

ORIGINAL RESEARCH ARTICLE

Utilization of water resources in Pingtian Lake wetland and its protection countermeasures

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ABSTRACT

In order to better protect and utilize the water resources of the wetlands along the river in Anhui, through a comprehensive analysis of the current situation of water resources development and utilization in Pingtian Lake National Wetland Park in Chizhou, Anhui Province, the key factors affecting the ecological function of the water resources of the Pingtian Lake Wetland were explored, and specific wetland water resources protection measures were proposed: first, to restore the topography of the wetland habitat and improve the ecological function of the lake itself; second, to promote modern ecological agricultural technology and reduce non-point source pollution in rural agriculture; and third, to take the opportunity of “sponge city” construction and centralized environmental management to strictly control the discharge of urban sewage and corporate pollutants; fourth, to innovate the wetland ecological compensation system and increase the protection of wetland water resources; fifth, to strictly abide by the red line of ecological protection and implement wetland water resources management in accordance with laws and regulations.

Keywords: Pingtian Lake Wetland Park; Water Resources Conservation; Biodiversity

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1. Introduction

Wetlands are natural or man-made, permanent or temporary stagnant or flowing water, freshwater, brackish or brackish marshlands, peatlands, or waters, including areas of seawater with a water depth of not more than 6 m at low tide^[1]. Wetlands are one of the most important ecological environments for human beings^[2]. Wetland ecosystems are the natural ecosystems that carry the most ecological functions on the earth, have high biological productivity, and have significant ecological benefits^[3]. However, wetland ecosystems are also the most degraded and loss-free ecosystems in the world today^[4]. Compared with rivers, lake wetlands are greatly affected by human activities and have poor water fluidity, more lake facies deposition, and slow water quality renewal. It is prone to eutrophication and other characteristics, and its ecological system is the most fragile. With the development of the economy and society, the utilization of wetland water resources in China faces many threats, and the improper utilization and protection of wetland water resources will inevitably lead to the weakening of wetland flood regulation and storage functions and the degradation of wetland habitats. At the same time, wetland biodiversity conservation, ecological security, and ecosystem stability are also constrained. Wetlands play a huge role in water transmission, storage, and supply. Hydrology is a key factor in determining the characteristics and types of

wetlands^[5], and the integrity and quality of wetland water resources are of great significance for wetland conservation. Taking Pingtian Lake National Wetland Park in Chizhou City, Anhui Province as an example, the purpose is to analyze the current situation of water resource utilization of urban lakes and wetlands in the middle and lower reaches of the Yangtze River and to explore the water resources protection strategy of urban lakes and wetlands.

2. Overview of Pingtian Lake wetlands

Pingtian Lake, formerly known as Baisha Lake, is located in Guichi District, Chizhou City, Anhui Province (longitude 117°29'28" to 117°34'20" E, 30°37'31" to 30°41'59" N)^[6], with Chizhou City. The urban area is closely connected and is one of the important ecological function areas in the overall planning of Chizhou City. The total area of Pingtian Lake wetland is 4,290 hm², of which the water area is 1,100 hm², which is one of the important components of the lake wetland group in the middle and lower reaches of the Yangtze River. The catchment of Pingtian Lake is mainly three small rivers in the southeast direction and the disorderly runoff of the surrounding surface, and the effluent enters the old road of Qiupu River from the north-facing flood ditch, which is a typical small shallow water Lake^[7].

Chizhou is the first state-level ecological and economic demonstration zone in China, and there are three major river systems in the territory, namely the Yangtze River system (Yaodu River, Huangxiang River, Qiupu River, Baiyang River, Datong River, Jiuhua River), Qingyi River system (Qingxi River, Lingyang River, Laba River) and Poyang Lake water system (Longquan River). Chizhou belongs to the northern subtropical humid monsoon climate zone^[8]. The Yangtze River flows through Chizhou City for about 145 km, and its shoreline is about 162 km long. Chizhou is rich in surface water resources, which are 4 times and 2 times the average of Anhui Province and the whole country, respectively^[9].

Pingtian Lake is located on the northern edge of the subtropical region and has a warm and humid subtropical monsoon climate. According to the

wetland classification system of the "National Wetland Resources Survey Technical Regulations (Trial)", statistics are carried out on the basis of the second wetland resource survey in Anhui. It is believed that there are four types of wetlands in Anhui Chizhou Pingtian Lake National Wetland Park, namely lake wetlands, swamp wetlands, constructed wetlands and river wetlands; there are 6 kinds of lakes and wetlands, and there are 1 kind of wetland type of permanent freshwater lakes and 1 kind of wetland type of rivers and wetlands of rivers. There are three types of wetlands: aquaculture farms, artificial water transmission rivers, and reservoirs, and the swamp wetlands are mainly herbaceous swamps^[10]. The average annual sunshine hours of Pingtian Lake are 1,730–2,100 h, and the average annual temperature is 16.1 °C. The annual temperature was the lowest in January with a range of 3.1–3.5 °C, and the highest in July with a range of 27.9–28.7 °C. The average frost-free period is 220 d^[11].

3. Main functions of the Pingtian Lake wetland

3.1 Flood control

Hydrology is the most important factor in wetland environment^[5]. Similarly, wetlands also affect the hydrological situation in the basin. According to research, the distribution rate of wetland in one river in the United States is 4%, and its ability to store flood is 50% higher than that in the case of wetland disappearance, while the distribution rate of wetland in another river basin is 40%, and its ability to store flood is 140% higher than that in the case of wetland disappearance^[12]. Compared with the surrounding areas, the wetland of Pingtian Lake is relatively low-lying and has the function of allocating and homogenizing the river runoff in Chizhou City, which is an important part of the hydrological cycle in Chizhou City and the surrounding rural areas. Pingtian Lake wetland is close to the foot of Qishan Mountain. The lake branches with large areas and different sizes are densely distributed, and the beach soil is deep, so it has a strong ability to store water resources. At the same time, Pingtian Lake wetland is rich in plant resources, and the diversity of plant

communities is obvious. It can significantly slow down the flood flow rate and reduce the flood peak, which plays an important role in effectively preventing and controlling flood disasters in the surrounding areas, especially in the downstream areas.

3.2 Irrigation of farmland

The low-lying area in the wetland area of Pingtian Lake is mainly the lake areas and the nearby residential agricultural production areas, and the existing cultivated land is 1,400 hm², which is planted the main things are rice (*Oryza sativa*, *Oryza glaberrima*), rapeseed (*Brassica napus*), and russet (*Zizania latifolia* Stapf), lotus root (*Nelumbo nucifera* Gaertn), corn (*Zea mays*), soybean (*Glycine max*), sweet potatoes (*Ipomoea batatas*) and so on. Pingtian Lake Wetland has a strong water transmission and water supply capacity, which can be used for farmland within the wetland area and villages around the wetlands seven natural villages, including Xiashan villages, Shunli villages, Bishan villages, Qishan Village, Yang'an Village, Baisha Village and Shishan Village, provide sufficient water for agriculture and domestic use.

3.3 Aquaculture

There are many lakes in the Pingtian Lake area, and the aquaculture industry is relatively developed, mostly based on artificial aquaculture, mainly cultivating freshwater fish, such as bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), carp (*Cyprinus carpio*), crucian carp (*Carassius auratus*), bream (*parabramis pekinensis*), yellow catfish (*Pseudobagrus fulvidraco*), etc.

3.4 Ecological landscape

Pingtian Lake is vast in smoke, the mountains around the lake are raised, the trees are verdant, the grass is full of flowers, the water spirit leaves are lush, and the forest vegetation coverage rate is 95%, which is known as "Chizhou West Lake" and "Venice of the East". The natural environment in the area is beautiful, rich in history and culture, and in history, "Pingtian Spring Rise" is one of the famous Ten Scenic Spots in Chizhou. Successive generations of literati and writers of all dynasties have traveled here to appreciate, and left many popular poems, when Li Bai wrote "Water is like a white

silk, and this place is flat. You can ride the bright moon and watch the flowers on the wine boat". The history books record that Yue Fei of the Southern Song Dynasty once stationed troops in Guichi Qishan to cross the river to resist Jin, and trained sailors at Pingtian Lake. Prince Zhaoming of the Southern Dynasty fiefdom was here, and often fished by the Pingtian Lake. Guishan Island in Pingtian Lake, its shape resembles a god turtle, facing south and worshipping, is known as the god turtle worshipping Jiuhua. In 2014, Pingtianhu Wetland Park was named one of the top ten "China's most beautiful moon-viewing places" by CCTV.

The unique topography and rich biodiversity resources of Pingtian Lake Wetland have constructed a typical "landscape in the city" characteristic landscape of Chizhou City. At the same time, it is also an important object of the majority of environmental protection and scientific research workers to carry out wetland resource surveys and urban wetland resource utilization and protection research. In addition, Japanese astronomical experts have considered that it occurred in 2009 through a multi-party investigation, combining factors such as geographical location, resource environment and air quality. During the total solar eclipse on July 22, Chizhou Pingtian Lake Observation Deck is one of the best places to observe.

3.5 Leisure and fitness

With its unique geographical location and natural environment, Pingtian Lake Wetland provides local residents with good leisure and recreation and sports and fitness places, especially with the improvement of transportation facilities in the lake area, becoming a resident walking, cycling and morning running, fishing, moon viewing, entertainment good place. In recent years, the number of projects in Pingtian Lake Wetland Park for leisure and entertainment, homestay catering, sports and fitness has gradually increased, such as Pingtian Peninsula Hotel Floating restaurant, fisherman's delight, farmer's delight (leisure farm, homestay), water sightseeing cruise, tourist resort area (Shuiyunjian Villa), music square, water beach, wetland coffee bar, lake viewing pavilion, lotus terrace, etc. In 2004, the State General Administration of Sport

held an international motorboat competition in Pingtian Lake, which is now designated by the State General Administration of Sport as the training base of the Aquatics Center.

4. Environmental impact factors of water resources in Pingtian Lake wetland

4.1 Municipal sewage discharge

Pingtian Lake National Wetland Park is adjacent to Chizhou Municipal Education Park (Chizhou College, Anhui Health Vocational College, Chizhou Vocational Education Center and other schools) in the east, and Chizhou City in the north. The Economic and Technological Development Zone is closely connected to Chizhou High-speed Railway Station and Chizhou Long-distance Bus Station in the south, and Pingtianhu Road and Wanluoshan Road in the main urban area of Chizhou City in the west. In recent years, the wetland waters of Pingtian Lake have passed through Baisha village bridge, Baisha No. 1 bridge, Anhui health vocational college, Chizhou college, and so on. The sewage outlet of Chizhou Transportation School accepts a large number of pollutants discharged by domestic sewage and industrial enterprises, resulting in high total phosphorus and total nitrogen indicators of lake water quality (both exceeding the water quality requirements of Class IV), showing a more serious eutrophication trend.

4.2 Rural non-point source pollution

Rural agricultural population around Pingtian Lake Wetland 1. 20,000 people, large and small livestock 17,950,000 heads, lake aquaculture water surface 732 hm². Farmers around the wetlands mainly make their living from crop cultivation, livestock and poultry breeding, and aquaculture. In the process of agricultural production, some farmers lack the awareness of ecological environmental protection and the concept of food safety, rely too much on chemical pesticides to control diseases and insect pests, and blindly increase the amount of pesticides and the number of sprays. The overall application of chemical fertilizers is too large, and the proportion of nitrogen, phosphorus and potassium is

out of balance, the phenomenon of nitrogen fertilizer application is more common, and the application period is not reasonable^[13]. The low utilization rate of chemical fertilizers and pesticides and the high rate of loss not only lead to soil pollution in farmland but also cause organic pollution to water bodies through surface runoff of farmland Eutrophication pollution and even groundwater pollution and air pollution^[14]. In addition, a small number of farmers randomly sprinkle a large amount of manure, lees, etc. into the lake waters where aquatic products are cultivated, the aquaculture density is high, and the excess bait is scattered in the lake water. Some city dwellers and farmers around the lake area like to bathe and wash their clothes in Pingtian Lake, and use soap a lot. All this will accelerate the deterioration of the water resource environment of the Pingtian Lake wetland.

4.3 Project construction

Due to the lack of strict natural ecological environmental protection elements in the early engineering construction planning and design of Pingtian Lake wetland, the wetland agricultural water conservancy project in the lake area, the highway around the lake, the cultural landscape, transportation, and leisure farms. The construction of various types of projects such as homestay services, floating restaurants, and educational parks is frequent, and the contradiction between biodiversity conservation and the maintenance of the vested interests of the local people is becoming increasingly prominent^[15]. The construction of various engineering projects has artificially destroyed the topography and landform in the Pingtian Lake basin to varying degrees, changed the surface runoff mode, and is difficult to communicate with the surrounding lakes and rivers, and the frequency of lake water renewal is reduced. The speed of lake water flow slowed down, and the lake sediment remained for a long time, resulting in the decline of the flood regulation and storage function of the wetland ecosystem of Pingtian Lake, and the situation of flood prevention during the flood season was grim. It also artificially destroys the balance of natural ecosystems, which is not conducive to the conservation of wetland biodiversity.

In addition, due to the construction of roads and related engineering projects in the lake area, many lakes in the wetland have been artificially isolated into “orphan ponds” (some of which are only connected by artificially set up culverts), and the runoff mode of the wetland surface has changed, the effective water area of the lake is reduced.

4.4 Tourism project development

The environmental quality of Chizhou is second to none in the central and eastern regions, and it is a national garden city, a national forest city, a national green ecological demonstration urban area and an excellent tourist city in China, and won the “Chinese Environment Award” in 2013. In recent years, the Chizhou Municipal Government has attached great importance to the construction and promotion of Pingtian Lake wetland tourism projects, focusing on the construction of Pingtian Lake Tourist Resort, and planning to build an boardwalk in Pingtian Lake Square and Lotus Terrace. There are 4 tourist piers in Peach Blossom Island and Pingtian Peninsula, and water sports attractions include water speed boats, water walking balls, and water sports Jet skis, banana boats, water skiing, self-paddling rubber boats, self-rowing wooden boats and self-driving boats. Although the development of wetland tourism projects can help promote local economic and social development and better play the function of wetland resource service, improper management and implementation will also lead to the degradation of the self-purification function of lakes and the flow. The surface runoff mode of the inland area has changed, and the wetland habitat has been artificially destroyed, affecting the stability of the wetland ecosystem and biodiversity. For example, water activities such as water restaurants, water yachts (boats) and other water activities produce a large amount of garbage, oil, wastewater and other pollutants are directly discharged into the lake, if not properly disposed of, it will inevitably aggravate the degree of lake water pollution, and the total phosphorus and nitrogen of the lake’s nutrient salts cannot flow out normally, which destroys the balance of nutrients and salts in the lake. Thus enriching in the lake area, the growth rate of algae organisms such as

cyanobacteria and green algae accelerates, resulting in an accelerated process of eutrophication of lake water and poor water quality in the lake.

4.5 Artificial control of schistosomiasis

Schistosomiasis is one of the major infectious diseases that seriously endangers the health of the people and affects economic development and social stability^[16,17]. Pingtian Lake was once known as the “Schistosomiasis Nest”^[18]. In recent years, although schistosomiasis in the administrative villages around the Pingtian Lake wetland has been effectively controlled, some places will occasionally adopt measures such as surface hardening of the wetland and drug snail eradication, to prevent schistosomiasis from rebounding and epidemic. However, surface hardening and drug snail extermination will artificially destroy wetland habitats to varying degrees, change the way of surface runoff, and affect wetland biodiversity.

5. Water resources protection measures for Pingtian Lake wetland

5.1 Restore the topography of wetland habitats and enhance the ecological function of the lake itself

Strengthen the construction of the interconnection project between the lake and the lake within the Pingtian Lake wetland and the construction of the connection project between the surrounding rivers and lakes, restore the surface runoff mode of the wetland, increase the speed of lake water flow, reduce lake phase sedimentation, and improve the self-purification ability of lake water. Further promote and improve the ecological transformation of the Pingtian Lake embankment, the construction of the inner slope view of the embankment, the construction of the low-drainage ditch boardwalk, and the reconstruction of the Pingtian Lake Official Kiln Tsui Flood control gates and other key projects will enhance the ability of wetlands to regulate and store floods. Establish a wetland ecological buffer zone between the wetland of Pingtian Lake and the surrounding low hills (such as Qishan Mountain), pay attention to the protection of wetland habitat diversity, and gradually restore and enrich the over-

all ecological function of Pingtian Lake wetland. The barge of the lake body should adopt the method of natural barge as much as possible, and advocate the extensive use of aquatic plant barges and grass slopes into the water barge, so as to absorb pollutants and reduce the flow rate of surface runoff^[19].

In addition, the Wetland of Pingtian Lake often appears invasive alien plants, such as Canada's "Yellow Flower", etc., and the wetland management department should strengthen the inspection of the natural biodiversity of the wetland. Invasive alien plants should be treated in a timely manner by a combination of artificial removal and chemical control to ensure the ecological safety of wetlands.

5.2 Promote modern ecological agricultural technology and reduce non-point source pollution in rural agriculture

Pingtian Lake wetland surrounding Xiashan village, smooth village, Bishan village, Qishan village, Yang'an village, Baisha village, Shishan village and other rural areas to strengthen wetland protection knowledge propaganda, enhance farmers' awareness of wetland ecological environment protection. Strengthen the modern ecological agriculture technology training service, guide the wetland farmers scientific and safe application of pesticides and fertilizers. In accordance with the relevant requirements of wetland protection, it is necessary to strictly control the scale and methods of poultry, livestock and aquaculture. Put feeds and bait scientifically, properly dispose of animal manure, breeding waste and other pollutants, prohibit unauthorised throwing of manure, distiller's grains, etc. into lake waters, and minimize non-point source pollution in wetland and rural agriculture.

In addition, for a small number of areas prone to schistosomiasis, it is necessary to strengthen the training and business guidance of drug snail control technology, and minimize the artificial hardening of the wetland surface due to the prevention and control of schistosomiasis.

5.3 Take the construction of "sponge city" and the centralized treatment of the environment as an opportunity to strictly control the discharge of urban sewage and corporate pollutants

"Sponge city" means that the city can be like a sponge, in adapting to environmental changes and responding to natural disasters and other aspects of good "elasticity", when it rains, absorb, store, seep, purify water, and "release" and use the stored water when necessary^[20]. Chizhou is one of the first batch of national-level "sponge city" construction pilot cities in China, along with the "sponge city". The development of construction, combined with the centralized treatment of the environment, the overall ecological environment of Chizhou City has been significantly improved. The management department of Pingtian Lake Wetland should seize the opportunity of the construction of "sponge city" and centralized environmental governance, consolidate and expand the achievements of sponge city construction and centralized environmental governance, and increase the transformation of urban sewage treatment facilities. Optimize the layout of the regional industrial structure, strictly control the discharge of pollutants by enterprises, curb the pollution of water resources in Pingtian Lake from the source, and make the water quality conditions of the wetlands of Pingtian Lake meet the basic requirements of the water function area. Accelerate the construction of ecological ditches, and use plants in ecological ditches to absorb surplus nutrients in wetland runoff. For algae organisms such as cyanobacteria and green algae that thrive in large quantities in the waters of some lakes, the means of moderately increasing the stocking of algae-eating fish such as bighead carp and silver carp can be adopted. Reduce the distribution of algae organisms in the lake and improve the quality of water resources in the lake.

5.4 Innovate the wetland ecological compensation system and increase the protection of wetland water resources

Ecological compensation is one of the important means to protect wetland biodiversity. Pingtian Lake National Wetland Park should strictly implement the "Interim Measures for Ecological Compensation of Surface Water Sections in Chizhou City"^[21], insisting the principle that "who exceeds the standard, who pays, who benefits, who compensates", pay attention to the decisive role of

the market in the allocation of resources, and widely introduce society groups and citizens, as well as special funds for wetland biodiversity conservation from various sources outside the region, gradually improve and innovate the ecological compensation mechanism for wetlands in Pingtian Lake. It is necessary to guide residents and enterprises around the wetland to consciously abide by the wetland ecological compensation system, rationally develop and utilize the ecological resources of the wetland, and promote the harmonious development of man and nature^[22]. It is necessary to increase the daily inspection of wetland water resources protection and the publicity of the legal system, and prohibit unauthorized reclamation, illegal discharge of pollutants, illegal establishment of enterprises, and unauthorized raising of poultry and livestock in the Pingtian Lake wetland. Illegal drug fishing and other acts of artificial destruction of the ecological environment of wetlands. Strengthen the management of river and lake shorelines and river floodplains, implement the return of fields to lakes and the return of fields to wet, strictly prohibit encroachment on the ecological space of rivers and lakes, and orderly promote the recuperation of rivers and lakes^[23].

5.5 Strictly abide by the red line of ecological protection, and implement wetland water resources management in accordance with laws and regulations

Delineating the red line of ecological protection and implementing the strictest ecological control strategy is the need to implement the spirit of the 18th and 19th National Congresses of the Communist Party of China. Scientifically and rationally delineating ecological redlines and strictly controlling ecological redline areas are important contents and inherent requirements for the construction of ecological civilization in China's new era, and are also the most important tough means and arduous tasks for protecting regional ecological environment and biodiversity^[24]. On June 27, 2018, the People's Government of Anhui Province officially issued the "Anhui Province Ecological Protection Red Line". The total area of ecological protection redlines in Anhui Province is stipulated to be

21,233.32 km², accounting for about 15.15%, including 16 precincts in three categories^[25], including Chizhou Pingtianhu National Wetland Park. Pingtianhu National Wetland Park and relevant government departments of Chizhou City should strictly abide by the red line of ecological protection, strengthen communication and coordination between departments, and balance the relationship between the development and utilization of all parties and the protection of interests. To implement the wetland ecological control system according to local conditions, we can establish an incentive and constraint mechanism for the utilization of water resources in combination with the current river chief system, and consolidate the responsibility for the management of wetland water resources. Ensure that the development, utilization and protection of water resources in the Pingtian Lake wetland are carried out in an orderly manner. It is possible to explore the establishment of a unified water resources database for the Pingtian Lake wetland and even the entire Anhui River wetland, and coordinate water conservancy, environmental protection, transportation, and transportation. Hydrology and other government departments and relevant scientific research institutions data, the use of big data technology, the water quantity, quality, and spatial distribution of water resources to carry out timely monitoring and data updates, the establishment of the real-time monitoring system, provide fast and effective services for the utilization and protection of wetland water resources and the protection of the natural ecological environment.

6. Conclusion

The utilization and protection of the water resources of Pingtianhu National Wetland Park are of great significance to the conservation of biodiversity along the river in China and have a positive role in promoting the construction of ecological civilization in Chizhou City and even Anhui Province. The government department where Pingtian Lake is located needs to effectively increase the sense of responsibility, and learn from the experience of wetland water resources utilization and protection in large national nature reserves such as Shengjin Lake and Poyang Lake nearby, and use modern infor-

mation technology means. Organize special forces to carry out in-depth research on the utilization and protection of wetland water resources, and constantly explore new paths for the utilization and protection of wetland water resources in Pingtian Lake.

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Conflict of interest

The authors declared no conflict of interest.

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