Application of Ecological Planning Concept in Wetland Landscape Design and Environmental Protection Analysis

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ABSTRACT Wetlands provide suitable habitats for various organisms, maintain rich biodiversity, and play an important role in water conservation, climate regulation, and ecological security. However, current wetland park landscape design projects still face problems such as ecological environment disturbance, insufficient protection of native habitats, and homogenization with ordinary water scenic parks. The ecological planning concept is an important component of the ecological environment governance system, and systematic research on its application in wetland landscape design and environmental protection is of practical significance for wetland conservation. This paper first reviews the research status of wetland parks, then analyzes the current conditions and existing problems of wetland landscape design and environmental protection. On this basis, it focuses on the specific application of ecological planning in wetland landscape design, including site selection, functional zoning, plant configuration, and hydrological design, as well as in environmental protection, including water purification, biodiversity conservation, and soil remediation. Practical cases are used to demonstrate the feasibility of the proposed planning approach. In addition, intelligent monitoring technologies, such as wireless sensor networks and electromagnetic sensing methods, can provide technical support for long-term wetland environmental observation and management. By analyzing the application of ecological planning theory in wetland landscape design and environmental protection, this paper provides a scientific theoretical basis and practical reference for future wetland landscape design and ecological protection projects.

INDEX TERMS ecological planning, wetland landscape design, environmental protection, electromagnetic sensing, wireless sensor networks

I. INTRODUCTION

A. RESEARCH BACKGROUND

WETLANDS not only provide a suitable living environment for various organisms but also support extremely rich biodiversity and abundant resources. Globally, wetland resources are widely distributed. They are ecosystems with rich species in the natural environment and also an important part of the natural environment [1]. As scarce ecological resources in urban areas, wetland resources within cities play a role in improving the urban ecological environment. They are a key component of the urban green space system, capable of preventing floods, combating droughts, improving the air environment in urban and rural areas, and facilitating the daily leisure activities of urban residents [2]. However, compared with other forms of urban ecological systems, wetland systems have unique ecological value and are therefore often regarded as the most scientific type of urban natural ecology [3]. Wetland plant landscapes not only bring vitality and life to wetlands but also offer sustainable raw material sources for the textile industry, allowing them to address problems faced by the natural environment through ecological design methods. Plant landscapes are undoubtedly the best choice, and it is urgent to develop wetland plant landscapes to improve the ecological environment [4].

At present, China's research and design on wetland landscapes are still in the initial stage, and the landscape value and ecological functions of wetlands need further utilization and enhancement. Ecological environmental protection planning is a long-term overall plan for a country's ecological environmental protection and an important part of the ecological environment governance system [5]. A scientific and reasonable indicator system is a crucial part of environmental protection planning. It serves not only as the basis and standard for comprehensive evaluation of environmental conditions but also as the foundation and prerequisite for determining planning objectives and formulating ecological environmental protection plans. The restoration and construction of wetland ecosystems utilize ecological science to restore and rehabilitate wetland resources that are degenerating or on the verge of disappearance. This further enables the ecological system to function normally again and realizes the natural functions of the wetland environment [6,7].

Although the construction of wetland landscapes in urban areas mainly follows professional ecological theories and has achieved certain results in many fields, such as safeguarding regional ecological resources, establishing sound artificial ecosystems, protecting the diversity of ecological resources, providing leisure and popular science education services, and realizing the harmonious development of humans and nature [8-10], the relevant professional theories for urban wetland landscape construction are still relatively underdeveloped. Most of these theories are from fields such as ecology, environmental protection, and forestry, while research on comprehensive ecological landscapes remains in the initial development stage. The backward development of professional theories and vague concepts have led to unreasonable elements in landscape design, which in turn have had a negative impact on the planning of wetland landscapes in urban and rural areas [11,12]. Therefore, in-depth research on the application of the ecological planning concept in the planning of wetland landscape resources has practical significance and is also an urgent demand for urbanization construction.

B. RESEARCH STATUS

Research on wetland landscapes started relatively late in China. Currently, domestic research on wetland landscape design is still in the stage of imitation and exploration, and the theoretical research on wetland landscapes is not yet mature. Due to the continuous deterioration of the environment in most parts of China, the country has attached increasing importance to wetland protection and has successively issued a series of policies, laws, and regulations. Guided by these policies and laws, wetland landscapes have continued to develop [13]. Organisms bring vitality, vigor, and life to wetlands. A wave of enthusiasm for protecting biodiversity, wetlands, and flora and fauna has emerged in China. The goal is to solve problems such as the destruction and overutilization of the natural environment, biological resources, and biodiversity through ecological design methods.

With the rapid development of the times, the construction of wetlands in China has gradually accelerated, and wetland landscapes are undoubtedly the best choice for this purpose. By planting a variety of plants, wetlands can leverage the role of wetland plants in restoring the ecological environment and purifying water bodies. Wetland plants can not only reduce suspended solids in water and improve water quality but also restore wetland biodiversity [14,15]. The earliest work on wetland research was compiled by Leland in the 17th century [16]. He believed that swamps evolved from forests. In 1869, Forel conducted research on wetland hydrology, laying the foundation for wetland research [17]. Currently, the world's most comprehensive wetland theory monograph, with a complete theoretical system, detailed data, and rich content, is *Wetlands for the Future*, compiled by McComb A.J. et al. in 1998 [18]. Paul A. Keddy focused on the basic principles and advanced applications of wetland ecology and wrote *Wetland Ecology: Principles and Conservation* [19].

In recent years, countries around the world have gradually begun to attach importance to wetland protection, wetland development, and the rational development and utilization of wetlands. An increasing number of wetland parks have been established worldwide. Many foreign wetland parks adopt a development model centered on the harmonious coexistence of humans and nature. A typical example is the Shortland Wetland Centre in Newcastle, Australia, which focuses on biodiversity conservation and ecological education. The London Wetland Centre has planted a large number of aquatic plants and wetland trees. Through the rational combination of different aquatic plants and wetland trees, it not only provides London citizens with opportunities and spaces to connect with nature, creating a wetland plant landscape model of harmonious coexistence between humans and nature, but also improves London's air quality.

C. RESEARCH SIGNIFICANCE

Wetland parks have certain advantages. For instance, they can not only maintain urban ecological balance and sustainable development but also alleviate the urban heat island effect, increase air humidity, and enhance hydrological characteristics. They not only provide habitats for flora and fauna but also create a beautiful scenic belt for residents. Therefore, with the rapid development of wetland park construction at present, more attention should be paid to the ecological balance between wetlands and cities. Through scientific and systematic wetland park landscape design, the stability of wetland resources can be effectively maintained and the wetland environment protected. By combining practical experience with theoretical research, the application of the ecological planning concept in wetland landscape design and environmental protection can be improved, thereby serving the better construction of green and ecological wetland parks.

D. RESEARCH CONTENT AND METHODS

Research Content. The research content of this paper mainly includes the following aspects:

(1) The connotation, core principles, and development history of the ecological planning concept.

(2) The current status and existing problems of wetland landscape design and environmental protection.

(3) The specific application of the ecological planning concept in wetland landscape design, including aspects such as site selection, functional zoning, plant configuration, and hydrological design.

(4) The specific application of the ecological planning concept in wetland environmental protection, including content

such as water purification, biodiversity conservation, and soil remediation.
(5) Combining practical cases to analyze the application effects of the ecological planning concept in wetland landscape design and environmental protection.
(6) Proposing optimization strategies for applying the ecological planning concept to wetland landscape design and environmental protection.
Research Methods.
(1) Literature Research Method: By studying relevant literature, gain an in-depth understanding of the ecological planning concept, and conduct research on the theoretical principles that landscape design under the guidance of the ecological planning concept must follow.
(2) Field Investigation Method: Conduct on-site inspections and investigations of mature wetland landscape parks, focus on inspecting and sorting out the composition of existing landscapes in wetlands, and sort out and analyze the types of various organisms in wetlands, their seasonal changes, and configuration methods.
(3) Case Analysis Method: Focus on analyzing two cases, namely the London Wetland Centre and the Hangzhou Xixi National Wetland Park, and conduct corresponding research on these two cases.
(4) Analysis of the current status and existing problems of wetland landscape design and environmental protection.

II. CURRENT STATUS AND EXISTING PROBLEMS OF WETLAND LANDSCAPE DESIGN AND ENVIRONMENTAL PROTECTION

A. CURRENT STATUS OF WETLAND LANDSCAPE DESIGN

Gradual Shift of Design Concepts towards Ecologization.

An increasing number of wetland landscape design projects have begun to focus on the integration of ecological concepts to enhance the ecological functions of wetland landscapes.

- Construction of constructed wetlands
- Restoration of natural wetland vegetation
- Protection of wetland biological habitats

Increasingly Rich Design Content.

Currently, the content of wetland landscape design is no longer limited to traditional landscape aesthetic design, but places more emphasis on the integration of multiple functions such as ecological functions, recreational functions, and popular science education functions.

Continuous Innovation in Design Technologies.

With the continuous development of science and technology, more and more new technologies and materials have been applied in wetland landscape design.

- 3S technology can be used for current situation investigation, planning and design, and monitoring and evaluation of wetland landscapes;
- New materials such as ecological concrete and permeable pavement can be used for ground pavement in wetland landscapes;
- Constructed wetland technology can be used for the purification of wetland water quality and improvement of the wetland ecological environment.

B. CURRENT STATUS OF WETLAND ENVIRONMENTAL PROTECTION

Continuous Improvement of Protection Awareness.

As the ecological value of wetlands becomes increasingly prominent, the awareness of wetland environmental protection among all sectors of society has been continuously improved.

- Government departments have issued a series of relevant policies and regulations to strengthen the protection and management of wetlands;
- Scientific research institutions have increased research efforts on wetland ecosystems, providing a scientific basis for wetland protection;
- The public has actively participated in wetland protection activities, forming a good atmosphere for the whole society to jointly protect wetlands.

Continuous Strengthening of Protection Measures.

To protect wetland ecosystems, various regions have adopted a series of effective protection measures.

- Establish protected areas such as wetland nature reserves and wetland parks to provide key protection for wetlands;
- Implement wetland ecological restoration projects to restore and reconstruct degraded wetland ecosystems;
- Strengthen the control of pollution sources around wetlands to reduce pollution to the wetland ecological environment;
- Carry out wetland biodiversity monitoring and protection work to protect rare and endangered species in wetlands.

C. EXISTING PROBLEMS IN WETLAND LANDSCAPE DESIGN AND ENVIRONMENTAL PROTECTION

Insufficient In-depth Application of the Ecological Planning Concept.

In the actual application process, due to the insufficient in-depth understanding of the ecological planning concept by some designers, the following problems exist.

- During the site selection process, the ecological sensitivity and ecological functions of wetlands are not fully considered;
- During the plant configuration process, appropriate plant species are not selected according to the ecological environment characteristics of wetlands.

According to surveys, about 30% of urban wetland parks in China have alien species invasion in plant configuration, which poses a serious threat to local biodiversity. The insufficient in-depth application of ecological planning concepts is affected by multiple factors. Firstly, interdisciplinary training is lacking–most designers have a background in landscape architecture or environmental engineering alone, lacking systematic knowledge of ecology, hydrology, and soil science, making it difficult to comprehensively apply ecological planning principles. Secondly, cost constraints lead some project parties to prioritize short-term construction costs over long-term ecological benefits, avoiding the additional investment required for ecological surveys and scientific configuration (such as native plant cultivation and ecological waterfront construction). Thirdly, policy enforcement is inadequate–although relevant policies emphasize ecological protection, there is a lack of detailed implementation standards and supervision mechanisms, resulting in the ecological planning concept being merely a formality in actual design.

Inadequate Integration of Landscape Aesthetic Functions and Ecological Functions.

In wetland landscape design, some designers pay too much attention to the creation of landscape aesthetic functions while ignoring the protection of ecological functions.

- In pursuit of uniform landscape, large-scale transformation of the natural terrain and vegetation of wetlands is carried out, destroying the natural ecological landscape of wetlands;
- In water body design, the water banks are excessively hardened, which reduces the material exchange and energy flow between water bodies and soil, and lowers the water purification capacity and ecological regulation function of wetlands (see Table 1).

Imperfect Environmental Protection Monitoring and Evaluation Mechanism. In the work of wetland environmental protection, the lack of a sound monitoring and evaluation mechanism is one of the main existing problems. On the one hand, some wetland protection areas have not established a long-term ecological monitoring system, making it impossible to timely grasp the dynamic changes of the wetland ecosystem. On the other hand, the evaluation of wetland environmental protection effects lacks a scientific indicator system and methods, and the evaluation results are often highly subjective (see Table 2).

Homogenization with Water Scenic Parks: Performance and Root Causes. Homogenization has become a prominent problem in current wetland park design, mainly manifested in the following aspects: First, the convergence of functional positioning–most wetland parks overemphasize recreational and ornamental functions, while neglecting unique ecological protection and popular science education functions, which is consistent with the functional positioning of ordinary water scenic parks. Second, the similarity of landscape elements–excessive use of standardized landscape facilities (such as artificial plank roads, decorative fountains), uniform plant configuration (such as large-scale planting of exotic ornamental flowers instead of native wetland plants), and rigid waterfront design (excessive hardening) make the landscape style of wetland parks identical to that of water scenic parks. Third, the simplification of ecological functions–due to the lack of scientific ecological planning, wetland parks lose their unique ecological functions such as water purification, biodiversity conservation, and flood regulation, and only retain the basic water landscape viewing function, which is difficult to distinguish from ordinary water scenic areas.

The root cause of homogenization is the lack of in-depth understanding and application of ecological planning concepts. On the one hand, designers ignore the unique ecological attributes of wetlands and simply copy the design model of water scenic parks, which leads to the loss of the ecological uniqueness of wetland parks. On the other hand, the lack of systematic ecological planning makes it impossible to integrate the ecological functions, landscape characteristics, and regional culture of wetlands, resulting in the convergence of wetland park designs. In addition, the one-sided pursuit of economic benefits by project parties and the lack of public participation in the design process also promote the homogenization of wetland parks. Project parties tend to choose mature and low-cost water scenic park design schemes to reduce investment risks, while ignoring the ecological and cultural value of wetlands.

III. SPECIFIC APPLICATION OF THE ECOLOGICAL PLANNING CONCEPT IN WETLAND LANDSCAPE DESIGN AND ENVIRONMENTAL PROTECTION

A. APPLICATION OF THE ECOLOGICAL PLANNING CONCEPT IN WETLAND LANDSCAPE DESIGN

Site Selection: Based on Ecological Sensitivity Assessment.

The core of applying the ecological planning concept to site selection for wetland landscape design lies in ecological sensitivity assessment.

- Conduct ecological surveys of the planned area using 3S technology (Remote Sensing, Geographic Information System, Global Positioning System);
- Establish an ecological sensitivity evaluation indicator system;
- Select areas with medium to low sensitivity as the site for wetland landscape design based on the results of ecological sensitivity zoning.

3S technology is applied in ecological sensitivity assessment through the following specific steps:

- Data collection and preprocessing: Use Remote Sensing (RS) technology to obtain land use type, vegetation coverage, and water body distribution data of the planned area; use Global Positioning System (GPS) to conduct field sampling and verify the RS data, and collect soil quality (pH value, heavy metal content), hydrological data (water depth, flow velocity), and habitat distribution data of key species; use Geographic Information System (GIS) to integrate and preprocess the collected data to form a standardized spatial database.
- Establishment of ecological sensitivity evaluation index system: Select key evaluation indicators including ecological factors (vegetation coverage, habitat type, biodiversity), hydrological factors (water body proximity, water depth, flow velocity), soil factors (soil

TABLE 1. Statistics on Water Bank Design of 10 Typical Urban Wetland Parks in China

Name of Wetland Park	Waterfront Hardening Rate (%)	Proportion of Waterfront (%)	Ecological Water Purification Capacity (COD Removal Rate, %)	Number of Biological Habitats (Species)
Wetland of Beijing Olympic Forest Park	52	48	32	28
Shanghai Dongtan Wetland Park	38	62	45	42
Guangzhou Haizhu Wetland Park	55	45	28	30
Hangzhou Xixi National Wetland Park	20	80	68	65
Wuhan East Lake National Wetland Park	42	58	38	35
Chengdu Qinglong Lake Wetland Park	48	52	32	32
Nanjing Xuanwu Lake Wetland Park	35	65	42	40
Xi'an Chanba National Wetland Park	25	75	55	52
Kunming Dianchi Wetland Park	50	50	30	29
Shenzhen Overseas Chinese Town Wetland Park	18	82	72	70

TABLE 2. Composition of the Evaluation Index System for Wetland Environmental Protection in China

Indicator Type	Specific Indicators	Indicator Proportion (%)	Indicator Defects
Ecological Indicators	Water quality, biodiversity, soil quality, vegetation coverage rate	35	Indicators are not detailed enough and lack support from dynamic monitoring data
Economic Indicators	Tourism income, surrounding land value appreciation, output value of ecological products	40	Excessive focus on economic interests while ignoring ecological benefits
Social Indicators	Public satisfaction, popular science education effect, employment promotion	25	Difficult to quantify indicators, and evaluation results are highly subjective

quality, soil erosion degree), and human activity factors (distance from roads, construction land density). Assign weights to each indicator using the analytic hierarchy process (AHP), and grade the sensitivity (high sensitivity, medium sensitivity, low sensitivity).

- Sensitivity zoning using GIS spatial analysis: Overlay the spatial distribution maps of each evaluation indicator in GIS, and calculate the comprehensive sensitivity index of each grid unit through spatial analysis functions such as superposition analysis and buffer analysis. According to the comprehensive sensitivity index, divide the planned area into high-sensitivity areas (key ecological protection areas, such as core habitats of rare species, natural wetland vegetation concentration areas), medium-sensitivity areas (ecological buffer areas, such as riparian buffer zones), and low-sensitivity areas (suitable for landscape construction and human activities).

Case example: In the site selection of a certain urban wetland park in eastern China, 3S technology was used for ecological sensitivity assessment. Through RS image interpretation, the vegetation coverage of the planned area was obtained, and GPS was used to verify the distribution of *Phragmites australis* communities (key wetland vegetation). GIS was used to overlay the habitat distribution map of wintering waterbirds, soil quality map, and road distribution map. The results showed that the high-sensitivity area accounted for 35% of the planned area (mainly distributed in the central water body and surrounding natural vegetation areas), the medium-sensitivity area accounted for 40% (riparian buffer zone), and the low-sensitivity area accounted for 25% (peripheral areas far from water bodies and with low human activity intensity). Finally, the low-sensitivity area was selected as the site for wetland landscape design, which effectively avoided the impact on high-sensitivity ecological areas.

Functional Zoning: Following the Principle of Ecosystem Integrity.

The application of the ecological planning concept to functional zoning in wetland landscape design follows the principle of ecosystem integrity, mainly including the following zones:

- Ecological Protection Zone: Its main function is to protect the integrity of the wetland ecosystem. It selects areas with high ecological sensitivity and rich biodiversity.
- Ecological Buffer Zone: Its main function is to reduce the interference of human activities on the Ecological Protection Zone and play a transitional and buffering role.
- Leisure and Entertainment Zone: Its main function is to provide leisure and entertainment spaces for humans, meeting people's needs for viewing and relaxing in the wetland landscape.
- Popular Science Education Zone: Its main function is to popularize wetland ecological knowledge to the public and improve the public's environmental protection awareness.

Plant Configuration: Emphasizing Native Species Priority and Diversity.

(1) Principle of Native Species Priority

In the plant configuration of wetland landscapes, priority is given to local plant species. This not only reduces the cost of planting and maintenance but also avoids damage to the local ecosystem caused by the invasion of alien species. The Principle of Native Species Priority means that in wetland landscape plant configuration, native plant species that are naturally distributed in the region and adapted to the local ecological environment should be given priority. These species have a high degree of adaptability to the local climate, soil, and hydrological conditions, which can reduce the cost of planting and maintenance, and effectively avoid the ecological risks such as alien species invasion caused by the introduction of exotic plants.

(2) Principle of Diversity

Plant diversity is the foundation of the stability of the wetland ecosystem. In the plant configuration of wetland landscapes, emphasis should be placed on the diversity of plant species.

Different types of plants play different roles in the wetland ecosystem:

- Arbor trees can provide shade and improve the climate; shrubs can consolidate soil, protect slopes, and prevent soil erosion;
- Herbaceous plants can purify water quality and provide habitats;
- Aquatic plants can regulate hydrology and maintain the ecological balance of water bodies.

(3) Principle of Ecological Adaptability

In the plant configuration of wetland landscapes, appropriate plant species should be selected for configuration according to the ecological environment conditions of different areas in the wetland.

Table 3 shows the plant configuration plan in a wetland landscape design. This plan follows the principles of native species priority, diversity, and ecological adaptability.

Note: Mesophytic plants in wetland parks are mainly distributed in the riparian buffer zone, which is a transitional area between wetland and dry land. They are adapted to moderate water supply conditions and play an important role in connecting the wetland ecosystem and the surrounding terrestrial ecosystem, preventing soil erosion, and regulating microclimate. The selected species such as *Salix babylonica* and *Taxodium ascendens* have strong adaptability to the riparian environment and are not typical upland species, but species that can coexist with the wetland ecological environment.

B. SPECIFIC APPLICATION OF THE ECOLOGICAL PLANNING CONCEPT IN WETLAND ENVIRONMENTAL PROTECTION

Water Purification: Utilizing the Self-Purification Capacity of Wetland Ecosystems.

The water purification function of wetland ecosystems is mainly achieved through the following processes:

- Physical purification process: It mainly includes the effects of sedimentation, filtration, and adsorption.
- Chemical purification process: It mainly includes the effects of redox, neutralization, and complexation.
- Biological purification process: It is mainly achieved through the joint action of wetland plants, microorganisms, and animals.

The comparison of water purification effects of different types of constructed wetlands is shown in Table 4.

Biodiversity Conservation: Constructing a Complete Ecological Habitat.

The application of the ecological planning concept in biodiversity conservation for wetland environmental protection is mainly realized through the following aspects:

- Diversified design of habitat types: Construct diversified habitat types through terrain shaping, vegetation configuration, hydrological regulation and other means.
- Protection of key species and construction of ecological corridors: While focusing on protecting key species in wetlands, ecological corridors are built to connect different wetland patches and eliminate the impact of habitat fragmentation on biodiversity.
- Reduction of human activity interference: Reduce the interference of human activities on wetland organisms by delineating protected areas, restricting tourism activities, and prohibiting illegal development.

Soil Remediation: Improving the Wetland Soil Ecological Environment.

The application of the ecological planning concept in soil remediation for wetland environmental protection mainly includes the following aspects:

- Physical remediation methods:
  Remove or isolate pollutants in wetland soil through physical means to improve soil quality.
- Chemical remediation methods:
  Add chemical agents to wetland soil to react with pollutants in the soil, converting the pollutants into harmless substances or reducing their toxicity.
- Biological remediation methods:
  Biological remediation methods use the role of soil microorganisms, plants and other organisms to degrade or absorb pollutants in the soil and improve the soil ecological environment.

IV. CASE ANALYSIS

A. CASE 1: HANGZHOU XIXI NATIONAL WETLAND PARK (NATURAL LAKE-TYPE CASE)

Project Overview. Hangzhou Xixi National Wetland Park is located in the western part of Hangzhou City, with a total area of 10.08 square kilometers. Among them, ecological protection landscapes and tourism and leisure landscapes are the main landscapes of the wetland park.

Design Concept.

1) Site selection and functional zoning

It is divided into three functional areas: core protection area, buffer area and experimental area.

- The core protection area mainly protects the original ecological landscape of the wetland and rare and endangered species, and prohibits any interference from human activities;

TABLE 3. Plant Configuration Plan for a Wetland Landscape Design

Plant Type	Plant Species	Planting Area	Ecological Function	Landscape Effect
Submerged Plants	*Hydrilla verticillata*, *Ceratophyllum demersum*, *Vallisneria natans*	Deep water area (water depth: 2–3m)	Purify water quality, provide habitats for fish	Increase water transparency and create underwater landscapes
Floating Plants	*Nymphaea tetragona*, *Lemna minor*, *Eichhornia crassipes*	Medium-deep water area (water depth: 1–2m)	Absorb nutrients in water, inhibit algae growth	Rich flower colors, long flowering period, enhance landscape appreciation
Emergent Plants	*Phragmites australis*, *Typha orientalis*, *Acorus calamus*, *Nelumbo nucifera*	Shallow water area (water depth: 0.5–1m)	Purify water quality, consolidate soil and protect slopes, provide habitats for birds	Elegant form, with high landscape aesthetic value
Wetland Plants	*Iris tectorum*, *Canna indica*, *Thalia dealbata*, *Lythrum salicaria*	Waterfront edge area (water depth: 0–0.5m)	Prevent soil erosion, purify surface runoff	Bright flower colors, long flowering period, enrich landscape layers
Mesophytic Plants	*Salix babylonica*, *Populus alba*, *Pterocarya stenoptera*, *Metasequoia glyptostroboides*, *Taxodium ascendens*	Terrestrial area	Improve climate, provide shade, consolidate soil and protect slopes	Elegant tree shape, obvious seasonal changes, enhance landscape diversity

TABLE 4. Comparison of Water Purification Effects of Different Types of Constructed Wetlands

Type of Constructed Wetland	Hydraulic Retention Time (d)	COD Removal Rate (%)	Ammonia Nitrogen Removal Rate (%)	Total Phosphorus Removal Rate (%)	Turbidity Removal Rate (%)
Surface-Flow Constructed Wetland	3–5	45–60	30–45	25–40	60–75
Subsurface-Flow Constructed Wetland	2–4	60–75	50–65	45–60	75–90
Composite Constructed Wetland (Surface-Flow + Subsurface-Flow)	3–5	75–90	65–80	60–75	90–95
Vertical-Flow Constructed Wetland	1–3	65–80	55–70	50–65	80–90

- The buffer area is located around the core protection area, mainly carrying out ecological restoration and vegetation restoration projects to reduce the interference of human activities on the core protection area;
- The experimental area mainly carries out wetland landscape design and tourism activities to meet people's needs for viewing and leisure of wetland landscapes.

2) Vegetation configuration and hydrological design

- Priority is given to selecting local plant species, such as *Phragmites australis*, *Typha orientalis*, *Acorus calamus*, *Nelumbo nucifera*, etc., to construct a diversified plant community.
- By planting aquatic plants, wetland plants and mesophytic plants, a multi-level vegetation landscape is formed, which improves the landscape aesthetic value of the wetland.
- Simulate the natural hydrological process and construct a complete water cycle system. Through the setting of sluices, pumping stations and other water conservancy facilities, the dynamic adjustment of water level is realized;
- Adopt ecological waterfront design methods to avoid waterfront hardening and create a natural and ecological waterfront environment;
- By building a constructed wetland system, the purification effect of wetland plants and microorganisms is used to improve the water quality of the wetland.

Application Effect. Xixi Wetland has a beautiful natural environment, with lush field plants and crisscross water networks. Plum trees, persimmon trees, camphor trees and bamboo stand side by side along the waterfront. Reeds and water chestnuts sway in the water, with abundant fish and shrimps and flying herons, forming a unique scenery of Xixi Wetland Park [20].

B. CASE 2: WWT LONDON WETLAND CENTRE (ARTIFICIALLY RESTORED WETLAND CASE)

Project Overview. Located in southwest London, the WWT London Wetland Centre is an urban wetland park converted from disused reservoirs, covering a total area of approximately 42 hectares. Launched in 1995 and officially opened to the public in 1999, it ranks among the largest urban artificial wetland parks in Europe. The construction of the London Wetland Centre aims to restore the wetland ecosystem and improve the urban ecological environment through the application of ecological planning concepts, while providing urban residents with a venue for leisure and popular science education.

Design Concepts. The site consists of various wetland landforms such as a main lake and lagoons, interspersed with other water areas and land surrounding the main lake. These components are both independent and closely interconnected. The topographical design has transformed the relatively flat hills and cultivated land along the water diversion ditches into stretches of shallow wetlands [21].

Water, as one of the most crucial components of the wetland park, flows through the entire area. The design requires that the water area of each zone be relatively independent, with varying frequencies and ranges of water depth fluctuations. This meets the diverse growth and reproduction needs of wetland organisms, forming hydrologically "isolated wetlands" – a technical challenge. The following solutions were adopted:

(1) Site Renovation and Ecological Restoration

- Clear garbage and pollutants on the site, improve soil quality, and restore water quality;

- Create diverse habitat types through topographical shaping, providing a suitable living environment for wetland organisms;
- Plant a variety of native plants such as reeds, cattails, and water lilies to establish stable plant communities.

(2) Hydrological Design

- Add a concrete dyke on the existing concrete-earth dam to stabilize the original maximum water level of the reservoir. The same method is used to construct relatively independent water environments, ensuring stable habitats for wetland flora and fauna that live at different water depths;
- Install water stop valves between each water area from north to south. These valves enable precise water level regulation in habitats even during seasons with varying precipitation, meeting the specific water level requirements of each habitat.

(3) Public Participation and Popular Science Education

- Set up facilities including popular science billboards, a wetland museum, and ecological laboratories to popularize wetland ecological knowledge among the public;
- Organize a series of popular science activities to enhance the public's awareness of wetland protection.

Application Effects. It not only satisfies visitors' needs to observe wetland organisms up close, learn wetland-related knowledge, and engage in leisure activities but also serves as an excellent site for various wetland plants and animals to grow, reproduce, inhabit, and migrate for wintering.

V. OPTIMIZATION STRATEGIES FOR THE APPLICATION OF ECOLOGICAL PLANNING CONCEPT IN WETLAND LANDSCAPE DESIGN AND ENVIRONMENTAL PROTECTION

A. OPTIMIZATION OF WETLAND ENVIRONMENTAL PROTECTION EVALUATION INDEX SYSTEM

To address the defects of the existing evaluation index system, such as insufficient detail of ecological indicators, excessive focus on economic interests, and difficulty in quantifying social indicators, this paper proposes an optimized evaluation index system based on ecological planning concepts, as shown in Table 5.

The optimized index system has the following characteristics. First, it enriches and refines ecological indicators, increasing the proportion of ecological indicators to 50% to highlight the core position of ecological protection. Second, it optimizes economic indicators, shifting the focus from simple economic benefits to sustainable ecological product output value and ecological tourism income, avoiding excessive pursuit of economic interests. Third, it improves the quantifiability of social indicators, proposing specific quantification methods for public satisfaction and popular science education effect to reduce subjectivity in evaluation.

B. OTHER OPTIMIZATION STRATEGIES

In addition to optimizing the evaluation index system, the following strategies are proposed to promote the in-depth application of ecological planning concepts:

(1) Strengthen interdisciplinary cooperation: Establish a design team composed of ecologists, landscape architects, hydrologists, and soil scientists to ensure that ecological planning concepts are fully integrated into each link of wetland landscape design.

(2) Improve policy support and supervision mechanisms: Formulate detailed implementation standards for ecological planning in wetland park design, and establish a whole-process supervision mechanism from design, construction to operation to ensure the implementation of ecological protection requirements.

(3) Strengthen public participation: Incorporate public opinions into the design and decision-making process through public hearings, questionnaire surveys, and other forms, and enhance the public's awareness and participation in wetland protection through popular science education and volunteer activities.

(4) Promote technological innovation and application: Further expand the application scope of 3S technology, constructed wetland technology, and ecological remediation technology in wetland landscape design and environmental protection, and improve the scientificity and effectiveness of ecological planning.

VI. CONCLUSIONS

Through a systematic study on the application of ecological planning concepts in wetland landscape design and environmental protection, this paper draws the following key conclusions:

(1) Ecological planning concepts provide core guidance for wetland protection

- The core connotations of ecological planning concepts include integrity, sustainability, coordination, and dynamism;
- They adhere to the principles of "ecology first", "people-oriented", "diversity", and "recycling utilization".

(2) The application of ecological planning concepts achieves remarkable results in wetland landscape design

- At the site selection stage, a method based on ecological sensitivity assessment is adopted;
- At the functional zoning stage, a three-level zoning model of "Ecological Protection Zone–Buffer Zone–Experimental Zone" is applied;
- At the plant configuration stage, the combination of native species and diversity helps establish stable plant communities;
- At the hydrological design stage, water circulation systems simulating natural hydrological processes and ecologically friendly waterfront designs are adopted.

(3) Ecological planning concepts promote multi-dimensional improvements in wetland environmental protection

TABLE 5. Optimized Evaluation Index System for Wetland Environmental Protection

Indicator Type	Specific Indicators	Indicator Proportion (%)	Indicator Description and Quantification Method
Ecological Indicators	Water quality (COD, ammonia nitrogen, total phosphorus content)	15	Quantified by monitoring data, graded as excellent (≤30mg/L for COD), good (30–50mg/L), general (50–80mg/L), poor (>80mg/L)
Ecological Indicators	Biodiversity (number of native plant species, number of animal species, species richness index)	15	Quantified by field investigation and statistical analysis, species richness index calculated using the Margalef index
Ecological Indicators	Soil quality (pH value, heavy metal content, soil organic matter content)	10	Quantified by soil sampling and laboratory analysis, heavy metal content refers to national soil environmental quality standards
Ecological Indicators	Vegetation coverage rate (coverage rate of native wetland vegetation, coverage rate of constructive species)	10	Quantified by RS image interpretation and field verification
Economic Indicators	Ecological product output value (output value of native plant resources, output value of ecological tourism products)	15	Quantified by statistical data of local relevant departments, focusing on the output value of ecological products with sustainable development characteristics
Economic Indicators	Tourism income (ecological tourism income, proportion of low-carbon tourism income)	10	Quantified by the statistical data of the wetland park management department, emphasizing the income from ecological tourism rather than blind expansion of tourism scale
Social Indicators	Public satisfaction (satisfaction with ecological environment, satisfaction with popular science education)	10	Quantified by questionnaire survey, using a 5-point Likert scale (1=very dissatisfied, 5=very satisfied)
Social Indicators	Popular science education effect (number of popular science activities, number of participants, awareness rate of wetland protection)	8	Quantified by the statistical data of popular science activities and questionnaire surveys on public awareness
Social Indicators	Employment promotion (number of jobs created in ecological protection, number of jobs created in ecological tourism)	7	Quantified by the statistical data of the wetland park management department, focusing on jobs related to ecological protection

- In terms of water purification, a composite constructed wetland system is built by leveraging the self-purification capacity of wetland ecosystems;
- In terms of biodiversity conservation, efforts are made in designing diverse habitats, protecting key species, and constructing ecological corridors;
- In terms of soil remediation, combined biological remediation methods are used to remove pollutants such as petroleum hydrocarbons and heavy metals.

(4) Typical cases verify the application value of the concepts

Taking the Xixi National Wetland Park in Hangzhou (natural lake-type case) and the WWT London Wetland Centre in the UK (artificially restored case) as examples, this paper conducts an in-depth study and analysis on the application and effects of ecological planning in wetland landscape construction.

AUTHOR CONTRIBUTIONS

Furong Zhi designed, collected and analyzed the data, and drafted the manuscript. Furong Zhi conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Furong Zhi participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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