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Water resources carrying capacity of wetland conservation in Dongting Lake

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ABSTRACT

This paper studies the water resources carrying capacity of lake wetland tourism development. This paper studies by establishing DPSIR model. In this paper, several important factors influencing the water resources carrying capacity of lake wetland tourism development in each criterion layer are understood through DPSIR model, among which the weight value of surface water resources is 0.0367, the weight value of per capita water consumption in criterion layer is relatively large, 0.0369, the weight value of do in state value is 0.0450, the weight value of air quality excellent rate in criterion layer is 0.0400, and the weight value of sewage in response is 0.0367. Among them, the weight value of recycling amount is the largest, which is 0.0539. In addition, the order of weight of criterion layer is: state (0.2298) > driving force (0.1413) > response (0.1337) > pressure (0.1071) > impact (0.0753). It can be seen that the comprehensive weight of state subsystem is the largest.

Keywords: Lake wetland; Tourism development; Water resources carrying capacity; Sustainable utilization

1. Introduction

Lake wetland is closely related to human survival, reproduction and development. It is one of the ecological landscapes with the richest biodiversity in nature and one of the most important environments for human beings [1,2]. On the other hand, lake wetland has rich comprehensive functions, which not only meets the high-level tourism needs of people in today's society, but also brings huge social and economic benefits to the tourism destination [3,4]. Lake wetland tourism as a new type of eco-tourism, with its unique ecological structure, rich biodiversity and rich tourism resources, has become a tourist hotspot [5,6].

As a concentrated discharge area of various natural resources and human pollutants, lake wetland is difficult to develop and manage Lake reasonably and scientifically [7,8]. In order to reasonably develop, utilize and protect lake wetland resources, and fully realize lake wetland functions and values under the concept of sustainable development, it is necessary to study the water resource carrying capacity of lake wetland tourism development, which is of great significance for sustainable development [9,10].

In this paper, the factors affecting the carrying capacity of lake wetland resources are analyzed comprehensively, and an evaluation index system which can not only accurately express the carrying capacity, but also reflect the impact of internal changes of water resources system, social system and economic system on the carrying capacity is established. In this paper, the mathematical method is used to calculate the carrying capacity of water resources, and it can quantitatively reflect the coordination state among water resources system, social system and economic system, which lays a solid foundation for the study of comprehensive utilization of water resources in lake wetland. This paper first analyzes the connotation of water resources carrying capacity, and puts forward the relevant calculation formula of water resources carrying capacity. After exploration, through the construction of DPSIR model for analysis, it summarizes the factors affecting water resources carrying capacity, then summarizes the evaluation index system and evaluation criteria of lake wetland ecosystem, and finally puts forward the strategies to improve the lake wetland water resources ecosystem [11].

2. Water resources carrying capacity

2.1. Connotation of water resources carrying capacity

According to the definition of domestic water resources carrying capacity, water resources carrying capacity is generally represented by population scale or economic scale. Although the final forms are different, the concept of supporting capacity is emphasized. Some scholars believe that the water resources carrying capacity refers to the water resources in a specific area [12]. At a certain stage of social history and scientific and technological development, the largest carrying capacity of agriculture, industry, urban scale and population capacity is a comprehensive goal changing with the development of society, economy, science and technology without destroying the society and ecosystem. Other scholars define the water resources carrying capacity as follows: in a specific area, under a certain living standard and a certain ecological environment quality, the water obtained from natural water resources can support the coordinated development of population, environment and economy, or the limit, which can be measured by three indicators: available water quantity, regional population quantity and economic growth limit [13].

2.2. Calculation formula of water resources bearing capacity

2.2.1. Population carrying capacity of water resources

The concept of population carrying capacity of water resources is the population that the regional water resources can carry under the existing water supply capacity. The calculation formula is as follows:

$$C_t = \frac{\varepsilon W_r}{W_P} \tag{1}$$

2.2.2. GDP water resources carrying capacity

The bearing capacity of GDP water resources reflects the bearing level of regional water resources to the overall economic activities in the region [14]. The bearing capacity of water resources GDP can be calculated by the following formula:

$$C_{\text{GDP}} = \frac{\varepsilon W_r}{W_{\text{GDP}}} \tag{2}$$

3. DPSIR model

DPSIR model (driving force pressure state impact response) evolved from PSR model. It links the causality among the five categories within the framework, and is used to analyze and evaluate the social and ecological problems caused by human actions in aquatic ecosystem [15,16]. To a certain extent, it can deeply analyze the causality between human and environment.

3.1. Constructing index system

The lake wetland in tourist area is mainly affected by social economy, water resources and social system. Therefore, based on the principles of scientificity, coordination, systematization and functionality, this paper selects the relevant indicators that affect the water environment carrying capacity of lake wetland in tourism area according to DPSIR model, and establishes the evaluation index system of water environment carrying capacity of lake wetland in combination with ecological environment indicators and water quality measurement indicators [17].

3.2. Weight determination

Different rating indicators have different degrees of importance. In order to quantify the importance of each indicator, the weight of each indicator should be determined. The commonly used weight determination methods are analytic hierarchy process, Delphi method and entropy method. In order to avoid the subjective influence of weight, we should choose the objective weight method entropy method [18]. Table 1 shows the calculation classification standard of water environment bearing capacity.

4. Water resources carrying capacity and water ecosystem

4.1. Factors affecting water resources carrying capacity

Because of the different dimensions of indicators, it is difficult to compare, so use SPSS17.0 to standardize all indicators. The total score of water environment carrying capacity of each lake wetland is obtained by the product of weight value of each index and data normalization value, namely:

$$Y = \sum_{i=1}^{n} W_i P_i \tag{3}$$

where W_i is the weight value of the ith index, P_i is the normalized value of the ith index [19].

The analysis of weight value of each index is shown in Fig. 1.

From Fig. 1 it can be seen that the factors influencing the water resource bearing capacity in the driving force are the surface water resource quantity, with the weight value of 0.0367, the per capita water consumption weight value of 0.0369 in the criterion layer, the do weight value of 0.0450 in the state value, the air quality excellent rate weight value of 0.0400 in the criterion layer, and the sewage treatment recycling amount weight value of 0.0539 in the response,

Table 1
Classification standard of water environment bearing capacity

Grade	Score
Good load	0.8–1.0
Basically bearable	0.5–0.8
Weakly bearable	0.2–0.5
Not bearable	0–0.02

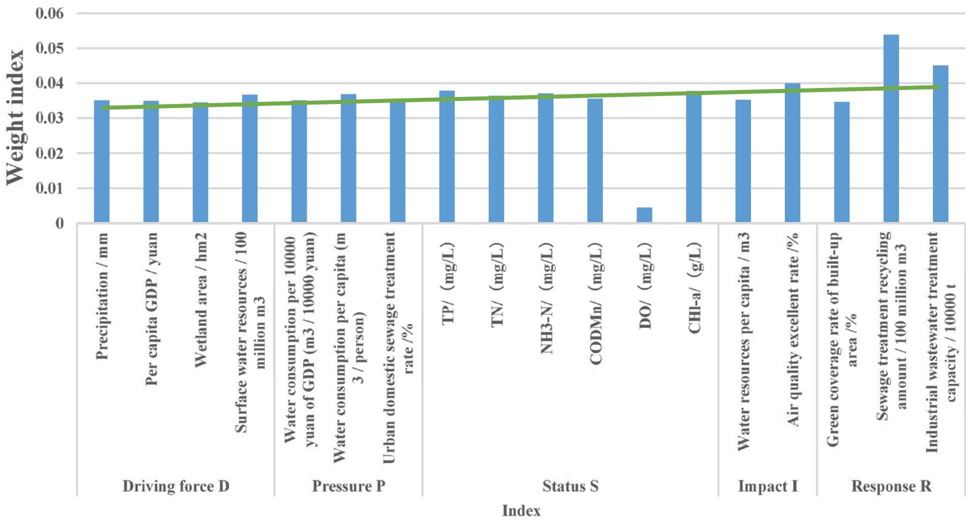

Fig. 1. Water environment bearing capacity index and weight.

while the criterion layer has the largest weight value of 0.0539. The weight of the layer is: state (0.2298) > driving force (0.1413) > response (0.1337) > pressure (0.1071) > impact (0.0753). The comprehensive weight of the state subsystem is the largest, indicating that the water quality of the lake wetland has the greatest impact on the water environment carrying capacity [20]. In summary, the above factors affecting the water resources carrying capacity of tourism lake wetland are divided into the following three categories:

4.1.1. Water resources ecosystem

Water resources system is the support of water resources carrying capacity, and regional water resources are generated and maintained by water cycle. The size of regional water resources is undoubtedly the most important factor to determine their carrying capacity. The available quantity of water resources is the maximum available quantity for the rational development of water resources. Rational development refers to the development and utilization of water resources to make water resources renewable and replenished in the natural hydrological cycle, without affecting the formation and occurrence conditions of water resources. At the same time, it is necessary to ensure that the impact on the ecological environment is controlled within a certain range to prevent the damage to the ecological environment caused by the development and utilization of water resources.

4.1.2. Social system

The direct consumption of water resources by the population in the social system, that is to say, the size of domestic water is affected by the number, structure and dynamic changes of the population, as well as the social system, policies and regulations, water-saving awareness, development level and other factors. At present, the calculation of domestic water mostly adopts the product of regional per capita comprehensive water quota and population. The factors affecting domestic water use, except for the population, are all reflected by water quota. The characteristics of population, such as gender, age, occupation, nationality, population growth and population quality, are the main characteristics of regional population and also the important influencing factors of regional economic development. From the perspective of water resources utilization, these characteristics are also the decisive factors that affect the size of the regional population's domestic water quota, and determine the size of the population's water consumption.

4.1.3. Economic system

The economic system is the main body of water resources support. In the economic system, not only all water demand activities have an impact on water resources carrying capacity, but also the change of economic activities on water quality will affect the carrying capacity of water resources.

4.2. Evaluation index system and standard of lake wetland ecosystem

Guided by the principles of system integrity, combination of dynamic index and static index, and combination of qualitative index and quantitative index, based on the analysis of composition, structure and functional characteristics of lake wetland ecosystem and relevant external social and economic data of wetland, and according to the availability and operability of index, six evaluation indexes are finally selected. The index system of lake wetland ecosystem health evaluation was constructed.

The sub index of wetland composition structure characteristics:

- Water quality: reflect the hydrological characteristics of wetland system from the quality level.
- Species diversity: measured by the number of species in wetland ecosystem.
- Tourism function: measured by the value of landscape

aesthetics and the total annual income of lake and wetland tourism.
- Standard rate of sewage treatment: it is also an indicator of social resilience of wetland system.
- Population density: it reflects the population pressure index of the lake wetland system, and reflects the external pressure on the wetland system through the population maintained by the wetland system.
- Wetland protection degree: it reflects the awareness of human wetland protection and the scientific management of lake wetland. It is measured by the proportion of the protected wetland area to the total wetland area.

In this paper, lake wetland ecosystem health assessment indicators are divided into four levels. See Table 2 for specific index grading standards.

As can be seen from Table 2, each indicator is divided into four levels. Each level corresponds to different values, such as species diversity. If the number of species is greater than 1,500, it means that the species indicator in this area is healthy. If the number is less than 500, it means that the species indicator in this area is in disease status.

The level of fuzzy comprehensive evaluation of lake wetland ecosystem health is not strictly divided, and it is difficult to describe with accurate scale. Therefore, the multi-level fuzzy comprehensive evaluation model is used to evaluate the health of Nansihu lake wetland system. Combined with the above assessment index system of wetland health in Nansihu Lake, two-level fuzzy comprehensive assessment is adopted for assessment. The model is as follows:

$$B = A \times R = A \times \begin{bmatrix} B_1 \\ B_3 \\ B_3 \end{bmatrix} = A \begin{bmatrix} A_1 & \bullet & R_1 \\ A_2 & \bullet & R_2 \\ A_3 & \bullet & R_3 \end{bmatrix}$$

$$W = B \times C^T \tag{4}$$

Among them, A_1 is the weight vector of sub category I index, a is the weight vector between sub category indexes, R_1 is the single factor fuzzy membership evaluation matrix of sub category I index relative to comments, R is the evaluation matrix between sub category indexes, B_1 is the evaluation result of sub category I index, B is the final comprehensive evaluation result between sub categories; W is the comprehensive evaluation score, In this paper, the health degree of lake wetland ecosystem is expressed, C is the rating vector of the comment, and C^T is the transposition matrix of C. In this paper, the evaluation is divided into two levels. First, the second level evaluation is carried out for the three sub categories, and then a comprehensive evaluation is made between the sub categories.

4.3. Sustainable utilization of lake wetland tourism water resources

By analyzing the factors that affect the water resources carrying capacity and ecosystem of lake wetland, this paper puts forward countermeasures for sustainable development of lake wetland tourism water resources, as shown in Fig. 2.

It can be seen from Fig. 2 that this paper puts forward the following suggestions for the sustainable development of Lake Wetland Tourism Water Resources:

4.3.1. Strengthen sewage treatment in tourism industry, accounting for 25.7%

Strengthen the environmental management of the scenic spot, guide the basin tourism development activities to be centralized in the "basin ecotourism development corridor" and "ecotourism development environment control area", and other environmental functional areas should not carry out high-intensity tourism development activities. Control point source pollution. Construction projects that may cause water pollution are forbidden to be built, rebuilt or expanded in the scenic area. Existing water pollution sources shall be treated and discharged within a time limit. Projects that are difficult to be treated and discharged within a time limit shall be removed or closed within a time limit. We will clean up and rectify sources of pollution in the tourism industry and prevent and control unorganized emissions. Clean up and rectify the existing unorganized food stalls along the lake and wetland, control the development scale of catering and hotel industry, and make a reasonable layout so as to facilitate the centralized treatment of tourism sewage.

4.3.2. Promote the concept of low-carbon leisure tourism, 13.2%

Wetland tourism is a kind of ecological leisure tourism, and low-carbon tourism is the further upgrading of eco-tourism, which has a more specific goal than eco-tourism: to reduce carbon emissions, which fundamentally determines the possibility of low-carbon tourism quantification. Therefore, low-carbon tourism is an inevitable choice for sustainable development of wetland tourism.

Table 2
Quantitative standard of lake wetland ecosystem health assessment index

Health comments	Very healthy	Healthy	Sub-health	Disease
Water quality	I, II class	III class	IV class	V class
Species diversity	>1,500	1,000–1,500	500–1,000	<500
Tourism function	>100,000 × 10^3	60,000–80,000 × 10^3	40,000–60,000 × 10^3	<40,000 × 10^3
Sewage treatment rate > 80%		50%–80%	20%–50%	<20%
Population density	<100	100–200	200–300	>300
Wetland protection rate > 80%		50%–80%	20%–50%	<20%

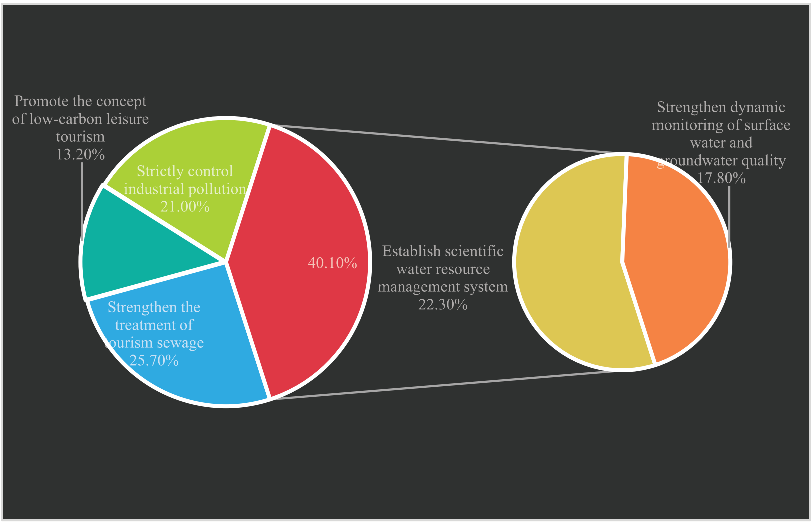

Fig. 2. Sustainable utilization of lake wetland tourism water resources.

4.3.3. Strictly control industrial pollution, accounting for 21.0%

The industrial pollution source is the main factor of the surface water pollution, which is heavy and difficult to control. The measures to be taken are as follows: to reduce the amount of pollution discharge by adjusting the industrial layout and industrial structure of the whole county, to shut down the enterprises with serious pollution, to limit the construction of projects with large amount of pollution discharge, and to guide the industry to develop in the direction of protecting ecology and environment: the main water consuming enterprises must build sewage treatment facilities to ensure that the sewage can reach the discharge standard; At the same time, they should actively promote clean production process and improve the rate of water resources reuse, Strengthen the comprehensive utilization of water resources.

4.3.4. Establish scientific water resource management system, accounting for 22.3%

First, the comprehensive planning of water resources should be done well. On the premise of ensuring the sustainable utilization of water resources, the comprehensive planning of water resources and other relevant plans should be formulated to ensure the balance of water supply and demand. Secondly, the scientific distribution of water rights is the key to the optimal allocation of water resources.

4.3.5. Strengthen the dynamic monitoring of surface water and groundwater quality, accounting for 17.8%

In order to ensure the quality of water entering the lake, according to the actual situation of the rivers along the water supply line, establish monitoring points for the surface water environment quality around the lake wetland, install automatic water quality monitoring instruments in some river sections with serious pollution and large flow into the lake for all day monitoring; In order to ensure the gradual improvement of the water quality of the rivers along the water supply line and the water quality of the lake reservoir, it is necessary to ensure that the pollution sources meet the discharge standards, It is necessary to establish a monitoring station at the sewage discharge outlet of the unit to form a monitoring network of key pollution sources; Set up an automatic monitoring device at the sewage discharge outlet of the river and the sewage discharge outlet of the key industrial pollution sources to form a monitoring network, which is under the unified dispatching and management of the municipal environmental monitoring station, formulate an early warning plan for water pollution accidents, timely reflect the water quality status, and prevent the occurrence of water pollution events; Through the water quality monitoring, pollution source monitoring, river mouth monitoring, environmental comprehensive investigation and physical characteristics investigation of rivers, lakes and reservoirs, an accurate, continuous and high-quality environmental and disaster monitoring data management system along the water transfer line in the territory is established, and the water quality and pollution prediction research is carried out.

5. Conclusions

Water resources carrying capacity is a scientific proposition which starts from the practical problems and serves for the practice of water resources management. In the new historical period when water resources problems and governance concepts have changed profoundly in China, the research on water resources carrying capacity must be problem-based. The water environment carrying capacity level of lake wetland can reflect the overall development level of the city, and also contribute to the further development of the city. Therefore, we must pay full attention to and strengthen the water environment carrying capacity of lake wetland to promote sustainable economic development and urban environment construction.

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