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Urban Lakeside Land Use Evolution Analysis and Landscape Ecology Research: A Case Study of Nanhu Lake in Hongshan District, Wuhan

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Abstract: The urban lakeside landscape, as an important component of the urban ecosystem, its ecological design not only showcases the civilized style of the city, but also carries many important ecological functions. These functions are not only reflected in the pollution discharge and flood prevention of urban rivers, but also play an indispensable role in beautifying urban landscapes, improving environmental benefits, and ensuring the ecological and sustainable development of urban lakeside landscapes. The urban lakeside landscape is still a treasure trove of urban biodiversity. Rich aquatic and terrestrial organisms have found ideal habitats here, jointly building a vibrant ecological network. This not only provides citizens with opportunities to have close contact with nature, but also enhances the ecological resilience of the city, enabling it to maintain a stable ecosystem in the face of various environmental challenges. As an important lakeside area in Wuhan, South Lake's landscape environment is of great significance for enhancing the city's image and promoting leisure activities for residents. This article is based on the research of Wuhan Nanhu Ecological Landscape Park, following the principles and basic technologies of ecological landscape design. Starting from the ecological architecture aspect based on the environmental problems of Nanhu, specific environmental planning is made according to the characteristics of the lakeside landscape, providing a basis for the planning and design of the urban lakeside landscape. In depth analysis is conducted on the current situation and existing problems of Nanhu Ecological Landscape Park.

Keywords: Urban Waterfront Lake; Landscape Design; Water Ecological Restoration; Land Use Evolution; Sustainable Development.

1. Introduction

1.1. Research Background

Urban lakeside landscapes play a pivotal role in urban ecosystems. The ecological design of urban lakeside landscapes, as a vivid manifestation of urban civilization, not only carries the functions of pollution discharge and flood prevention for urban rivers but also undertakes the important mission of landscape beautification and environmental protection, thereby ensuring the ecological balance and sustainable development of urban lakeside landscapes [1]. This study takes Wuhan Nanhu Ecological Landscape Park as an example, based on the fundamental principles and key technologies of ecological landscape design, addresses the environmental problems of Nanhu from the perspective of ecological architecture, and combines the unique characteristics of lakeside landscapes to formulate detailed environmental planning schemes, aiming to provide a scientific basis for urban lakeside landscape planning and design.

Urban lakes, as important components of urban ecosystems, have made lakeside areas valuable natural resources amid accelerating urbanization. Rational utilization of these resources will powerfully promote urban construction and development, further improve the urban sustainable development system, enhance overall image and quality, effectively strengthen interpersonal cohesion, and promote harmonious coexistence of economy, society, and nature. Furthermore, the lakeside landscape has become an important window for displaying urban character [2]. To build an organic urban landscape system and create a high-quality urban spatial environment, Nanhu Ecological Park will connect distinctive venues, providing visitors with rich and diverse sensory experiences, becoming a beautiful scenic line for Hongshan District and the entire city.

1.2. Research Purpose and Significance

1.2.1. Research Purpose

This paper aims to explore the core concept of "forest as the body, water as the vein, culture as the soul," committed to building an ecological pattern of "clear water and beautiful forest," fully leveraging the functions of large forestlands in ecological barriers, water conservation, and forest carbon sequestration, and transforming Nanhu into a sustainably developing lake. In this process, attention is paid to integrating Nanhu with surrounding natural elements—mountains, water, fields, forests, lakes, and grasslands—to jointly construct a complete ecological grand pattern. Furthermore, in advancing Nanhu's ecological governance, respect and protection of Wuhan's profound historical context is maintained. Adhering to the principle of designing with limited resources, emphasis is placed on the intrinsic connections among human emotion, regionality, and nationality, combining traditional design with contemporary design concepts, striving to inherit and promote Wuhan's historical culture while protecting the ecology.

1.2.2. Research Significance

First, from a macro perspective, urban lakeside landscape design plays a significant role in the overall development and planning of a city. As a key component of an urban area, the landscape design of lakeside regions is not only closely related to the urban ecological environment, but also directly influences the city's image and attractiveness. Carefully crafted lakeside landscapes can elevate the overall appearance

of a city, enhance its appeal and competitiveness, and thus drive the sustainable development of the city. In addition, urban lakeside landscape design helps foster harmonious coexistence between the city and nature. Amid the accelerated pace of urbanization today, protecting natural ecology and achieving harmonious coexistence between humanity and nature is of particular importance. As the interface connecting cities and nature, properly designed and managed lakeside landscapes can strike a balance between urban development and ecological protection, ultimately realizing the green, sustainable development of the city.

From a micro perspective, urban lakeside landscape design is of great significance for improving residents' quality of life and sense of happiness. As precious urban resources, lakeside landscapes can offer residents beautiful leisure venues and comfortable living environments. Exquisitely designed lakeside landscapes integrate natural waterfront scenery with urban atmosphere, where parks and buildings sit in close proximity. Natural elements are organically and skillfully embedded into the city, creating a warm, vibrant public social space that resonates emotionally with people. Residents have distinct individual lifestyles, and their diverse use of space often brings unexpected surprises. It is the participation and usage of residents that endow urban open spaces with boundless vitality, and allow their spatial value to be fully realized. By building connections between humans and nature, as well as between people themselves, the space allows residents to enjoy pleasant leisure time in the park.

In summary, urban lakeside landscape design carries important significance at both the macro and micro levels. The most fundamental presentation of a city is reflected in its green landscapes; countless mountains and rivers converge at the lakeside; ecological civilization is inscribed in the vegetation and mirrored on the surface of the lake.

1.3. Research Content

Based on this topic, this paper proposes the overall approach of "natural ecology and humanistic care," aiming to promote ecological restoration and sustainable development within the watershed based on Nanhu's ecological governance. The construction of Nanhu Ecological Park takes "ecological governance" as its core concept, creating an ecological park integrating ecological protection, leisure sightseeing, and cultural inheritance. "Forest as the body, water as the vein, culture as the soul" is the core principle of Nanhu Ecological Park design.

1.4. Research Methods

The research methods adopted in this project mainly include:

Literature Research Method

The literature research method is a method of obtaining new knowledge and understanding through in-depth study and analysis of previous literature. It requires researchers to possess broad knowledge, a rigorous attitude, and scientific methods.

Questionnaire Survey Method

The questionnaire survey method is a survey method that distributes questionnaires to specific populations and collects data. It is typically used to understand the views, attitudes, and behaviors of the general public. Through questionnaire surveys, large amounts of data can be obtained quickly and efficiently, and quantitative analysis can be conducted to a certain extent.

Quantitative Analysis Method

The quantitative analysis method is a research method based on quantity, which reveals quantitative relationships and patterns between phenomena through statistics, calculation, and analysis of data and information. This method is very important in both scientific research and practical applications because it can provide objective, accurate, and reproducible results.

1.5. Chapter Summary

This chapter aims to explore in depth the importance of Nanhu's ecological governance and, based on this, propose the overall approach of promoting ecological restoration and sustainable development within the watershed. Meanwhile, emphasis is placed on the core concepts and design principles of Nanhu Ecological Park construction, aiming to present readers with a clearer, more comprehensive, and vivid perspective. Nanhu, as a lake with rich ecological resources, has its ecological status directly related to the health and sustainable development of the surrounding environment. In recent years, with accelerated urbanization, Nanhu has faced severe ecological pressure. To improve this situation, the overall approach of promoting ecological restoration and sustainable development within the watershed with Nanhu's ecological governance as the core is proposed.

2. Wuhan Location Analysis and Current Characteristics

2.1. Location Analysis

Wuhan is located in the eastern part of the Jianghan Plain and the middle reaches of the Yangtze River. The Yangtze River and its largest tributary, the Han River, converge here, forming the pattern of Wuhan's three towns (Wuchang, Hankou, and Hanyang) standing across the river. The city has crisscrossing rivers combined with lake ports, with water area accounting for one-quarter of the city's total area, and has been rated as an international wetland city. As China's economic and transportation hub, Wuhan has long been known as the "thoroughfare of nine provinces." It is the largest land-water-air hub in inland China and a shipping hub in the middle reaches of the Yangtze River. Its high-speed rail network covers most of China, making it the only city in Central China with direct access to five continents [4]. Wuhan is an important central city in the Yangtze River Delta Economic Belt, a strategic fulcrum for the rise of Central China, a comprehensive reform pilot zone, and China Optical Valley is committed to building an innovation and entrepreneurship center with global influence. According to the requirements of the National Development and Reform Commission, Wuhan is accelerating the formation of a national central city based on four functions: national economic and social center, high-level technological innovation center, trade and logistics center, and international exchange center.

According to relevant statistical data, with rapid economic development and deepening urbanization, Wuhan's built-up area has been showing an increasing trend. From the 1970s to the early 21st century, Wuhan's built-up area surged from 197.01 km^2 to 375.25 km^2, an increase of 178.24 km^2. Meanwhile, Wuhan's overall lake area showed a decreasing trend. Between 1978 and 2002, the lake water area in Wuhan's main urban area decreased from 157.61 km^2 to 122.66 km^2, a reduction of 34.95 km^2

2.2. Current Characteristics

2.2.1. Topography and Landforms

Wuhan's terrain is predominantly plain, with low mountains, hills. The city's low mountains, hills, ridge plains, and flat plains account for 5.8%, 12.3%, 42.6%, and 39.3% of the total land area, respectively. Flat plains are located on both banks of the Yangtze River, Han River, and their tributaries, as well as around lakes, and are cotton and vegetable production areas. Ridge plains are located around lakes and in the transition zone from hills to plains, rich in rice and fish. Hills are divided into three columns, all covered by forests. The northern column is distributed in Xinzhou District and northern Huangpi District, the middle column traverses the urban area, and the southern column is distributed in Caidian District and northern Jiangxia District. Low mountains are mainly distributed in Huangpi District and northeastern Xinzhou District, with elevations above 200 m to 500 m. Shuangjian Peak at the border of Huangpi District and Xiaogan City, with an elevation of 872.5 m, is Wuhan's highest point. The highest point in the central urban area is Dingguan Peak in Hongshan District, with an elevation of 200.1 m. Minerals mainly include coal, phosphorus, and pyrite.

2.2.2. Hydrological Conditions

Wuhan has abundant rainfall, with a multi-year average precipitation of 1284.0 mm. Rainfall is concentrated in months, with an annual average evaporation of 1391.7 mm, an annual average absolute humidity of 16.4 mb, an annual average relative humidity of 75.7%, a humidity coefficient of w = 0.903, an atmospheric influence depth of da = 3.0 m, and an atmospheric influence sharp depth of 1.35.

2.2.3. Regional Water Systems and Lakes

Wuhan's urban area has well-developed water systems. The Yangtze River and Han River traverse the city, "cutting" Wuhan into three towns. The two major rivers' tributaries include the Fu River, Manshui River, Chang River, and Daoshui River.

From the 1970s to the early 21st century, the average lake area in Wuhan's three towns showed a declining trend. This was particularly prominent from 1991 to 2002, when lake reduction was quite severe, dropping directly from 137.78 km² to 122.66 km², with a negative growth rate of -22.2%. During the same period, Wuhan's main urban built-up area increased from 197.01 km² to 375.25 km², with a growth rate of 53.95%. From these two sets of data, it is evident that with the expansion of urban construction areas and the increase in built-up area, lake areas are continuously decreasing [7].

Although lake area reduction is not entirely attributable to urban expansion, with soaring real estate values and the appreciation of original land value, the compatibility between water areas and territory has led to serious channelization and hardening problems, including separation of rivers and lakes, severe lake water environmental pollution, collapse of lake ecological functions, disappearance of aquatic organisms, and microclimate changes.

When studying lakes, they should be studied comprehensively as a complex. When utilizing lake water resources, comprehensive utilization strategies should be formulated. How to summarize the problems that existed in the historical development of Wuhan's lakeside land use, conduct comprehensive research, seek advantages and avoid disadvantages, and summarize its development characteristics and internal driving mechanisms will provide valuable material and theoretical basis for future comprehensive development and utilization of Wuhan's lakeside land use patterns.

2.2.4. Rich Urban Heritage

As the core city of Central China, Wuhan has a long history, splendid civilization, and glorious revolutionary tradition; the city has prosperous industrial production, commerce, and convenient transportation. Because it is the financial center and cultural education center of the central region, it has become a glorious historical and cultural city (Figure 1).

The convergence of the Yangtze and Han rivers, the confrontation of Turtle and Snake mountains, the distribution of lakes, and the lying waves of long bridges make Wuhan's beautiful natural landscape a unique landscape garden city. Understanding the formation and development trajectory of such a huge megacity has strong practical significance [8].

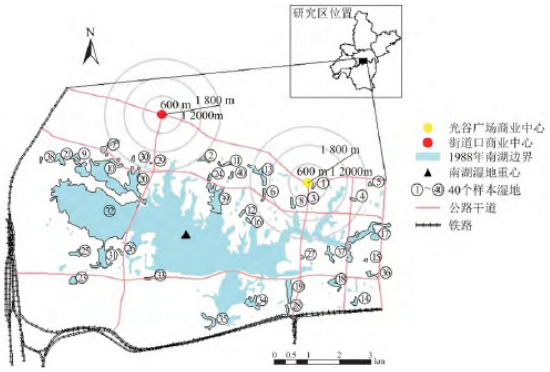


Figure 1. Overview of the Study Area and Sample Distribution Rich Urban Heritage
Source: https://wpn.wtu.edu.cn/https/

3. Domestic and International Research on Water Ecological Restoration

3.1. Design Theory

Due to rapid population growth, aquatic ecosystems are disintegrating under various pressures. Global impacts include homogenization of biological communities, disappearance of top predators and ecosystem regulators, chemical pollution from excessive nutrients and pollutants, and deterioration of structural diversity, connectivity, and dynamics. Contemporary society urgently needs to reverse the decline in biodiversity by promoting natural recovery or actively remediating lost ecosystem functions and services in aquatic ecosystems. The concepts and methods of conservation, restoration, and regeneration of lakeside systems, with the help of recent advances in ecological theory, have received widespread attention because of their linkage with wildlife protection, human activities, and climate change adaptation. Biodiversity loss and ecosystem degradation worldwide require the formation of new concepts of ecological restoration and reconstruction to improve urban ecosystem functions, services, and biodiversity maintenance.

Although relics of natural and semi-natural ecosystems can be found in urban areas, most urban ecosystems have undergone significant changes in environmental conditions and species composition, leading to the development of new ecosystems and mixed ecosystems. The result of this ecological innovation is the lack of semi-natural reference systems that can be used to determine restoration targets and

assess restoration success in urban areas. This hinders the implementation of urban lakeside ecological restoration. Considering these challenges, European and American countries have proposed a new conceptual framework to provide guidance and support for urban lakeside ecological restoration and reconstruction, formulating restoration targets for different degrees of ecological novelty (i.e., historical ecosystems, mixed ecosystems, and novel ecosystems). Although China started late in the green field, it has still invested effort in wetland restoration and water system protection policies. Properly learning from foreign ideas can promote the vigorous development of water ecological restoration.

To promote the restoration and reconstruction of new urban ecosystems, research suggests using established species-rich and well-functioning urban ecosystems as references. Such urban reference systems may exist in many cities. Emphasizing their value compared to degraded ecosystems can motivate and guide restoration initiatives.

Since urban restoration methods must consider local history and site conditions, as well as residents' needs, focus can also be placed on selected ecosystem functions, services, or biodiversity values to restore severely altered urban ecosystems. Ecosystem restoration and reconstruction in cities may be relatively inexpensive or expensive, but even expensive measures are rewarding if they effectively improve ecosystem services, such as mitigating climate change. By involving residents and other stakeholders, successfully reshaping and rethinking urban green spaces will help make urban lakesides more sustainable in the future.

3.1.1. Flood Theory Analysis

Flood theory, deeply rooted for centuries, has been well documented in ancient civilizations such as Egypt and Mesopotamia regarding flood events and their profound effects on respective communities. When explaining floods, they were often attributed to divine and supernatural forces, which were symbols revealing natural disasters and environmental evolution. Over time, with technological progress, flood theory gradually transformed from superstitious interpretations to its scientific foundations, deepening understanding of flood causes based on understanding of the hydrological cycle—including rainfall, runoff, and natural processes of river systems. Deep understanding of climate patterns causing heavy precipitation, watershed characteristics, hydrological behavior, and topography has led to scientific modeling and simulation technologies aimed at improving authorities' early warning and response capabilities for potential floods.

In contemporary society and disaster response strategies, the influence of flood theory remains significant and profound. By enhancing insight and predictive capability regarding flood behavior, governments and communities can adopt corresponding strategies to mitigate flood hazards, such as constructing levee defenses, planning evacuation plans, and promoting flood safety knowledge to the public. Forms of financial assistance include insurance plans and disaster relief funds spawned by flood theory, which provide economic support to those suffering from floods.

Looking back, the concept of flood theory exhibits multi-layered complexity and has undergone significant theoretical reshaping over time. Originating from historical context and based on scientific foundations, the effects of this natural phenomenon on modern society and disaster management constitute key insights for researchers to analyze and improve response strategies.

3.1.2. Urban Lakeside Theory Analysis

Theoretical analysis of lakeside cities occupies a significant position in the fields of urban layout and landscape construction. As a special interface between city and nature, lakeside areas' rich ecological environment, landscape resources, and cultural values have an indispensable impact on shaping urban character and optimizing urban appearance.

The abundance of wetland ecosystems and aquatic biological resources is often prominently reflected in lakeside areas. From an ecological environment perspective, the supply of fresh air and pleasant environments, maintenance of ecological balance, and climate regulation are precisely the key functions of these ecological elements. The core of urban lake theoretical analysis is how to properly balance ecological protection and utilization to shape a harmonious coexistence between humans and nature.

In the context of urban design, lakeside areas are often regarded as one of the open spaces most capable of attracting public attention. Rational spatial planning and ingenious landscape design can create ideal places suitable for citizens' leisure and entertainment. Regional culture and historical emotions are often manifested through lakeside landscapes, which, as the essence of urban culture, integrate distinctive elements and enhance the city's historical charm and cultural heritage. Transportation planning, functional configuration, and connectivity with other regions in lakeside areas are also indispensable focal points in urban lakeside theoretical analysis. Measures to optimize transportation organization, improve functional facilities, and strengthen regional connectivity can further enhance the overall efficiency and charm of lakeside areas.

The interweaving of numerous factors demonstrates the complex and multi-dimensional nature of urban lakeside theoretical analysis. Ecological, landscape, and cultural elements all need to be considered. Only through detailed investigation and analysis can more rigorous scientificity and fairness to waterfront planning and design, thereby promoting the sustainable evolution of the city.

4. Analysis of Lakeside Land Use Evolution in Wuhan

4.1. Analysis of Different Lakeside Land Use Conversion Types in Wuhan

4.1.1. Total Area Changes

In terms of total area, Wuhan's waterfront area had a total area of 150 km²in 2013, encompassing various land use types including cultivated land, construction land, water bodies, and other land. However, with the continuous advancement of urbanization, by 2023, the total area of the waterfront area had increased to 160 km². This growth mainly benefited from urban expansion and new development zone construction, making the waterfront area an important development region for Wuhan and even Hubei Province (Figure 4).

Wuhan's waterfront area underwent significant expansion and changes over just ten years. In addition to area growth, the land use structure of the waterfront area also underwent profound changes. Formerly cultivated land was gradually replaced by modern buildings and facilities, with construction land proportion rising year by year (Figure 5). Meanwhile, water bodies and other land types also continuously changed to adapt to urban development needs. In waterfront area

construction, the government focused on balancing ecological protection and sustainable development. While promoting economic development, protection of the waterfront ecological environment was also strengthened. Through implementing a series of ecological restoration and protection measures, the waterfront area's ecological environment was significantly improved, becoming a good place for residents' leisure and entertainment.

4.1.2. Agricultural Land

Especially in 2013, this land possessed abundant cultivated land resources, with a total area reaching an astonishing 80 km², accounting for 53.3% of the entire waterfront area's total area. These cultivated lands, like green pearls of the earth, nurtured abundant crops and provided a solid material foundation for Wuhan's agricultural production. However, with accelerated urbanization, the waterfront area's cultivated land resources faced unprecedented challenges. Large amounts of cultivated land were converted to construction land for building residences, commercial facilities, and public facilities. Although these changes drove rapid urban development, they also brought considerable impacts on agricultural production. By 2023, the waterfront area's cultivated land area had sharply decreased to 60 km², accounting for only 37.5% of the total area.

The reduction in cultivated land area not only affected the scale and efficiency of agricultural production but also had certain impacts on the ecological environment. Formerly green fields were gradually replaced by high-rise buildings, the ecological balance was disrupted, and biodiversity was threatened. The reduction in cultivated land also intensified the tension in land resources, bringing greater challenges to future agricultural development.

4.1.3. Construction Land

In 2013, the waterfront area's construction land area reached 40 km², accounting for 26.7% of the total area. This data provided a clear perspective for research, revealing the important position of the waterfront area in urban planning and development at that time. This construction land was mainly used for residential, commercial, and industrial development, not only promoting the urbanization process of the lakeside area but also injecting strong momentum into local economic development. At this stage, the waterfront area's real estate market was active, commercial atmosphere increasingly strong, and industrial output steadily climbing.

However, with continuous urban expansion and ongoing new project construction, the waterfront area's construction land area showed rapid growth over the decade. By 2023, this figure had surged to 70 km², accounting for 43.8% of the total area. This growth trend undoubtedly highlights the core position of the waterfront area in the urbanization process and reflects the local government's high regard for this region's development.

4.1.4. Water Body Changes

In 2013, the lakeside area's water body area reached 20 km², accounting for 13.3% of the entire region's total area. Lakes were clear and transparent, rivers had abundant water, and wetland ecology flourished, jointly bringing a pleasant living environment to waterfront area residents. With increasingly frequent lake renovation and urban development activities, these activities to some extent damaged the natural ecology of the waterfront area, causing water body area to gradually shrink. According to statistics, in just ten years, the waterfront area's water body area decreased from 20 km² to 15 km², with its proportion dropping from 13.3% to 9.4%. Although this change may seem minor, it has had profound impacts on the local ecological environment.

First, the reduction in water body area directly affected the biodiversity of the lakeside area. The shrinking of lakes, rivers, and wetlands caused many aquatic organisms to lose habitats, with population numbers plummeting. Meanwhile, the reduction in water bodies also affected vegetation coverage and soil moisture in the waterfront area, further affecting the stability and sustainability of the entire ecosystem. The reduction in water body area also affected local residents' lives. Formerly abundant water resources became increasingly scarce, with residents' domestic water and agricultural irrigation water both subject to varying degrees of restriction. Additionally, the reduction in water bodies led to fewer leisure places in the waterfront area, with residents restricted to barren land unable to engage in recreational activities.

4.1.5. Other Changes

In 2013, the lakeside area also included a certain amount of unused land and bare land. These lands had relatively low utilization value at the time, but with the continuous deepening of urban development, these lands were gradually incorporated into urban planning. By 2023, other land use areas had increased to 15 km², accounting for 9.3% of the total area. This growth mainly benefited from the effective utilization of unused land in urban development.

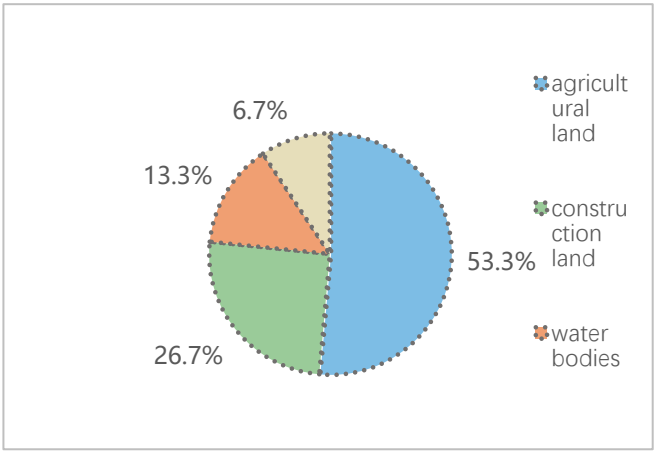


Figure 2. 2013 Wuhan Land Type Proportion Analysis
Source: Author's own drawing

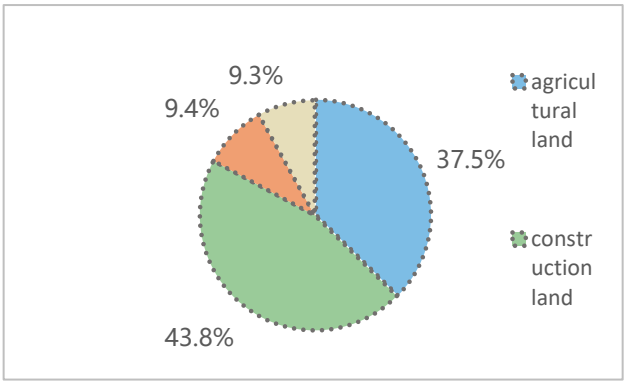


Figure 3. 2023 Wuhan Land Type Proportion Analysis
Source: Author's own drawing

4.2. Analysis of Different Lakeside Land Use Conversion Characteristics in Wuhan

During the decade from 2013 to 2023, the characteristics of

lakeside land use conversion in Wuhan mainly manifested in the following aspects:

(1) Conversion of agricultural land to commercial land. With accelerated urbanization, Wuhan's lakeside area agricultural land was gradually replaced by commercial land. This commercial land was mainly used for building shopping malls, hotels, office buildings, and other commercial facilities, injecting new vitality into urban economic development. According to statistics, during this decade, Wuhan's lakeside area commercial land area grew by nearly 50%.

(2) Conversion of natural wetlands to urban parks. To protect and restore the lakeside area's ecological environment, the Wuhan municipal government adopted a series of measures to convert some natural wetlands into urban parks. These parks not only provided citizens with leisure and entertainment venues but also improved the lakeside area's ecological environment. For example, East Lake Greenway, as a highlight of Wuhan, attracted numerous tourists and became a city card.

(3) Conversion of residential land to tourism land. With the vigorous development of tourism, Wuhan's lakeside area residential land gradually transformed to tourism land. Some areas originally used for residence were converted into homestays, resorts, and other tourism facilities, providing tourists with richer tourism experiences. This conversion not only promoted tourism development but also brought more employment opportunities and income sources to local residents.

In addition to the above main aspects, Wuhan's lakeside land use conversion also involved various other types, such as conversion of industrial land to research land, and conversion of transportation land to public facilities. These conversions all reflect the continuous optimization and adjustment of lakeside land use in Wuhan's urbanization process.

From 2013 to 2023, the characteristics of lakeside land use conversion in Wuhan showed a trend of diversification and complexity. This conversion not only reflects urban development needs but also reflects human respect and protection of the natural environment. In future development, Wuhan should continue to strengthen planning and management of lakeside areas, ensuring land use sustainability and ecological environment stability. Meanwhile, through scientific land use planning and rational policy guidance, promote coordinated development of economy, society, and culture in lakeside areas, creating a more livable, workable, and touristic living environment for citizens.

5. Nanhu Ecological Park Project Ecological Landscape Design

5.1. Nanhu Ecological Park Project Overview

Located in the southwest of Wuchang, Nanhu is the third largest urban lake in Wuhan after East Lake and Tangxun Lake, bordered by East Lake and Sand Lake to the north, and Tangxun Lake and Huangjia Lake to the south, with a water area of 763.96 hectares [9].

Currently, Nanhu's water quality has become moderately to severely eutrophic, with a deteriorating trend. In late spring and early summer, Nanhu and some branch lakes often experience large-scale fish kills due to pond turnover. There are 25 main sewage outlets around it, discharging approximately 145,000 tons of sewage daily. The Nanhu sewage interception project was launched in September 2005, with Wuhan investing 40 million yuan, first intercepting several main sewage outlets accounting for 80% of Nanhu's total sewage discharge (Figure 6). Subsequent work including dredging, water diversion, and ecological restoration requires huge investment and decades of time. After governance, Nanhu's water quality has improved, but long-term attention and governance are still needed. It is an important concern for provincial and municipal governments, people's congresses, and political consultative conferences.

To effectively manage and protect urban lake water as a precious natural resource, Wuhan has begun focusing on building a series of lakeside ecological projects represented by Nanhu Ecological Park in recent years. These projects not only focus on improving the ecological environment but also on the economic development of lakeside areas, providing citizens with more quality leisure and entertainment venues.

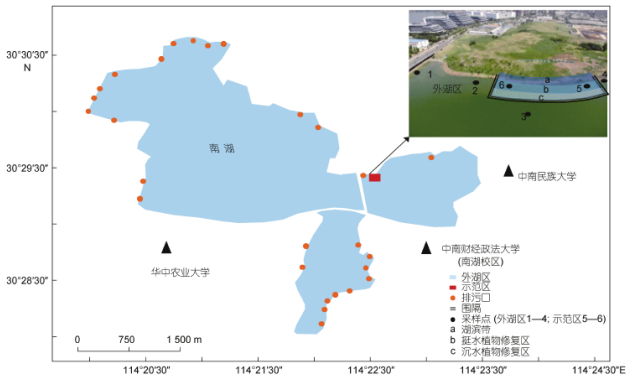


Figure 4. Wuhan Nanhu Demonstration Area Location and Sampling Point Schematic
Source: https://wpn.wtu.edu.cn/https/

5.2. Nanhu Ecological Park Design Content and Methods

5.2.1. Overall Concept and Positioning of Nanhu Ecological Park Design

The current ecological condition of the Nanhu watershed is increasingly severe, reaching a point where restoration is urgently needed. Therefore, this planning and design is committed to proposing the overall approach of "natural ecology and humanistic care," with Nanhu ecological governance as the core foundation. Comprehensive ecological restoration of the Nanhu watershed will be conducted through measures such as dredging and ecological water replenishment to improve water quality and provide good survival conditions for aquatic organisms. Vegetation restoration and wetland protection will be strengthened to enhance the Nanhu watershed's ecological carrying capacity. Additionally, biodiversity protection will be strengthened by introducing suitable aquatic organisms and birds to enrich Nanhu's ecosystem.

In the field of humanistic care, the cultural connotations of the Nanhu watershed will be fully explored, integrating traditional cultural elements into ecological governance. For example, cultural landscape nodes will be set up along the shoreline and surrounding areas to display the historical culture and natural features of the Nanhu watershed; simultaneously, a series of environmental education and science popularization activities will be conducted to enhance public awareness of ecological protection and sustainable development.

5.2.2. Overall Planning Concept of Nanhu Ecological Park

With "forest as the body, water as the vein, culture as the soul," build "golden mountains and silver mountains," leverage the ecological barrier, water conservation, and forest carbon sequestration functions of large forestlands, transform Nanhu into a sustainably developing lake, integrate into the surrounding mountain, water, field, forest, lake, and grassland ecological system, and jointly build a grand ecological pattern. Meanwhile, based on Nanhu ecological governance, respect and protect Wuhan's historical context, design for limited resources, emphasize the relationship among human emotion, regionality, and nationality, and combine traditional design with contemporary design.

5.2.3. Ecological Design Principles of Nanhu Ecological Park

(1) Principle of adapting to local conditions. Fully consider the landscape greening foundation, geographical natural conditions, and historical cultural foundation around Nanhu, with the central focus on reflecting Wuhan's regional cultural characteristics, integrating the city's rich historical and cultural heritage.

(2) Principle of ecological sustainability. Based on the current lakeside status and functions, reconstruct lakeside waterfront landscapes and riverbank greenway ecosystems that conform to the lakeside regional ecological characteristics. Through urban design, incorporate the ecological environment into the city's basic structure, focus on building energy conservation and environmental protection, advocate green travel, and achieve harmony between humans and nature, and between city and nature.

(3) Principle of cultural characteristics. Culture is the trace of history and the precipitation of time. In the changes of the times, today's civilization will become tomorrow's history. While respecting and inheriting history, we should conform to the times, follow technological progress, and create new history. Combine tradition and modernity, stimulate unique ideas and creativity, and form new landscapes. Excavate cultural connotations, display local characteristics, integrate diverse cultures, showcase new city appearance, and inherit and carry forward regional culture.

(4) Principle of enhancing economic vitality. Strengthen the public space system through urban planning, shape rich spaces, guide public facility layout, and enhance urban vitality.

(5) Principle of landscape and biodiversity. Under the premise of achieving lakeside flood control functions, simultaneously integrate the unique landscapes of both lakeside banks to create a beautiful urban scenic line. This can not only enhance urban charm but also help improve the urban natural environment and living environment, further enriching the urban lakeside waterfront space landscape.

5.3. Nanhu Ecological Park Landscape Planning and Design Scheme

5.3.1. Planning Structure System Construction

As the core carrier of this planning, Nanhu's existing natural landscape and cultural heritage provide rich materials for design. Fully relying on Nanhu's current situation, efforts are made to build a distinctive mountain-water pattern. This pattern not only integrates nature and city but also allows the park and surrounding residential areas to form a mutually echoing and harmonious coexistence relationship.

Through introducing diverse vegetation and water systems, create an ecologically diverse and vibrant green space. Second, in spatial layout, focus on spatial fluidity and layering, making the park's internal areas both independent and interconnected. Additionally, by improving landscape quality and adding leisure facilities, make the park a social place full of life atmosphere and emotional resonance.

Extensive research and investigation were conducted in the early stage, deeply understanding Nanhu's ecological characteristics, historical culture, and community needs, providing strong data support and reference basis for planning.



Figure 5. Nanhu Ecological Park Master Plan
Source: Author's own drawing

5.3.2. Recreation System Construction

Three carefully designed green ecological corridors not only provide fresh breathing space and comfortable living environment for Nanhu Greenway but also infiltrate natural aesthetics into people's inner world, allowing busy urban life to be immersed in nature's tranquility and balance.

The first high-level ecological green corridor located in the eastern part of the park passes through the colorful Joy Park, with beautiful scenery along the way. In the corridor design concept, the primary principle is to balance biological habitat protection and aesthetic landscape, thus adopting diverse eco-friendly building materials and plant layouts. In the corridor covered by green shade, fragrant flowers accompany bird songs, and every traveler seems to become a participant in an ecological feast, experiencing endless natural freshness and beauty.



Figure 6. Nanhu Ecological Park Ecological Corridor
Source: Author's own drawing

The second green ecological corridor winds in the western part of the park, running parallel to a babbling stream. In the corridor design, water-friendly elements are extensively incorporated to fully utilize the rich resources of rain gardens, including viewing platforms and waterside trails. The design of water-friendly facilities not only gives residents the possibility to appreciate the magnificent beauty of rivers up close but also substantially promotes deeper understanding of

water resource conservation and ecological protection concepts.



Figure 7. Nanhu Ecological Park Ecological Corridor
Source: Author's own drawing

Three carefully designed green ecological corridors are conceived and established, not only providing clean breathing space and comfortable living environment for Wuhan but also infiltrating natural aesthetics into people's inner world, allowing busy urban life to be immersed in nature's tranquility and balance.

The first high-level ecological green corridor located in the eastern part of the park passes through the colorful Joy Park, with beautiful scenery along the way. In the corridor design concept, the primary principle is to balance biological habitat protection and aesthetic landscape, thus adopting diverse eco-friendly building materials and plant layouts. In the corridor covered by green shade, fragrant flowers accompany bird songs, and every traveler seems to become a participant in an ecological feast, experiencing endless natural freshness and beauty.

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Figure 8. Nanhu Ecological Park Detailed Plan—Bird Watching Platform
Source: Author's own drawing

A third green ecological corridor connecting the magnificent bird-watching garden winds through the northern part of the city. The richness of biodiversity is fully demonstrated in the wetland park, becoming a survival paradise for many rare species. The corridor design particularly emphasizes the role of ecological enlightenment and science popularization, using ecological interpretation signs, bird observation platforms, and other facility arrangements to promote public deep insight into the mystery and value of wetland ecosystems.

Residents can enjoy an excellent leisure environment, and the overall quality of the urban environment has been elevated, thanks to these three ingeniously crafted green ecological corridors. The tranquility and beauty of quiet nature have become an ideal refuge for people escaping urban noise and fatigue.

5.3.3. Greenway System Construction

The construction of the greenway system helps improve the urban ecological environment. Green veins connect natural elements such as parks, green spaces, and water systems in the city, providing citizens with patches of green rest spaces. These spaces not only provide citizens with fresh air and pleasant environments but also help alleviate urban heat island effects and improve urban microclimates.

Roads extend from the forest reception hall, providing citizens with diverse travel options. Slow traffic modes such as walking and cycling are revitalized. Residents can stroll along the greenway, enjoying urban beauty and feeling nature's charm; they can also ride bicycles through the greenway, enjoying the happiness brought by exercise. This diversified travel mode not only enriches citizens' lives but also helps alleviate urban traffic pressure, reduce vehicle exhaust emissions, and promote sustainable urban development.

Interesting walking experiences become the unique value that the greenway system adds to residents' lives. The greenway design concept focuses on integrating cultural factors and aesthetic connotations, thereby creating public places that effectively serve residents' leisure needs, entertainment experiences, and cultural dialogue. The greenway becomes a stage for residents to hold diverse cultural activities, including light walking, jogging, competitive cycling, etc., thereby strengthening mutual communication and understanding. The greenway gives residents a possibility for intimate contact with nature, transforming into a corner of calm and relaxation amid urban busyness.

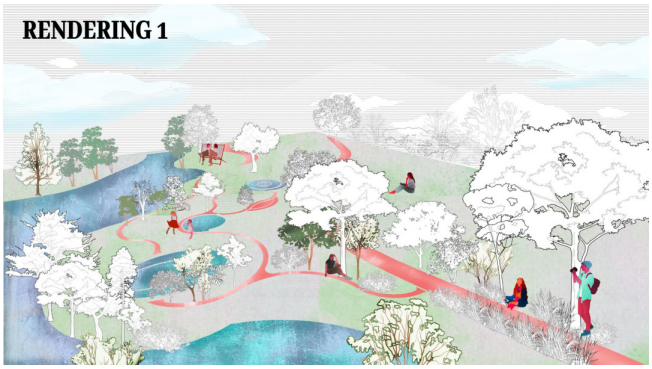


Figure 9. Nanhu Ecological Park Green Road
Source: Author's own drawing

The construction of the greenway system is equivalent to a significant marker of a city moving toward a sustainable

transportation development model. The construction of slow-traffic loops, by eliminating urban breakpoints, provides residents with smoother, more comfortable, and healthier mobility spaces, thereby promoting urban-rural interaction and exchange progress. In prospects, the role of the greenway system will become increasingly critical, as it conforms to the pace of urbanization and the public's high standards for quality of life, thus playing an important role in building urban green travel models, bringing more comfort to citizens' lives.

5.3.4. Living Water System Construction

Using new concepts and technologies conforming to natural ecological sustainable development such as micro-intervention and micro-water storage, adhering to combination with "three rural issues" and ecotourism, coordinating comprehensive improvement of mountains, waters, forests, fields, lakes, grasslands, and sand with grain stability and security, and gathering development of green low-carbon industries with vitality, attractiveness, and driving force. Construct three micro-water storage areas [10], utilize river beach resources, design ecological diving wetlands, local artificial dredging, bionic restoration to sort out large and small sub-channels, forming natural ecological water landscapes with deep pools, shallow shoals, and trickling streams, becoming "life water" for animal and plant survival during dry seasons.

Establish a complete aquatic ecosystem, enabling the water system to form a self-sustaining, virtuous cycle, and vital ecosystem [11].



Figure 10. Nanhu Ecological Park Water System
Source: Author's own drawing

5.4. Chapter Summary

The key to restoring Nanhu's ecological environment lies in following the concept of place spirit, requiring comprehensive assessment of its surrounding landscape structure, geographical characteristics, and profound historical and cultural background. Priority should be given to the principle of ecological sustainability, focusing on shaping lake waterfront landscapes and riverbank green corridor ecological systems that conform to lakeside regional ecological characteristics, aiming to achieve ecological environment restoration and optimization.

The restoration strategy for Nanhu's ecological habitat is based on the principle of local adaptation. The primary task is to deeply analyze the current status of surrounding landscape greening, identify existing greening assets and developable potential spaces. Focusing on Nanhu's unique geographical features, such as geomorphological structure and climatic conditions, is a key step in constructing a reasonable scientific basis for ecological habitat restoration. What cannot be underestimated is the crucial role played by historical and cultural heritage. We need to comprehensively explore the cultural elements of the Nanhu region and integrate them into ecological habitat restoration design, thereby highlighting local characteristics.

Following the principles of suitable site and species, ecological sustainability, cultural uniqueness, and economic benefit enhancement is the key to Nanhu's ecological habitat reconstruction. With these guidelines, Nanhu will give birth to an ecological space integrating local characteristics and vigorous vitality, endowing new energy pulses to the city's sustainable progress. In this process, landscape beautification and biodiversity enhancement work are equally indispensable. We are committed to building fascinating urban visual landscapes, optimizing the city's natural ecology and living environment, and creating an ideal habitat suitable for living and visiting.

6. Conclusion

During the urbanization process, the national economy grew rapidly, and land supply was severely insufficient. Lakeside land use is an integral part of exploring economic prosperity and development, but the tight situation of urban construction land can be addressed by extending local areas to achieve higher intensity level demands. Lakeside land use has become an important expansion target, and how to measure and evaluate the value of lakeside land has become a core issue in rational urban development and market mechanisms. Based on this, in pursuing the urbanization process, lakeside land use brings economic takeoff while also requiring reasonable regulation of the development structure of urban lakeside land use to create favorable conditions for sustainable urban development. The main purpose of in-depth research on the development characteristics of Wuhan's lakeside land use is to provide a data foundation for alleviating problems in urban lakeside land use and to provide technical support for improving the development structure of Wuhan's urban lakeside areas.

Through the landscape design within Nanhu Ecological Park, "awakening lakeside vitality—building riverside green life," realizing the design concept of "returning the lake to the people, returning the shore to the people", creating a natural, healthy, romantic, and harmonious linear ecological comprehensive lakeside park for residents and tourists.

The cross-integration of ecological lakeside natural landscape and urban scenery helps beautify the overall urban natural environment and improve the vitality of urban rivers. Let urban lakesides become urban open spaces for human participation and interactive experience. Based on ecological concepts, create natural-form shorelines, use ecological paving and environmental materials on ecological lakeside embankments, and through rational vegetation matching and integration of urban historical context, can urban lakesides be full of vitality, and urban residents also be more vibrant, ultimately achieving the design goal of harmonious coexistence between humans and nature. Combine Nanhu's own natural form with the city's artificial ecology to establish a natural green lakeside landscape effect.

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