing problems such as neglect of users' experience, lack of quantitative evaluation and effective public participation seriously restrict the further development of waterfront landscape.

(To be continued in P13)

social conditions of the time. Typically, historical parks are situated in aesthetically pleasing natural settings and exhibit distinctive garden styles that are influenced by the surrounding architecture and human activities. Since modern times, the design and construction of Western parks, influenced by political and civilizational factors, have developed into a comprehensive system that integrates multiple cultures, incorporating both traditional Eastern elements and contemporary styles. However, as society continues to evolve, the diversity of individuals' needs has increased, necessitating ongoing improvements in the construction of multicultural spaces. With urban development, both the form and function of parks have undergone significant transformations. The transformation and construction of Nanchang Bayi Park exemplify the diversity inherent in Chinese urban parks, highlighting its historical origins, distinctive style, and its interaction with the surrounding environment. This development contributes

to a more varied and dynamic development of urban historical parks. Consequently, there exists a responsibility to undertake the transformation and construction of Nanchang Bayi Park, thereby fostering the advancement and evolution of urban historical parks throughout the nation.

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In the future, waterfront landscape optimization should closely focus on the needs of users, use scientific methods to build a comprehensive evaluation system, strengthen the deep integration of multi-disciplines, excavate deeply the connotation of regional culture, and establish a long-term dynamic monitoring mechanism. These measures are adopted to realize the sustainable and coordinated development of waterfront ecology, society and economy, improve the quality of urban waterfront space, satisfy people's yearning for a beautiful waterfront living environment, and inject new vitality into the sustainable development of cities. This is not only a research direction in the field of waterfront landscape optimization, but also an inevitable requirement for promoting high-quality urban development.

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