Study on the Sustainable Development of Urban Water Landscape Space Based on GIS Geographic Information Technology

—— Take the Water Landscape Space in Nankai District, Tianjin as an Example

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ABSTRACT

With the advancement of urbanization and the introduction of concepts such as double urban repairs, water landscape spaces, as an essential part of urban public spaces, have gained increasing attention due to their significant advantages like hydrophilicity, diversity, and openness. They are playing an increasingly important role in urban life and have become indispensable public activity areas for city residents. However, with the growing environmental and spiritual needs of people and the rapid social development, the sustainable development capabilities of water landscape spaces have become inadequate, failing to meet the rapidly evolving demands of citizens. This indicates that there is an urgent need to improve existing water landscape spaces. Taking the water landscape space in Nankai District, Tianjin as a case study, this paper combines field surveys with GIS geographic information technology analysis to thoroughly investigate the current shortcomings of water spaces and proposes specific measures for their sustainable development. The aim is to enhance the practicality of Haihe River water landscape spaces and provide optimization suggestions for better urban construction and citizen services.

Key words: Double Urban Repairs: Water Landscape Space; GIS Geographic Information Technology; Sustainable Development

1.Introduction

As urbanization rapidly advances, the original land and natural ecological structures of cities face transformation. Large amounts of land are being used for urban development and population habitation, often altering their intended uses and impacting the surrounding natural environment. Extensive natural green spaces and water resources have also been transformed to support urban growth. To ensure that the natural environment is not overly affected during urban development, the state has proposed the concept of "dual urban repairs," emphasizing the coordinated and focused attention on ecological restoration and functional recovery in the process of urban development. The aim is to promote sustainable urban development and improve living environments through green development, resource protection, and spatial reshaping. However, in the current urbanization process, there is more focus on how to create a more comfortable living environment, with insufficient attention paid to ecological restoration and functional recovery.

This study, based on the original field survey of water landscape spaces, applies GIS technology and combines it with the Gaode Map API to achieve precise positioning of waterfront landscape spaces within cities and accurate statistical analysis of relevant data. This ensures a more scientific understanding of the current status of water spaces and provides solutions and recommendations for improvement. Consequently, it aims

to assist in advancing dual urban repairs processes and enhancing water landscape spaces.

2. Policy support and research status

The concept of "dual urban repairs" has been highly valued by all sectors of society since its inception. At the national level, policies have been introduced to support this new urban renewal philosophy. In the “National New-Type Urbanization Plan (2014-2020)”, the government explicitly emphasized the importance of ecological civilization construction, advocating for the protection and restoration of the ecological environment while promoting urbanization. It stressed the balanced development of environmental protection and urban function restoration, proposing to build green smart cities with comprehensive functions such as livability, workability, and visitability. Additionally, in the “14th Five-Year Plan” for Ecological and Environmental Protection released in 2021, strategic guidance was provided for Chinas ecological and environmental protection over the next five years, particularly focusing on integrating urban development with ecological conservation. The plan emphasized the need to restore the ecological environment and promote the construction of green infrastructure, combining ecological restoration with urban function restoration. On this basis, various fields including landscape, ecology, and urban planning have conducted in-depth research and discussions on dual urban repairs.

Currently, research on dual urban repairs and water landscape spaces in China mostly involves urban ecological restoration, multi-faceted evaluation of the effects of dual urban repairs, specific implementation strategies for dual urban repairs, the concrete role of ecological restoration in cities, the importance of water landscape spaces in urban development, and the ecological aesthetics of water landscapes. In terms of dual urban repairs, Zhou Jianhua et al. systematically expound on the implementation strategies of urban repair and ecological restoration during the process of urban renewal; Wang Rusong et al., from a theoretical perspective, focus on exploring the concept and theoretical foundation of dual urban repairs, as well as its specific application in Chinese urban planning. Regarding the study of water landscape spaces, Zhang Xiaoyan et al. analyze the ecological and structural characteristics of water landscape spaces and discuss the impact of water bodies on landscape systems; Sun Lei studies the role of water landscape spaces in urban water environment governance and proposes that water landscape spaces should be integrated with urban ecological restoration. Therefore, based on existing research concepts, this paper conducts a survey and study on the water landscape spaces in Nankai District, Tianjin.

Nankai District of Tianjin was officially established in 1952. The background for its establishment can be traced back to the administrative adjustments of Tianjin after the founding of New China. With the development of the city and the expansion of urban areas, Nankai District now has a jurisdictional area of 41 km^2. As the focus of urban development shifts from east to west, Nankai District has consistently been one of the core areas for Tianjins development in recent years. The water landscape space of Nankai District ranks among the top in all districts of the city. However, with the advancement of urbanization, large amounts of land have been designated for commercial and residential use, affecting the original natural ecological environment of Nankai District. Therefore, under the broader context of dual urban repairs, it is necessary to assess the existing ecological environment and water landscapes of Nankai District improving and restoring spaces is a necessary condition for promoting sustainable development in Tianjins urban area. A correct understanding of the current status of urban water landscape spaces is a prerequisite for ecological restoration and landscape protection. This paper uses GIS geographic information technology combined with web map APIs, landscape ecology, geography, and other research theories and methods to conduct a quantitative study on the existing water landscape conditions in Nankai District. Through scientific statistics and calculations, it summarizes the current state of water landscapes in Nankai District, providing a reference for subsequent dual urban repairs implementation strategies.

3. Research area and research method

(1) Research area and data source

Nankai District of Tianjin is located in the core area of the main urban district, covering a total area of about 41 km². It is situated at the heart of Tianjins economic, cultural, political, and medical development zones. Influenced by the shift in the citys focus, Nankai District has been a hot spot for development since 2008 and remains a popular choice for property purchases and other significant investments among residents. Two key 985 universities, Tianjin University and Nankai University, are also located in Nankai District, making it one of the most densely populated areas with talent in Tianjin. Additionally, Nankai District boasts some of the best water landscapes among the six districts of the city, even rivaling those in the four suburban districts. Notable examples include the Water Park, Nankai Park, and Nan Cuiping Park. Furthermore, due to the rich distribution of water bodies in Tianjin, some scenic spaces at the boundaries between districts can also be classified as water landscapes. Therefore, targeting Nankai District as a research subject for the development of water landscapes in Tianjin is feasible.

The data sources for this study include the latest urban geographic images and real-time water areas and landscape distribution in the study area for 2024, the 1:60000 topographic map of Tianjin City and the vector map of Nankai District, the regional structure map of Nankai District, and GPS field survey data (on-site investigation and documentation of water landscape space within the jurisdiction of Nankai District from June 20, 2024 —— January 15, 2025).

(2) Research method

First, it is necessary to locate and statistically analyze the water landscapes within the Nankai District of Tianjin. Water landscapes, as a category in urban landscapes, not only include comprehensive water spaces with large bodies of water but also community water spaces facing residential areas and ecological water spaces focused on protection and restoration. These must be included in the research scope because the sustainable development of urban ecosystems requires the coordinated efforts of multiple dimensions of water landscape spaces. Therefore, the water landscape spaces involved in this study cover most of the water spaces within the research area.

Secondly, through the Gaode Map API platform, obtain precise locations of real-time landscape spaces and water systems within the study area, thereby acquiring accurate geographic information of water landscapes within the region. In conjunction with the vector map of Nankai District, process the boundaries of the study area to ensure accurate definition of the geographical information of water landscape spaces. Utilize comprehensive data such as topographic maps and landscape distribution maps of Nankai District, water system maps of Nankai District, and GIS geographic information data to screen conditions for landscape spaces within the region; import eligible landscape space patches into GIS for digital visualization processing and establish corresponding spatial databases; then use GIS to conduct spatial data statistics, create and output project thematic maps; summarize and analyze the obtained data using information processing software to derive specific parameters of water landscape spaces within the region and their comparison parameters with overall landscape spaces; finally, combine the thematic maps with field survey data on water landscape spaces to scientifically predict the current status and development trends of water landscape spaces within the study area, and propose corresponding improvement and enhancement measures to achieve the expected goals of this survey.

4.Research results and analysis

Using the online map API platform in conjunction with the GIS geographic data analysis system to extract information on landscape distribution and water body landscape distribution within Nankai District, Tianjin City in 2024, corresponding thematic maps (Figures 1, 2) were created. Information processing software was used to calculate the spatial pattern index of the landscapes, resulting in various statistical index characteristics of the water body landscape space in Nankai District, Tianjin City (Tables 1, 2).

(1) Distribution characteristics of water landscape

The distribution of water landscape patches in Nankai District exhibits a certain degree of irregularity and unevenness. The shapes of these patches are mostly irregular, and according to the specific urban water landscape planning area, they form interconnected patches with clustering characteristics. Within the Nankai District, there is a trend of "fewer in the north and more in the south" for water landscape patch distribution. In the northern region, water landscape patches are mainly concentrated around Houtai Wetland Park, Changhong Ecological Garden, and along the rivers near Hongqi Road; in the southern region, water landscape patches are distributed in regular clusters, with Shuishang Park serving as the core of the distribution radiating outward. The most concentrated areas are Shuishang Park, Nan Cuiping Park, and the Olympic Center area, while other patches are scattered throughout the surrounding regions. This indicates that the spatial development of water landscapes in Nankai District primarily focuses on improving and developing the natural geographical features within the existing area. There remains room for improvement in the exploration of community-based water landscape spaces near large residential areas. During subsequent phases of dual urban repairs implementation, certain strategic inclinations can be given to improve the current uneven distribution to some extent.

(2) Characteristics of landscape water patch units

The number of landscape patches in Nankai District, Tianjin City is 340, among which the number of water landscape patches is 191, accounting for about 56%. In terms of total area, the total area of landscape patches is 311.54hm², with the total area of water landscape patches being 263.64hm², accounting for about 85%. Based on this data, it can be concluded that water landscape patches in Nankai District, Tianjin City, occupy a significant proportion both in terms of quantity and total area. Additionally, according to statistics on the maximum, minimum, and average areas of water landscape patches, there are considerable differences between these patches within Nankai District, and small-sized water spaces account for a higher proportion.

(3)Characteristics of water landscape patches

In the water landscape patches of Nankai District, those smaller than 1hm² account for 69%, while in the entire region, this proportion rises to 80%. This indicates that most of the landscape patches in Nankai District are small areas less than 1 hm². Water landscape patches between 1 and 5hm² make up 15.88% of the total, while those larger than 5hm² are relatively rare, mostly found

Figure 1 Landscape pattern of Nankai District

Figure 2 Water landscape pattern of Nankai District

within typical water activity spaces such as Water Park and South Cuiping Park. Based on current data and the urban development concept of "dual urban repairs," it can be inferred that the distribution of water landscape patches and their area ratios in Nankai District will not change significantly in the future. They will still primarily consist of small-scale landscape patches, as ecological restoration efforts must balance urban living and other functions, rather than solely focusing on environmental improvement and recovery. The original functions of the city must also be preserved. However, considering the extensive urban renovations, residential expansions, and new real estate projects in recent years, the actual landscape spaces and water landscapes within the district have seen a reduction in both area and quantity compared to the past.

(4)Driving factors of landscape water status

In recent years, with the acceleration of urbanization and the updating of urban land structure and industrial structure, the overall area and quantity of urban water landscape spaces have decreased compared to the past. Based on the data collected and organized so far, combined with statistical information and socio-economic data from Nankai District in recent years, it can be concluded that the factors driving this change in the water landscape space of Nankai District can be categorized into internal and external drivers. Internal drivers mainly include location conditions, economic development, and changes in social psychology; external drivers primarily consist of regional policies and urban expansion needs. By studying these driving factors, we can better understand the formation process and corresponding development mechanisms of current water landscape spaces, providing recommendations for the implementation of subsequent dual urban repairs policies and the sustainable development of urban living environments.

First, lets discuss the internal driving factors. As a core area of Tianjin City, Nankai District boasts superior geographical location. From the perspective of cultural development, Nankai District has a rich history and profound cultural heritage. Many well-known universities in the city are located within Nankai District or have branches there, making it a place of cultural richness. Notable landmarks such as the Ancient Cultural Street, Zhou Deng Memorial Hall, and Tian Tower are also situated in Nankai District, with related historical legacies deeply rooted here. Economically, Tianjins economic development has primarily focused on the southwestern

Table 1 Characteristic index of landscape units in Nankai District

Type	Patch number	Total plaque area	Maximum plaque area	Smallest plaque area	Average plaque area
	N/ individual	A overall /hm²	A max/hm²	A min/hm²	A mean/hm²
Green landscape	340	311.54	21.19	0.0005	0.92
Waterfront landscaping	191	263.64	21.19	0.0012	1.38

Table 2 Area percentage of green landscape and waterfront green landscape patches in Nankai District

Type	1hm²	1-5hm²	5-10hm²	10-15hm²	15hm² and above
	below %	%	%	%	%
Green landscape	80.59	15.88	1.47	1.47	0.59
Waterfront landscaping	69.63	24.08	2.62	2.62	1.05

direction in recent years, and Nankai Districts economic data consistently ranks among the top in the city. In terms of lifestyle, Nankai District is one of the most integrated and diverse areas within Tianjin, blending the historical charm of old towns with modern urban flair. It retains the vibrant atmosphere of city life while making significant contributions to various fields such as smart technology and biotechnology in the new era. These multifaceted advantages have further enhanced Nankai Districts status as the city center and its economic development capabilities. As an excellent representative of revitalizing old urban areas, during the initial stages of urban construction, the region actually faced a shortage of population. However, the superior geographical conditions attracted many young people who yearned for a better life, undoubtedly accelerating the development of this areaWith the acceleration of urbanization, people living here generally have a higher level of pursuit for life, and this psychology will help them to live harder and build and develop their living areas.

The higher dimensional external driving factors are mainly regional policy factors and urban expansion demand. After the year 2000, with the development and construction of Tianjin City, Nankai District was designated as a core development area. The superior geographical conditions and strong cultural and educational capabilities further attracted outstanding talents from Tianjin and even across the country to settle in Nankai District, striving for their own and regional development. At the same time, as a region rich in scientific and educational resources, Nankai District has relied on the Tiankai Higher Education Science and Technology Park for spatial layout, promoting integration of industry, academia, and research, and attracting tech companies and university innovation teams to settle in. This supports the implementation of Tianjins new economic overall planning, which aims to "consolidate pillar industries such as green petrochemicals and automobiles, expand emerging industries like information technology innovation and biopharmaceuticals, and proactively lay out future industries such as international engineering and biomanufacturing." In terms of urban expansion needs, Nankai District has also performed exceptionally well. On the basis of existing subway layouts, it has improved Line 10 and Line 11, enhancing regional livability. It has also deepened cooperation with neighboring areas, driving the steady development of suburban districts like Jinnan and Xiqing under the impetus of Nankai District, undoubtedly boosting the development and expansion of surrounding areas around the core city.

5.Conclusion

This paper employs the principles of landscape ecology and integrates GIS geographic information systems to study the development and current status of water landscapes in Nankai District. The aim is to uncover the patterns and mechanisms behind changes and developments in the water landscape layout of Nankai District, while also providing a basis for the sustainable development of urban water landscape spaces. According to existing research findings: the water landscape in Nankai District exhibits uneven spatial distribution, with small-scale water landscapes being predominant. The development of water landscape spaces is significantly influenced by urban activities and development. Under the dual influence of internal and external factors, the sustainable development of water landscape spaces will increasingly depend on the comprehensive development of their respective regions. Three feasible suggestions can be offered in response to existing issues: First, to address the uneven spatial distribution, data from existing residential areas and water landscape spaces within the region can be compared. For densely populated areas, appropriate increases in water landscapes can be achieved by improving the environment around rivers. Second, given that most water landscape spaces are small-scale, environmental governance measures can be taken to connect and integrate these small-scale water landscape spaces through the construction of connecting roads or greenery, systematically summarizing them to form cultural or formal featuresThe landscape relevance. Furthermore, in the sustainable development of water landscape spaces, it is necessary to coordinate urban

construction and ecological improvement. We cannot overly emphasize ecology or solely pursue the efficiency and convenience of urban construction. Finally, for the sustainable research of water landscape spaces, it needs to be deeply integrated with the policies of dual urban repairs. For related construction and research work, support should be given from the perspective of regional management and policy, thereby promoting the continuous study of water landscape spaces.

6.References

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