

Integrated Planning and Ecological Restoration of Urban Wetlands: A Study on Shenyang Xiuhu Wetland Park

Ying Pan

Liaoning Communication University, Shenyang, 110136, Liaoning, China

Keywords: Wetland Park, Ecological Protection, Planning Research, Water Source and Quality, Waterfront, Habitat

Abstract: This paper focuses on Xiuhu Wetland Park in Shenyang, Liaoning Province, and deeply analyzes its ecological protection needs and existing problems. The study finds that the wetland park faces issues such as water pollution, fragile ecosystems, flood discharge hazards, and reduced biodiversity. Through research methods such as field surveys, data analysis, and case comparisons, systematic planning strategies covering water source and quality protection, waterfront protection, and habitat protection are proposed. Specifically, for water source and quality protection, measures such as water cycle management and sewage discharge control are formulated, waterfront protection is achieved through rational selection of bank types and construction of vegetation belts, habitat protection starts with reducing human interference and optimizing species living environments. The research results are of great significance for maintaining the water ecological and environmental safety of the Xiuhu basin and restoring wetland ecosystem functions, providing a reference example for the ecological protection planning of similar wetland parks.

1. Introduction

Wetlands, one of the most productive ecosystems on Earth, are known as the "three major ecosystems of the Earth" together with forests and oceans. Their unique hydrological conditions and biodiversity play an irreplaceable role in regulating regional climate, purifying water quality, storing floods and preventing droughts, and fixing carbon while releasing oxygen. According to statistics from the United Nations Environment Programme, although global wetland area accounts for only 6% of the land area, it supports the survival of more than 20% of known species, and provides multiple service functions for humans, including drinking water sources, food resources, and tourism and leisure. In China, the total wetland area is about 56.35 million hectares, accounting for 5.8% of the country's land area. However, in recent years, affected by factors such as urban expansion, agricultural development, and industrial pollution, the problem of wetland degradation has been severe. The area of natural wetlands has decreased by nearly 3 million hectares in the past decade, and ecological functions have continued to decline.

At present, domestic ecological restoration research on urban wetland parks in northern China mostly focuses on the Yangtze River Basin, and there is still a lack of mature experience in systematic planning for wetland in cold regions. As a typical cold-region reservoir-type wetland, Shenyang Xiuhu Wetland Park faces regional special problems such as freeze-thaw erosion and seasonal water quality fluctuations, which urgently require the formulation of targeted protection strategies combined with climatic characteristics and ecological needs. Therefore, this study takes Xiuhu Wetland as the research object. By analyzing its ecological degradation mechanism, it constructs a systematic planning framework integrating water source protection, waterfront restoration and habitat reconstruction. This not only has practical significance for restoring regional ecological security, but also provides scientific reference for the sustainable management of wetlands in cold-region cities.[1]

2. Planning Principles

2.1 According to functional and ecological importance

Province is scientifically divided into five areas: Wetland Conservation Area, Wetland Ecological Function Reconstruction Area, Science Popularization and Education Area, Rational Utilization Area, and Management Service Area. Wetland Conservation Area and Wetland Ecological Function Reconstruction Area serve as core protection zones, strictly limiting human activities and implementing intensive ecological protection measures to maintain and restore the original state of the wetland ecosystem. Science Popularization and Education Area and Rational Utilization Area moderately carry out science education and leisure tourism activities on the premise of ensuring no damage to wetland ecology. They focus on enhancing visitors' ecological experience and participation, achieving an organic combination of ecological protection, public education, and economic utilization.

2.2 Principle of Combining Scientificity, Rationality and Sustainability

The ecological protection of Xiuhu Wetland Park is not limited to a specific planning scope, but regards water systems and the distribution of animal and plant resources as an interconnected and interactive organic whole. Based on the scientific division of regional ecological function zones, systematic planning methods are used to carry out overall optimal design for the sustainable development of the entire area. Through the rational layout of the ecological structure, the coordinated development of surrounding areas and key planning areas is ensured. While guaranteeing the ecological protection effect of key areas, it drives the collaborative development of surrounding areas, so as to achieve the scientificity, rationality and sustainability of ecological protection in the entire area and effectively ensure the water quality safety and ecological balance of Xiuhu Wetland Park.

2.3 Principle of People-Oriented and Ecology First

The construction and development of the wetland park adhere to the core concept of "people-oriented and ecology first," achieving harmonious coexistence with the natural environment based on full respect for natural laws. Ecological protection and restoration efforts are closely centered on safeguarding human health, promoting ecological balance, and creating an environment suitable for human survival and development. Guided by the needs of human beings, the ecological environment, and the natural environment, it fully explores and utilizes natural conditions and environmental characteristics to promote harmony between humans and nature, society, and the environment. This maximizes the multiple functions and benefits of the wetland ecosystem and ensures the sustainable utilization of wetland resources.[2]

3. Water Source and Water Quality Protection Planning

3.1 Current Status of Water Source and Water Quality

Xiuhu (Qipanshan Reservoir) in the planning area is located in the northern suburbs of Shenyang City, at the upper reaches of the Pu River, a tributary of the Liao River. Its ecological water sources mainly come from upstream river inflows and natural precipitation, with a controlled drainage area of 133 square kilometers. The Pu River originates from Xiang'er Mountain in Hengdaohezi Township, southeast of Tieling. Flowing from east to west through multiple regions, it merges into the Hun River south of Liaozhong County and eventually empties into the sea. The Pu River is 205 kilometers long, with a drainage area of 2,610 square kilometers, an average annual flow rate of 10 cubic meters per second, and an average annual runoff of 300 million cubic meters, playing a crucial role in the regional water resource cycle.

In recent years, influenced by various factors, the water quality of Xiuhu Wetland Park has become a cause for concern. The area around Xiuhu in Qipanshan is densely populated with hotels, and the high volume of pedestrian and vehicle traffic has led to the simplification of the natural environment, making it no longer suitable for migratory birds to stop and inhabit. The water body of the reservoir is severely polluted. According to monitoring, the water quality is classified as Grade IV - V, with the total phosphorus index exceeding the standard particularly significantly, posing a serious threat

to the aquatic ecosystem of the reservoir and the downstream Pu River. At the same time, the water conservation capacity has declined. A large amount of ecological water in the Pu River and Mantang River has been diverted, leading to a series of problems such as river shrinkage, habitat fragmentation, and reduced biodiversity. The drop in the groundwater level has caused phenomena such as vegetation decline and land subsidence, seriously affecting the sustainable utilization of water resources. The Mantang River has dried up, and the Pu River also experiences seasonal drying up. With its water quality classified as Grade IV, it fails to meet the required functional standards.

3.2 Water Source and Water Quality Protection Measures

To improve the water quality of Xiuhu Wetland Park, a water network system centered around Xiuhu with surrounding irrigation and drainage canals as branches is planned. By dredging the connections between various irrigation areas and strengthening wetland management, a water quality improvement path from the surface to the line is achieved. Leveraging the natural purification function of wetlands, the water flow is filtered and purified layer by layer, gradually enhancing the water quality. The goal is to ensure that the water quality of the final inflow into the Hun River meets the national Class III standard, restoring and optimizing the ecological functions of the regional water cycle system.

Water purification measures within the wetland park are closely integrated with the zonal design, creating diverse water body forms arranged in a top - down sequence: stream sedimentation area, wetland filtration area, natural wetland area, and restoration area, thus providing a rich ecological environment for water purification. Specifically, a purification method combining aquatic plants and filter materials is adopted. Downstream of sluices or dams, zeolite filter materials are used to adsorb pollutants in the water. In the river channels, highly purifying aquatic plants such as *Potamogeton*, *Hydrilla verticillata*, *Vallisneria spiralis*, *Najas*, *Typha latifolia*, *Typha orientalis*, and *Phragmites australis* are extensively planted. Through the physiological activities and ecological functions of these plants, pollutants in the water are effectively removed, enhancing the water body's self - purification capacity.[3]

Since the water bodies of Xiuhu Wetland Park are interconnected with those of the surrounding irrigation areas, the discharge of agricultural surface runoff, production and aquaculture sewage, and domestic sewage in the surrounding areas poses a serious threat to the water quality of Xiuhu. Taking the Pu River as an example, the sand washing plants in Tieling City, where the river originates, have caused turbid water quality at the Qipanshan section of the Pu River upon its entry, severely affecting the water quality of Xiuhu. Therefore, it is necessary to formulate long - term management plans for pollution control, water quality improvement, and ecological environmental protection. We should strengthen sewage discharge control from the source, strictly limit the discharge of various pollution sources, and enhance the supervision and treatment of sewage discharged by surrounding enterprises, agricultural production, and residential areas. We must ensure that sewage in the surrounding areas meets the discharge standards to reduce pollution to the water quality of Xiuhu Wetland Park.

During the construction process, a strategy of "construction - while - protection" is adopted. By building ecological filter fields, the biological treatment of water bodies is organically combined with the removal of suspended solids, effectively eliminating pollutants such as organic matter and nitrogen in the water, while also intercepting sediment to prevent pollutants generated during construction from entering the surrounding environment. During the production and operation period, in response to the large amount of domestic sewage generated in the wetland - feature science popularization and education area, rational utilization area, and management service area, the scale of catering and accommodation facilities within these areas will be strictly controlled to avoid pollution pressure caused by over - development. Sewage within these areas will be centrally collected and uniformly channeled into the municipal sewage treatment system for treatment. In areas with concentrated visitors, ecological public toilets, trash bins, and other infrastructure will be rationally set up to ensure that collected garbage is transported to waste treatment stations for harmless treatment, and then promptly transferred to urban waste transfer stations, preventing water quality and ecological environment damage caused by garbage pollution.

The local environmental protection department and relevant water conservancy authorities will designate a buffer zone of the original riparian plant community on both banks of the Pu River upstream of Xiuhu, replan the river buffer zones encroached by agriculture, and carry out the protective restoration project of the ecological wetlands along the Pu River. On the premise of meeting flood - discharge requirements, they will maintain the natural form of the Pu River channel, making it feature varying widths, meandering courses, and different depths to create a diverse wetland ecological environment. The technical teams of these departments will utilize native wetland and aquatic species to construct a rich and diverse wetland plant community, restore the biodiversity of riparian wetland vegetation, and provide suitable habitats for different organisms. Meanwhile, through the purification function of wetland plants and the synergistic effect of the ecosystem, they will achieve dual - level water quality purification and enhance the regional ecological environmental quality.

4. Waterfront Protection Planning

4.1 Principles of Waterfront Protection

For waterfront protection, permeable natural ecological revetments are given top priority, and the use of impermeable materials for revetments is avoided as much as possible. When engineering measures are necessary to reinforce the revetments, attention should be paid to the design of the revetment's appearance, as well as the selection of material texture and color to ensure harmony with the surrounding environment, achieving the unity of ecological protection and landscape beautification. Ecological revetments are constructed by adding gravel along the shore or planting aquatic plants, optimizing the ecological environment of the shoreline. This not only meets the functional requirements of flood control and revetment protection but also ensures the smooth material circulation and energy flow between land and water, creating a favorable habitat for wild animals such as fish, geese, and ducks to inhabit and reproduce.

4.2 Waterfront Protection Planning

Appropriate revetment types are scientifically selected based on the differences in water flow scouring intensity:

Shorelines with low water flow scouring intensity: We should adopt natural shoreline designs, fully utilizing the soil-fixing effect of plant roots to prevent the embankment from being scoured by water flow. Depending on the surrounding environment, plant growth conditions, and landscape requirements, natural wetland revetments or natural grassy slope revetments can be flexibly chosen, or a combination of both forms can be used to create a natural and harmonious waterfront landscape.

Shorelines with moderate water flow scouring intensity: In practical engineering applications, people often employ ecological engineering revetments, which commonly include forms such as mortar-laid stone pile revetments and gabion revetments. While enhancing the stability of the embankment, these revetment methods also focus on the exertion of ecological functions. By leaving gaps and planting plants, habitats are provided for aquatic organisms, promoting the healthy development of the ecosystem.

Shorelines with high water flow scouring intensity: Hard revetments can be used to effectively resist the strong erosion of the embankment by water flow and ensure the safety and stability of the embankment. When designing hard revetments, connection with the surrounding ecological environment should also be considered. By setting ecological grooves, planting climbing plants, and other means, habitats for organisms are increased, reducing the negative impact of hard revetments on the ecological environment.

The selection of plants for waterfront vegetation belts primarily focuses on native species, with the appropriate introduction of species that have undergone long - term acclimatization and pose no risk of invasion. In terms of species configuration, the vegetation stratification structure at the land - water interface, natural succession patterns, design functional requirements, and usage conditions are fully considered to construct diverse and multi - layered vegetation communities. By avoiding

monoculture and enriching plant species and the ecological system structure, the stability and ecological functions of the vegetation belt are enhanced, promoting the natural succession and ecological balance of the ecosystem.

Currently, within and around the planning area, there is a phenomenon of residents casually dumping domestic waste by the river and on slope revetments. These wastes not only spoil the landscape but also contaminate the land through chemical and physical changes, releasing foul odors and toxic gases. Some of the waste is washed into irrigation canals during rainfall, polluting the water bodies. Therefore, a comprehensive removal of such waste is necessary, followed by harmless treatment. After cleaning, the slope revetments are covered or replaced with new soil, and plants with strong pollutant - purifying capabilities are selected for planting, gradually restoring the ecological functions of the slope revetments and improving the quality of the regional ecological environment.[4]

5. Habitat Protection Planning

5.1 Principles of Habitat Protection

Comprehensive and specific protection measures are formulated according to the ecological and living habits of wild animals and plants in Xiuhu Wetland Park. These measures include strengthening the construction of fire - prevention facilities to enhance the ability to respond to fire risks, carrying out publicity and education activities on the protection of wild animals and plants and improving relevant protection systems, implementing habitat restoration and renovation projects to optimize the ecological environment, strengthening the monitoring, prevention, and control of harmful organisms to maintain the balance of the ecosystem, and establishing a monitoring system for wildlife epidemic sources and diseases to ensure the health of wild animals and public health safety. Through these measures, the species and quantity of wild animals and plants in the wetland park will be gradually increased, biodiversity will be enriched, and the stability and sustainable development of the ecosystem will be promoted.[5]

5.2 Habitat Protection Plan

Anthropogenic activities have severely disturbed the habitats of wild animals, mainly including coastal reclamation, environmental pollution, destruction of forest vegetation, construction of large - scale water conservancy projects, urbanization, and the development of market towns. These activities have caused many wild animals to lose their habitats or have fragmented habitats. Geological disasters have also damaged habitats, forcing some animals to migrate or die. Therefore, it is necessary to strengthen the management and regulation of various anthropogenic activities, minimize interference with and damage to wild animal habitats, and create a safe and stable living environment for wild animals.

Birds: Different bird species have varying preferences for habitats, but they generally pay attention to the conditions of nesting and foraging areas. Herons in Xiuhu mostly choose to build nests on tall trees in coniferous - broadleaved mixed forests and coniferous mixed forests to meet the co - inhabitation needs of various heron species, geese and ducks prefer herbaceous swamps and paddy field wetlands as nesting sites. Additionally, during the breeding season, birds have stricter requirements regarding the distance to foraging areas.[6]

Fish: Fish are sensitive to water quality. During the breeding season, they typically prefer to inhabit shallow beaches and slow-flowing areas with aquatic plants and deadwood, which provide suitable environments for breeding, foraging, and shelter.

Amphibians: Amphibians prefer to live in deciduous broad-leaved forests or coniferous-broad-leaved mixed forests dominated by deciduous broad-leaved trees, as well as related forest-edge shrubbery, forest streams, and forest swamps. Tadpoles mainly inhabit mainstream branches, water puddles with slow water flow and small discharge.

5.3 Habitat Protection Measures

In the ecological protection area, efforts will be intensified to restore and manage existing wetland

vegetation. A mixed forest of various trees and shrubs will be planted along the shorelines to provide habitats and shelters for wild animals. Meanwhile, herbaceous plants will be allowed to undergo natural succession, fostering a diverse ecological environment.

Along both sides of roads, green barriers composed of a combination of trees, shrubs, and herbs will be planted. These barriers will effectively reduce habitat disruption caused by vehicle traffic and mitigate the impact of human activities on wild animals.

The use of pesticides and fertilizers in surrounding agricultural areas will be strictly restricted. Local water quality improvement projects will be implemented to enhance water quality, creating a favorable living environment for aquatic organisms.

The initiative of returning farmland to wetlands around the ecological protection area will be promoted. By restoring wetland vegetation and simulating natural community compositions through the planting of suitable trees and plants, more spaces for wild animals to inhabit and reproduce will be created.

In areas with frequent human activities within the wetland park, well - concealed trails and bird - watching houses will be rationally designed. These facilities will guide visitors to stay within designated areas, minimizing disturbances to wild animals such as birds and achieving a harmonious coexistence between ecological protection and tourism activities.

6. Conclusion

This study, through in-depth investigation and analysis of the ecological environment of Shenyang Xiuhu Wetland Park, identifies issues in water quality, ecosystem, flood control safety, and biodiversity. Targeting these problems, systematic and comprehensive ecological protection planning strategies are formulated, covering key areas such as water source and quality protection, waterfront protection, and habitat protection.

By implementing these measures, it is expected to effectively improve the wetland park's ecological environment, restore the structural and functional integrity of the wetland ecosystem, and recreate its role as a water-green ecological corridor integrating ecological water storage, water purification, scientific research, and leisure landscapes. The research results not only provide significant guidance for the ecological protection and sustainable development of Xiuhu Wetland Park but also offer valuable references for ecological protection planning of similar wetland parks.

In the future, it is necessary to further strengthen the implementation and supervision of the plan to ensure all ecological protection measures are effectively carried out, achieving continuous improvement of the ecological environment and sound development of the ecosystem in Xiuhu Wetland Park.[7]

References

- [1] Wang Yuanyuan, Lu Fali, Ban Yufeng. Protection Planning of Linyi Urban Wetland Park [J]. Wetland Science and Management, 2013, 31(04): 81-84.
- [2] Li Hongqing. Wetland Ecological Protection and Restoration Technology for Major Water Conservancy Projects [M]. Science Press, 2022.
- [3] Wang Yujia. A Review of Research on the Protection and Management of Wetland Parks Abroad [J]. World Forestry Research, 2019, 32(04): 59-64.
- [4] Zhao Shukai. Current Situation and Protection Management Countermeasures of Wetland Resources in Shanxi [J]. Forestry Science and Technology Communication, 2019(7): 49-51.
- [5] Wu Houjian, Dan Xinqiu, Shu Yong. National Wetland Parks in China: Current Situation, Challenges, and Countermeasures [J]. Wetland Science, 2015, 13(03): 306-314.
- [6] Liu Xiaoli. Evaluation of Wetland Protection Legislation in China [J]. Qiushi Journal, 2011, 38(3): 64-69.

[7] Lü Yong, Chen Kelin. Case Studies on Wetland Protection and Utilization at Home and Abroad and Their Enlightenment for Ecotourism in Jinghu National Wetland Park [J]. Wetland Science, 2006(04): 268-273.