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Urban Waterfront Space Design under the Concept of Ecological Conservation: A Case Study of Hefei Swan Lake

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Abstract With the proposal of the concept that lucid waters and lush mountains are invaluable assets, ecological issues have become increasingly important issues of concern to people. The process of urbanization is accelerating, and the importance of urban waterfront space in improving the environmental quality of the city and people's quality of life, enhancing the vitality of the city, the overall appearance of the city, and the competitiveness of the city, is receiving increasing attention. And how to properly handle the construction and development of urban waterfront space has become increasingly prominent in urban planning. Under the the concept of "ecological conservation", it is thought that the construction of urban waterfront space should follow the principle of harmony between nature and man, and strengthen the multifaceted connection of the city. Through field research on Swan Lake, a comprehensive evaluation of the problems in the plank road and land ecology is conducted. It is proposed to improve the current situation of Swan Lake by grasping the two keywords of "waterfront" and "city", and starting from the improvement of water body and the enhancement of urban cultural construction in the lake area.

Keywords Ecological conservation, Urban environmental improvement, Waterfront space
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Cities are the closest and most relevant scenes to people's lives. With the development of economy and society, the development of cities has also undergone a series of transformations. Therefore, after the concept of "ecological civilization" was proposed at the 17th National Congress of the Communist Party of China, it was listed as one of the strategic tasks of the 18th National Congress of the Communist Party of China. From then on, the whole society began to attach unprecedented importance to the concept of "ecological conservation"[1]. With the convening of the 20th National Congress, major projects for ecosystem protection and restoration have been proposed, and the importance of ecology has become increasingly prominent. In the past urban development, there have been instances of unreasonable research and design of urban waterfront spaces in urban development. Waterfront space design in many cities has often been unsatisfactory, losing regional characteristics, and lacking innovation, and the local cultural characteristics have not been well reflected[2]. This study aims to better reflect local cultural characteristics and enhance urban vitality through the research and design of "waterfront spaces", providing a new approach for urban waterfront space design, and enabling future urban waterfront spaces to showcase different styles and colors.

1 Ecological conservation concept

To maximize the role of ecological conservation concept in urban waterfront spaces, it is first necessary to understand what ecological conservation concept is and its significance.

Ecological conservation concept and Ecosystem Conservation contain two aspects: protect and restoration. Its connotation is that guided by ecological concept, through the cultivation of humans and the environment, wild animals and plants, and the maintenance of the natural environment, by coordinating the relationship between humans and nature, a single biological population or multiple biological populations relying on each other's habitats is achieved, while sustainable unavailability of natural resources is implemented, and sustainable utilization of natural resources is achieved.

The implementation of the ecological conservation concept is conducive to the improvement of the ecological environment within the region, and can play a good role in protecting the unique flora and fauna of the area. It is beneficial for creating a more harmonious social relationship between humans and nature by guiding the research and design of waterfront spaces with the concept of ecological conservation.

2 Current research status at home and abroad

2.1 Research status at abroad

In the 1940s, the developed Western countries began the "waterfront revitalization" plan, which was famous for waterfront projects in cities such as Santiago and San Antonio. In the 1980s, the "revival of urban waterfront spaces" began to become a hot topic in the academic community at that time. The first systematic analysis of waterfront spaces in countries around the world from the perspective of "development phenomena" was conducted in the *Waterfront Renewal* edited by Hoyle. For example, a dedicated "Waterfront Space Research Center" was established in the US capital Washington[3]. The International Water Capital Conference was held in Osaka in 1990, and the famous *Osaka Declaration* was issued in the conference, which pointed out that water resources exist as an important element in urban space, and it should pay more attention to the protection and effective utilization of water resources. The important foundation of urban environmental landscape is the combination of water and green. In 1991, the Second International Conference on Water City Centers was held, which advocated the concept of "waterfront area—new field of urban planning and development". It emphasized that multiple factors should be comprehensively considered when constructing urban waterfront space, and the development process should coordinate with the market. It considered using sustainable development concept to carry out design work[4]. In 1994, the International Academic Conference on Cities and the New Global Economy was held in Melbourne. This conference proposed that the design of urban waterfront space should be linked to regional network strategy within the

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scope of regional space, which expanded the initial economic and cultural factors and added new research areas. In 1995, the International Conference on Urban Waterfront Development was held in Sydney. It was emphasized that urban design should be taken as a national policy and public government action to implement. Moreover, the design of urban waterfront areas should take into account the market and pay attention to the construction of "people and places"[5].

2.2 Domestic research status

With the rapid development of cities in China, research on hydrophilic landscape has been increasing year by year since the 1990s. At multiple China urban planning conferences held in China, the frequency of waterfront space has been consistently high. In 2002, Zhang Tingwei et al. conducted a systematic study on waterfront area. In 2010, scholar Zhang Ye published the *Planning and Design of Hydrophilic Facilities under the Influence of Landscape Regionality*, which focused on studying hydrophilic facilities in different regions and analyzed and summarized the facility planning, development issues, and design status of hydrophilic space in waterfront areas. In 2018, the *Waterfront Space in the Haicha Region under the Perspective of "Ecological Restoration"* was published at the China Urban Planning Annual Conference that year. Through studying relevant literature and materials, it can be clearly found that the scope of hydrophilic spaces in China is relatively broad, including embankments, plants, hydrophilic platforms, hydrophilic steps, hiking trails, etc. At the same time, with the proposal of the concept of sustainable development, the shaping of hydrophilic space prioritizes ecology, and it is people-oriented, and combines with regional characteristics to shape. In 2019, Li Hongxia conducted a comprehensive evaluation of the overview, design elements, design types, and other aspects of waterfront landscape design in the book *Application of Water Elements in Environmental Art Design—Review of Waterfront Landscape Design*, and also proposed the handling of details of hydrophilic facilities[6].

3 Research and design of urban waterfront space

3.1 Design principles of waterfront space

3.1.1 Clarifying urban needs and carrying out reasonable planning. When constructing urban waterfront space, it is necessary to clarify the nature of the waterfront space required by the local city. For planning, it is necessary to fully consider the local development status and actual usage situation. During the construction process, it is necessary to pay attention to ecological and environmental protection concepts, respect the local ecological environment, fully examine the local ecological environment, and strive to avoid serious damage to the local ecological environment during the construction process.

3.1.2 Integrating "people" into the construction of waterfront space. The design of waterfront space ultimately aims to serve people. As a group, "people" run through the entire process of urban waterfront space construction and use from beginning to end. So at the beginning of the design, it is necessary to understand the preferences of the local people, communicate with the local people face to face, and collect the opinions of the local people in the form of questionnaires[7]. On this basis, the essence is taken, and the dross is discarded, so that people's reasonable expectations can be fully reflected in the urban waterfront space. People can fully experience the beautiful scenery of the waterfront space after the completion of urban waterfront space construction. It could improve people's sensory experience, and also enhance people's souls.

3.1.3 Harmony between nature and humans, complementing each other. The natural ecological environment is the foundation on which urban waterfront space can be constructed and designed for survival. However, natural landscapes in some areas do not conform to people's viewing and sightseeing habits, which requires human intervention. Artificial landscape is a way to compensate for the shortcomings of natural ecological landscape. Through the organic complementarity between artificial landscape and natural ecology, the effect of one plus one greater than two is achieved. However, under the premise of manual intervention, it is necessary to make every effort to maintain the integrity of the local ecological environment, and not cause large-scale damage to the local ecological environment. Sustainable development should be integrated into construction. The concept of the unity of nature and humans and the harmonious coexistence between humans and nature can be repeatedly reflected in construction and design.

3.1.4 Inheritance and protection. The history of China is too ancient and grand, to the extent that a city is a part of history. These history is an important component of the Chinese national spirit and traditional culture, and integrating history into urban construction is both inheritance and innovation. In the process of transforming the natural environment, it is necessary to fully tap into the local culture, customs, and traditions, and integrate them into the construction of urban waterfront space[6].

3.1.5 Improved infrastructure construction. If a city is a surface, then for a city, waterfront space is a point, and lines are needed between points and surfaces. So for waterfront space, the surrounding infrastructure is the line. A good urban waterfront space must have developed transportation lines and reasonable transportation stations around it, allowing people to quickly reach it[7]. There should also be a certain commercial area around it, providing convenience for people's play[8]. The markings of the internal service facilities in the waterfront space park should be clear, and the map should be clear and easy to understand, so that people can plan their own travel routes well when playing.

3.2 Content of waterfront space (Table 1)

3.3 Significance of waterfront space for cities and human settlements

Waterfront space can effectively highlight the urban landscape and reflect urban culture. It can drive the development of the tertiary industry in the local area, improve the competitiveness of the city, enhance the image of the city, expand urban space, and expand urban greening, which is of great significance. Urban waterfront space can also reduce urban economic losses during the rainy and dry seasons. With the gradual improvement of urban waterfront space, the people have access to recreational venues, and the vitality of the crowd is also gradually increasing. The scenery that is closest to the natural landscape is the most attractive to the people[11].

4 Case study: Hefei Swan Lake

4.1 Current situation of the region

Swan Lake is located in Hefei of Anhui, with a total area of 67 hm^2 and a depth of approximately 3.5 m. Its original name was Lianhua Lake. The lake looks like a swan, hence its name. Swan Lake is located in the subtropical monsoon climate zone and the subtropical evergreen broad-leaved forest zone. Due to its location in mid latitude and its transition from subtropical to warm temperate zones, it has a warm winter and hot summer throughout the year. The lake water comes from the river water brought by Hongdian Reservoir, Foziling Reservoir, and Mozitan Reservoir through the Pi River diversion channel. It is surrounded by iconic buildings such as the Hefei Grand Theater and Provincial Museum, is adjacent to the central business district, and mainly faces all citizens of Hefei.

It is an extremely important urban waterfront space in the city center of Hefei.

4.2 Research design

4.2.1 Water body. The water body of Swan Lake in Hefei is playing an increasingly significant role in the development process of Hefei City today. It echoes with the surrounding artificial scenery, giving people a pleasing feeling. At night, the colorful lights of the surrounding buildings converge on Swan Lake, embellishing its night scenery with extraordinary beauty (Fig.1−2). Additionally, Swan Lake has improved the surrounding climate to a certain extent, forming a large ecological regulation system with the surrounding environment, which has the function of regulating the temperature of the city center and adsorbing dust.

4.2.2 Mudflat utilization. On the south side of Swan Lake, there is a golden artificial beach covered with pebbles. It makes good use of the surrounding environment of the lake and also provides a place for leisure and entertainment for the people. Stepping on sand and playing in the water provide a unique vitality to the entire lake (Fig.3−6).

4.2.3 Vegetation. The vegetation of Swan Lake combines foreign and local plants to form a unique plant community. Through on-site visits and research, it is found that the plants of Swan Lake cleverly integrates into the main roads and nodes around the lake, forming a progressive style. At the same time, it can also reduce environmental pollution and alleviate the pressure on the people. People can rest, walk, and exercise in it (Fig.7).

4.2.4 Plank path. The plank path allows people to walk on the lakeside or lake, enjoy the pleasant waves brought by the lake breeze, or take photos with their backs facing the water surface. People can overlook the wider lake from afar and enjoy the unique scenery of the lake. However, the materials used for the constructed plank path are mostly wood, which is highly susceptible to damage. Therefore, it is necessary to strengthen maintenance and repair.

4.2.5 People's recreational behavior. People come and go to Swan Lake mainly for three major activities: sitting and resting, walking, and playing with the water. Beach is one of the themes of Swan Lake Park. Therefore, it has a great attraction for people. At the same time, hydrophilicity and openness are also important factors that attract people to play. It indicates that people's recreational behavior has a high relationship with the spatial arrangement around the lake. In the future, efforts should be made to strengthen the development of other areas, so that people's activities can be greatly expanded and the service capacity of the park can be improved.

4.3 Problems with Swan Lake

4.3.1 Water pollution. Due to the impact of the original agricultural construction, some waterways leading to Swan Lake have been blocked, and the main source of its lake water comes from atmospheric precipitation. Due to its small body size, it is unable to self purify in a timely manner, resulting in eutrophication and foul odor in the lake water, seriously affecting people's gaming experience and the overall landscape.

4.3.2 Insignificant cultural prominence. Swan Lake is an important waterfront space in the urban area of Hefei, but its cultural characteristics are not prominent. In ancient times, Swan Lake was called the Lotus Land. But the lotus culture is only exhibited in a small area on the west side of the lake. At the same time, it cannot reflect the connection with swans. In the waterfront space, only a few safety signs are made in the shape of swans. The lack of prominent cultural attributes greatly weakens the cultural competitiveness of the region.

4.4 Solutions

4.4.1 Strengthening water restoration. It should strengthen ecological governance in lake areas and promote the transformation and development of agriculture towards modernization. Rivers that have been blocked due to agriculture should be dredged, and the circulation among lakes, rivers, and atmospheric precipitation should be strengthened. Cement revetment is not conducive to water circulation and can reduce biodiversity. Ecological revetments can be constructed to reduce the impact of artificial materials on the lake water. Local plants that favor humid environment in Hefei are planted along the shore, and a high, medium, and low plant community could be constructed, not only reducing precipitation, but also playing a role in fixing the shoreline. Through plant collocation, they can guide the view and give visitors a sense of tranquility when visiting the lake area. It should strengthen the application of wet plants and enrich the ecological effects of waterfront space.

4.4.2 Promoting cultural construction. Based on the cultural heritage of the hometown of the Three Kingdoms in Hefei, cultural promotion activities will be held around the lake area to highlight the local cultural characteristics of Hefei. Combining the concept of ecological conservation, resources such as lakes, plants, people, and urban heritage will be fully integrated to promote the maximum ecological landscape benefits of the lake area. It should build more recreational facilities that cater to different age groups, and strengthen the connection between tourists and the lake area. It should actively investigate the preferences of contemporary young people, promote the construction of commercial areas around the lake area, strengthen the connection between the lake area and

Table 1 Content analysis of waterfront space

Element	Content	Functional characteristics
Water body	Water is an important component of waterfront space and plays an irreplaceable role in regulating local microclimate. The temperature inside the waterfront space mostly makes people feel comfortable[9]. Meanwhile, water body also bears the role of retaining rainwater and reducing flood peaks	Regulating runoff, providing industrial and domestic water, strengthening connections with the region, and carrying out water activities
Plant	Aquatic plants and terrestrial plants together form a plant community in the waterfront space, enhancing the sense of hierarchy and texture of the space, and playing a role in guiding and shading visitors' sight[8]. Plants are mostly selected from local areas, and under the premise of protecting the original ecosystem, the basic principle of coordination and unity is to renovate and plant plants in the space[10]	Strengthening spatial connection, separating space, blocking noise, and forming a multi-level water purification system through reasonable planting[11]
Mudflat	Mudflat is located at the edge of water body, which is a unique urban construction land[12]. Under the concept of ecological conservation, its utilization in waterfront space is of great significance. Plank path, breakwater, etc. are built on them, and some plants suitable for planting on mudflat are cultivated to strengthen the protection of mudflat	Easily submerged by water, with a sandy texture. The land should prioritize protection, supplemented by planting plant protective belts
Plank road and greenway	The most common waterfront space is underwater plank road and slow walking greenway, which bear most of the landscape links in the park. Plank roads often pass through water body, enhancing people's sensory perception. The greenway and plank road are like capillaries in a waterfront space, connecting multiple scenic spots[10]	Connecting the hub of the landscape, organizing traffic, increasing accessibility, improving safety protection performance, and safety performance

the surrounding environment, and highlight the ecological concept of green, positive, and upward.

5 Conclusions

Based on methods such as data search, on-site investigation and summary, and questionnaire survey, through the research and organization of the Swan Lake Park in Hefei, various factors that exist in it are summarized. Moreover, how to optimize the design of urban waterfront space under the concept of ecological conservation is proposed to provide guidance.

(1) In the construction of urban waterfront space, it is crucial to grasp the extremely important keyword of ecology. Ecology is the foundation of everything, and without it, all construction cannot begin. Even if it can achieve temporary success, it will have a negative impact due to ecological damage, which is not conducive to long-term development in the future.

Fig.1 Southwest side of Swan Lake

Fig.2 South side of Swan Lake

Fig.3 Golden beach

Fig.4 Children's activity beach

Fig.5 Hydrophilic platform walkway

Fig.6 Plank road near landscape pavilion

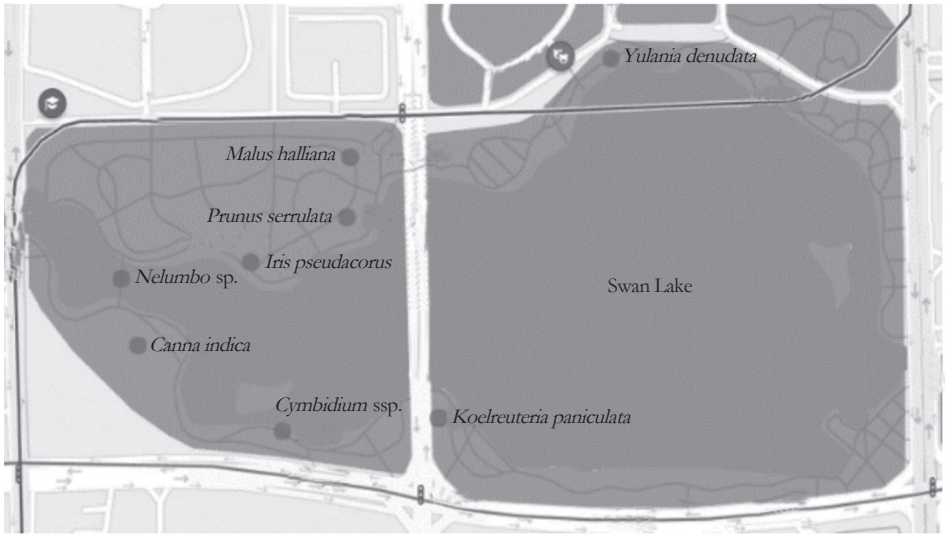

Fig.7 Main vegetation distribution in Swan Lake

(2) It should use various design techniques to strengthen the connection between urban waterfront space and the surrounding environment, and promote the diversity of biological populations. The rich plant population can also provide living space for various aquatic organisms and migratory birds, forming interdependence between plants and animals, and jointly promoting the diversity of biological population in the area.

(3) It should conduct specific and detailed research in the subsequent design of urban waterfront space, and fully grasp various factors in the area, promoting the continuous development of urban waterfront space towards ecology and sustainability.

Under the concept of ecological conservation, research and design of urban waterfront space need to focus on the key word of ecology. Ecology is the foundation of everything. Without ecology, sustainable development cannot be achieved. Fishing wholeheartedly may achieve high results in a short period of time, but it cannot be sustained. The fundamental purpose of building under the concept of ecological conservation is to achieve long-term development, and harmonious coexistence between humans and nature, and enable people to respect and support each other with nature, thereby creating a beautiful society where humans, animals, and plants coexist harmoniously for a long time.

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