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Urban Waterfront Ecological Greenway Landscape Planning Study—Tingjiang Greenway Landscape Planning in Shanghang County as an Example

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Abstract: The waterfront space of the city serves as a gentle dialogue between urban life and nature, embodying the dual missions of ecology and humanity. Here, the rippling blue waves and lush green trees create an urban ecological oasis, providing a habitat for the residents' souls. The waterfront greenway acts as the vital link of this space, uniquely blending natural beauty with humanistic charm.This paper analyzes the spatial structure design of the Tingjiang River Greenway in Shanghang County, focusing on its scientific and reasonable layout that achieves a harmonious coexistence of humans and nature. Additionally, it explores the diversity of its functions, addressing how it meets the public's multiple needs for leisure, fitness, and cultural experiences. Furthermore, the paper carefully depicts the landscape sequence and the harmonious beauty of its landscape nodes, detailing how thoughtful design can create a consistent and visually rich experience with a sense of hierarchy.The aim of this paper is to provide a visual feast for urban waterfront greenways and to serve as a detailed reference for the planning and development of such spaces. It seeks to assist cities in creating their own ecological and cultural treasures.

1. Preface

Urban ecological greenways refer to linear green open spaces typically established along natural or artificial corridors such as riverbanks, mountain slopes, stream valleys, and pathways. These greenways provide routes for pedestrians and tourists, offering opportunities to rest and enjoy the scenery. By integrating waterfront space planning with the concept of greenways, the waterfront greenway space has emerged as a new ecological planning approach and has become a top priority in contemporary ecological construction. The total length of the Tingjiang Greenway in Shanghang County is approximately 60 kilometers, with the Tingjiang River serving as the main axis. The project includes pathways established on both banks of the river and is divided into four cultural belts, linking with the new "Ten Scenic Spots of Hangzhou." This paper analyzes the spatial composition, functionality, and landscape sequence of the Tingjiang Greenway in Shanghang County, exploring the significance of the waterfront greenway space within the county.

2. Concepts of Greenways and Waterfront Spaces

Broadly speaking, "greenway" is a term that refers to interconnected linear green open spaces, including bicycle paths, habitat corridors designed to facilitate wildlife migration, waterfront pathways, and tree-lined trails. Greenways encompass a diverse range of environments, incorporating both natural and constructed landscapes. They serve as linear connectors that enhance ecological structures while linking natural and human-made spaces. Based on their location and function, greenways can be classified into three categories: urban greenways, countryside greenways, and ecological greenways.

The term "waterfront" refers to spaces adjacent to water bodies such as rivers, streams, and lakes. Waterfront landscapes are a crucial component of garden design, maximizing the use of water resources while successfully integrating natural environments with human-made landscapes. This integration enhances the harmonious coexistence of humans and nature and plays a significant role in regulating the ecological environment and constructing scientifically and aesthetically pleasing ecological regions.

The Ting River is the largest river in western Fujian and is often referred to as "the mother river of the Hakka people." The mountains flanking the Ting River are uniquely shaped, and the river meanders through Shanghang County, encircling the city three times, thereby creating a distinct "water vein" pattern in the region. The Tingjiang Greenway exemplifies a typical waterfront greenway space and is a vital component of the greenway system in Shanghang County. Firstly, it serves to protect the county's natural ecological environment, particularly important ecological nodes and corridors. Secondly, it emphasizes the organic maintenance of natural ecological processes at the boundaries of each block during construction. Thirdly, it enhances the connectivity among various spatial blocks within the county, improving the overall ecological network structure while considering the ecological characteristics of the entire area. Furthermore, the greenway focuses on enhancing connectivity among the different blocks, perfecting the ecological network structure by integrating ecological, socio-cultural, economic, and industrial functions. It provides habitats for the county's residents, flora, and fauna, serving as a crucial link between aquatic and terrestrial environments.

3. Spatial Composition of Tingjiang Greenway Landscape in Shanghang County

The urban waterfront greenway is a macro component of the urban greenway system, shaped by factors such as urban development patterns, road networks, river configurations, and natural landscapes. Its overall structure is linear, linking the green spaces throughout the city. The spatial system of the urban waterfront greenway comprises two dimensions: planar structure and three-dimensional structure. The planar structure primarily includes water spaces, green spaces, traffic corridors, and the intersections of these areas. In contrast, the three-dimensional structure refers to the volumetric relationships between the topography of the waterfront greenway and the surrounding environments, including buildings and mountains, such as the city's skyline.

3.1 Plan structure of the Tingjiang Greenway space

The spatial composition of the Tingjiang Greenway can be divided into four components: water space, green space, traffic space, and node space.

The water body serves as the visual centerpiece of the greenway space, and its overall spatial form changes in response to variations in the water body, creating distinct spatial interfaces. This area is also the most biodiverse, acting as an ecological corridor where animals and plants exchange nutrients, survive, and reproduce. The quality of the water impacts the entire ecological chain and

the watershed as a whole. Maintaining a healthy water space is a critical aspect of the waterfront greenway and plays a vital role in ensuring the continuity and integrity of the greenway. This continuity facilitates various functions, including material transformation, information exchange, biological migration and reproduction, water purification, and the cycling of green spaces. These natural processes enhance biodiversity, increase landscape heterogeneity, and promote ecological integration.

From an overall perspective, the water space of the Tingjiang Greenway emphasizes the connectivity and integration of different channels. Techniques such as ecological stacks and ecological bridges are employed to enhance the continuity and integrity of the greenway space. The arrangement of the waterfront landscape also adapts to changes in the form of the water space, considering the principles of "big cycle" and "small cycle" to facilitate the exchange and interaction within the waterfront landscape design. This approach combines soft and hard elements to maintain water quality and the ecological integrity of the aquatic environment.

The green space of a waterfront greenway is a linear ecological area composed of various types of plants, including trees, shrubs, vines, and grasses. This space serves as an ecological unit that bridges the water and land ecosystems. It features a diverse array of plant life, encompassing wetland vegetation, vegetation in the transitional zones between land and water, and species adapted to both aquatic and terrestrial environments.

The topography of the Ting River Greenway is narrow and significantly influenced by human activities. A combination of native plants and artificial landscaping creates a unique habitat. This green space not only maintains the ecological balance between the river corridor and surrounding vegetation but also serves as a habitat for terrestrial plants and animals. Additionally, it acts as a carrier for human activities, forming an essential part of the urban waterfront greenway. The green space adapts to changes in the shape and distribution of the water space, effectively blurring the boundaries between the greenway, external architectural spaces, and surrounding transportation corridors. It guides hikers, walkers, and cyclists along their routes while providing shade and cooling functions during the summer. Moreover, the formation of a local microclimate enhances the exchange of information among organisms, creating an effective area for ecological interactions beyond the water space.

The traffic space of Tingjiang Greenway has good accessibility, a total of 7 major types are set up, integrated slow walk to ≥ 4 m, walking path ≥ 1.2 m, cycle track double columns erected on the status quo mechanic's path = 3 m, cycle track ≥ 2.8 m, use of the existing pavement to change to a cycle track, integrated slow walk single columns driving on the edge of the Tingjiang River ≥ 4 m, the status quo walking path.

The linear spaces of water, green areas, and transportation routes within the urban waterfront greenway function as "lines" in the spatial arrangement. Nodes represent the "points" where these "lines" overlap and intersect, enhancing the hierarchical relationships among these various spaces.

The Tingjiang Greenway features overlapping linear pathways that connect various scenic spots, including the ten scenic areas and six smaller nodes. These nodes serve as the core of spatial activity, representing the most dynamic spaces with rich spatial structures, making them ideal for showcasing distinctive characteristics. The design of these nodes should respect the site's topography and geomorphology, embodying the spirit of the location while highlighting urban characteristics. Additionally, the design should promote interactivity among people, plants, and animals, fostering a vibrant and engaging environment.

3.2 The three-dimensional structure of the Tingjiang Greenway space

The skyline interface of an urban waterfront greenway should be composed of the building

masses surrounding the greenway and the vista skyline. The urban skyline in the waterfront area is perceived in relation to the line of sight, where various compositional elements and rhythmic variations create distinct visual perceptions. Shanghang County is characterized by its hilly terrain, surrounded by low hills and a limited number of residential buildings. The water space serves as a horizontal boundary, defining the city and enhancing its overall silhouette, making it easier for viewers to perceive the skyline's scale and contours. Additionally, the city skyline provides a backdrop for the waterfront greenway, serving as an essential feature that reflects the contemporary urban landscape (as illustrated in Figure 1).

Activities significantly influence the landscape structure of the greenway, primarily through five aspects:

Expansion of Habitat: Human activities expand the distribution areas of various plant and animal species. In the Tingjiang River Basin, which serves as the central fishing area for Shanghang County, this has implications for local fisheries.

Alteration of Plant Diversity: These activities can change the dominance and diversity of plant species in the landscape, particularly affecting forest-dominant species. The Seven Peaks Embrace Cui node, for example, is characterized by historical and notable trees, which contribute to a more pronounced microclimate compared to other nodes and enhance its three-dimensional vertical structure.

Invasion of Non-native Species: While human activities alter the landscape, they also create opportunities for the invasion of weeds (exotic species), impacting the local ecosystem.

Soil Nutrient Changes: Human actions can modify the nutrient status of the soil. In the four nodes from Changba Lekong to Nanta Zen Bell, the greenway flanks areas where residents have retained vegetable gardens, contributing to a rich landscape atmosphere and maintaining high-quality soil nutrients.

Landscape Mosaic Patterns: Human settlement and land use have transformed the landscape mosaic pattern. The Tingjiang Greenway functions as a connector, linking three significant areas of the county: Qifengshan, Ximen, and Dongmen. The spatial structures of these areas are shaped by environmental changes, contributing to a high-quality waterfront greenway landscape atmosphere.

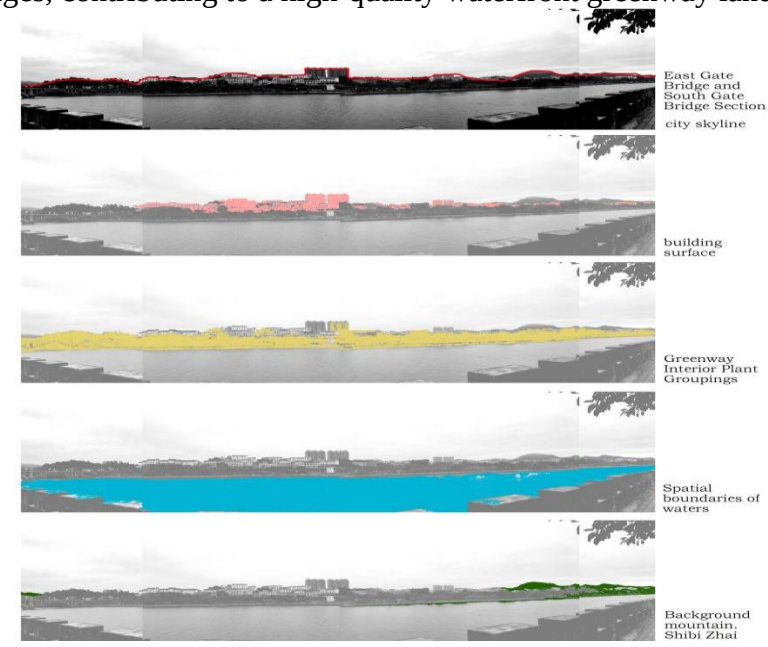

Figure 1: Tingjiang Greenway Section from Dongmen Bridge to Nanmen Bridge Structural Analysis Self-drawn

4. Functionality of the Tingjiang Greenway in Shanghang County

As a crucial corridor within the greenway system of Shanghang County, the Tingjiang Greenway plays a vital role in the ecological safety framework of the entire system. It serves multiple functions, including linking ecological patches, enhancing urban ecology, and providing social and cultural benefits. These functions are indispensable for shaping the future pattern of the greenway system across Shanghang County. Moreover, the Tingjiang Greenway is a key element in constructing the landscape rhythm of the entire system. As a linear rhythmic feature—whether curved or straight—it enhances the landscape vitality of the surrounding area and contributes to the creation of a "patch-corridor-substrate" system that exhibits a dynamic landscape rhythm.

4.1 Plaque Linking Function

Due to urban development, ecological patches are often fragmented and obstructed by construction. Urban greenways play a critical role in linking these fragmented ecological patches, forming urban ecosystem networks that are essential for enhancing the spatial quality of urban spaces and ecological environments. Waterfront greenways often serve as "bridges"; the Tingjiang River Greenway, in particular, functions as a connector that links scattered ecological patches within the city.By connecting individual patches, the greenway contributes to the formation of a cohesive ecological system, improving the continuity of both urban landscape and ecological spaces. This integration provides structure to the overall landscape planning of Shanghang County and facilitates the flow of materials, information, and energy within the environment. Such connectivity helps mitigate the fragmentation of urban spaces, creating diverse habitats for various species and expanding their activity ranges. This, in turn, increases the likelihood of gene exchange between populations, supporting the healthy development of species while also enhancing spaces for resident activities and information exchange (as shown in Figure 2).

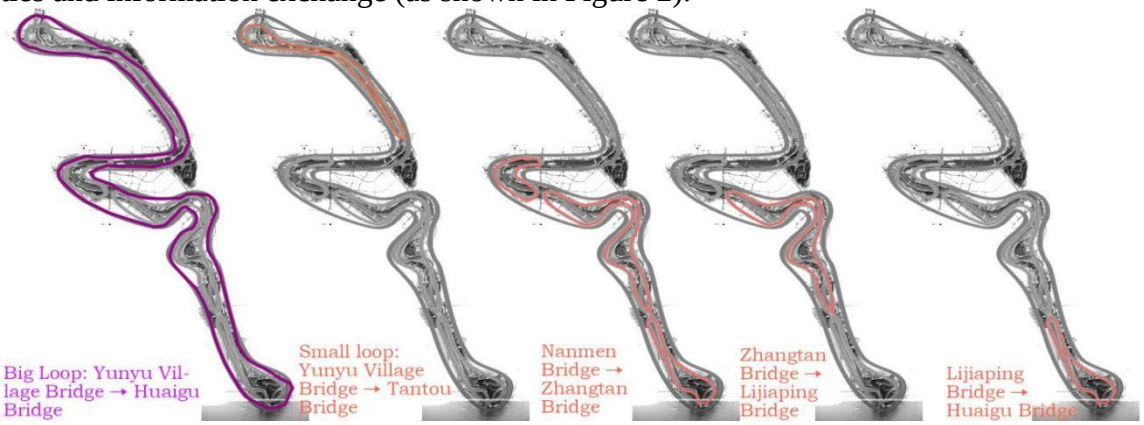

Figure 2: Link structure analysis diagram Self-drawn

4.2 Improvement of urban ecological environment

The greenway system utilizes greenways to connect surrounding green spaces, thereby forming a network of green open spaces that enhances the ecological environment and restores the city's natural ecological balance. The improvement of the block environment is primarily reflected in the regulation of microclimates, wind protection, noise reduction, and air purification. Through the thoughtful configuration of plant communities, the greenway provides shade and lowers local air temperatures via plant transpiration, effectively mitigating the urban heat island effect. The presence of numerous trees and plants within the greenway contributes to improving wind patterns in the city,

conserving water, reducing noise, and absorbing harmful gases. The comprehensive ecological and environmental benefits of greenways significantly enhance livability, addressing the growing demands of residents for a better living environment.

The goal of the Tingjiang Greenway is to "avoid cutting down trees, demolishing houses, relocating graves, or confiscating fields," thereby maximizing the protection of the original ecological environment. The strategy emphasizes the adoption of suitable plant configurations that safeguard existing natural resources and topographical features while maintaining the biological diversity of the greenway and ensuring its overall quality.

In general, the multi-layered community created by the "tree-shrub-grass" mixed planting pattern offers the highest ecological value. This approach fosters a variety of natural habitats, enhancing the quality of the greenway community (as illustrated in Figures 3 and 4).

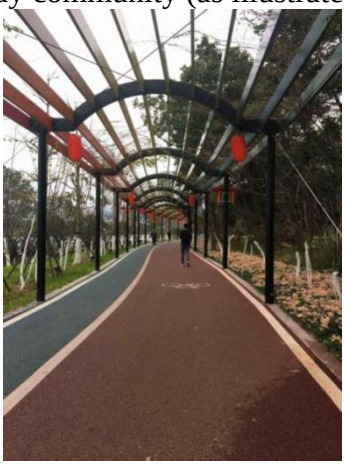

Figure 3: Environment of Tingjiang Greenway Self-photography (Left)

Figure 4: Plant group of Tingjiang Greenway Self-photography (Right)

4.3 Social and Cultural Functions

Due to regional differences, cities have distinct development histories and cultures, resulting in diverse cultural characteristics. The design of the Tingjiang Greenway respects various cultural heritages, protects cultural assets, and fosters an appreciation for traditional culture while also embracing contemporary developments. This approach introduces new cultural elements and lifestyles, ensuring that the spatial characteristics of the waterfront greenway reflect a diversity of cultural lineage and coexistence.

The Tingjiang River waterfront greenway aligns with the county's urban parks, ensuring compatibility in both positioning and thematic content. This continuity enhances the overall experience, as the Tingjiang Greenway serves as a linear space that connects the county's parks, green spaces, and cultural landmarks, including Seven Peaks Mountain, Team Bridge, Luoxing Tower, and South Tower.

The spatial characteristics and cultural functions of the Tingjiang Greenway are intrinsically linked to its environment and surroundings. Each node embodies a unique cultural theme, featuring core attractions and functional support mechanisms. This integration enhances the city’s cultural quality while facilitating development and construction. Ultimately, the greenway builds an ecological network based on natural landscapes, creating a vibrant green space along the Tingjiang River (as illustrated in Figures 5 and 6).

Figure 5: Tingjiang Greenway Environment Self-photo (Left)

Figure 6: Tingjiang Greenway Plant Group Self-photo (Right)

5. Landscape sequence of Tingjiang Greenway in Shanghang County

Tourists are the primary users of the Tingjiang Greenway and the main focus of its services. The physiological and psychological needs of individuals serve as the foundation for the greenway's design, which is reflected in the establishment of spatial themes and the distribution of key activities along the Tingjiang Greenway. This includes planning for slow walking and cycling systems, creating a conducive landscape environment, and addressing aesthetic demands, particularly through the analysis of the behaviors of surrounding residents.

To meet the diverse needs of various users, the design emphasizes a humane approach, ensuring rational planning and construction of the urban waterfront greenway. The waterfront greenway itself represents a continuously evolving ecological structure, characterized by linear water bodies and green spaces that connect both vertically and horizontally, creating a variety of landscape experiences.

Psychological continuity refers to the seamless and cohesive experience perceived by tourists during their recreation. This perception manifests as a continuous, extended, and organic landscape. These characteristics highlight that urban waterfront greenways are dynamic spatial sequences with a rhythmic flow, encompassing a spatial rhythm of prelude, alternation, climax, and conclusion.

Figure 7: Spatial Landscape Sequence Self-photography

The Ting River Greenway consists of 32 kilometers on the left bank, beginning at the Jiuzhou

Village Stage and ending at the Motuozhai Stage, and 28 kilometers on the right bank, starting at the Yumeqiao Stage and concluding at the Fuguang Village Stage. The left and right banks are distinct yet interdependent. For instance, the starting point symbolizes the beginning of a journey, while the path of the greenway represents the ups and downs of that journey. Each node space serves as a passage within this experience, and the thematic spaces correspond to the climax of the journey. This design approach creates a rhythmic spatial sequence that captivates visitors and conveys varied spatial sensations (as illustrated in Figure 7).

6. Conclusions

Greenways are effective tools for ecological protection and the construction of urban ecological environments. They play a significant role in addressing species protection, habitat restoration, and river conservation within fragmented habitats. Additionally, the connectivity offered by greenways facilitates the sharing of urban green ecological resources, contributing to the overall health and well-being of residents.

It is essential to understand the multifaceted functions of greenways, which include linking ecological patches, improving the ecological environment, and fostering social and cultural interactions. These functions are foundational to their complex roles.

In this paper, we synthesize previous analyses of waterfront greenway spaces and integrate findings regarding the spatial composition, functionality, and landscape sequence of the Tingjiang Greenway in Shanghang County. Our investigation concludes that the Tingjiang Greenway is crucial for establishing a robust ecological framework within the county. Furthermore, it serves as a vessel for regional culture, embodying the inheritance of "red genes" and reflecting confidence in the local environment and cultural identity. The promotion of the county's humanistic spirit and the cohesion of the Hakka spirit enhance its significance as a gateway landscape and an important cultural carrier for the region.

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