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Research on the Realization of the Ecological Product Value of Wetland Parks based on the Environmental Replacement Cost Method

-- Taking Nanjing Yuzui Wetland Park as an Example

Ruobingxue Yu[a], Wanwan Guo[b], and Ming Chen[c]

School of Nanjing Normal University, Nanjing 210000, China

[a]2992253504@qq.com, [b]2219623843@qq.com, [c]chenming.1008@163.com

Abstract

Establishing a sound and scientific mechanism for realizing the value of ecological products is a key factor in protecting the "kidney of the earth" and continuously improving the ecological quality and function of wetlands. Based on the environmental replacement cost method, this paper takes the Nanjing Yuzui Wetland Park as an example to construct a research and measurement model for realizing the value of ecological products in wetland parks. The environmental replacement cost of the wetland park is measured from the ecological restoration layer, ecological maintenance layer, and ecological strategic layer. By comparing the environmental replacement cost with income accounting, the following conclusions were drawn: (1) the ecological product value of Nanjing Yuzui Wetland Park has not been fully realized under the current economic model; (2) the measurement model constructed in this paper proves the operability and feasibility of the environmental replacement cost method, providing a scientific basis for the evaluation of the ecological product value of wetland parks; (3) this paper reveals the ecological functions of wetland parks in maintaining biodiversity, purifying water quality, and sequestering carbon and releasing oxygen.

Keywords

Ecological Product Value; Wetland Park; Environmental Replacement Cost Method.

1. Introduction

This study focuses on the realization of the ecological product value of wetland parks. As an important ecological resource, wetland parks have diverse forms and functions at home and abroad. Foreign wetland parks are mainly divided into three categories: sewage treatment, tourism and education, and ecological restoration and species diversity protection. For the study of the ecological product value of wetland parks, foreign research mainly uses economic assessment methods and ecosystem service assessment to systematically assess the ecological product value of wetland parks. Domestic research focuses on the economic benefits of ecotourism in wetland parks, ecological functions such as water resource regulation and water purification, and the production and utilization of ecological products, with the aim of exploring the potential economic value and sustainability of wetland parks. In addition, domestic scholars have also conducted some research on the realization path of wetland ecological product value, ecological product value accounting, and ecological product value assessment methods. However, the current academic community's research on the comprehensive evaluation of the value of ecological products in wetland parks and the path to their realization is still insufficient, especially the systematic research under the environmental replacement cost method is rare. This study selected the Yuzui Wetland Park in Nanjing, Jiangsu Province as a case study. The

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park integrates historical, ecological, economic, social and cultural values. Its landscape design and plant diversity have been studied in depth by scholars, but research on the realization of the value of ecological products is still in its infancy.

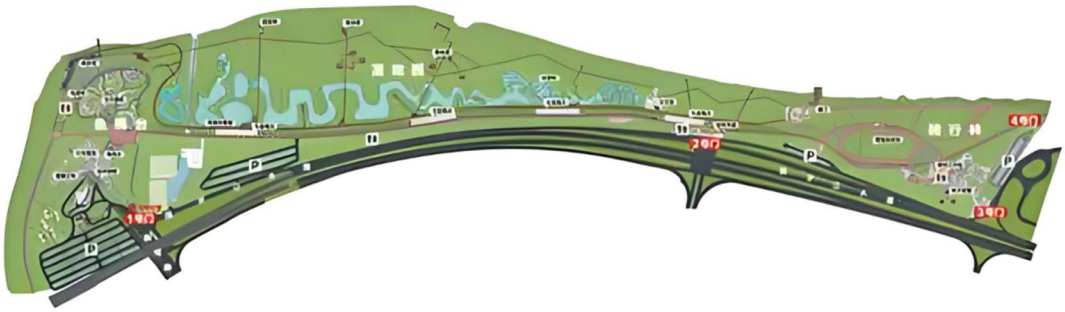

Figure1. Map of Yuzui Wetland Park

At present, the commonly used methods for measuring the value of ecological products at home and abroad mainly include the market price method, the replacement cost method, the hypothetical market method, and the ecological assessment method. Traditional methods for assessing the value of ecological products tend to focus on direct economic value and ignore the cultural, ecological, and genetic resource value of wetlands. The environmental replacement cost method is an innovative assessment method that estimates the replacement cost of environmental resources to assess their value. It can more accurately reflect the true value of environmental resources, take into account their dynamic changes and future value, and effectively make up for the shortcomings of traditional assessment methods. This study aims to conduct an in-depth analysis of the ecological product value of the Yuzui Wetland Park through the environmental replacement cost method, explore the possibility of realizing its ecological product value, and construct an evaluation model suitable for realizing the ecological product value of the wetland park. The purpose of the study is not only to verify the operability and feasibility of the environmental replacement cost method, but also to promote the sustainable development of the wetland park, realize the transformation of ecological advantages into economic advantages, provide detailed rectification plans for the operation and management of the wetland park, help realize and add value to the ecological product value, practice sustainable development strategies, and achieve a win-win situation for ecology and economy.

2. Methods and Materials

2.1. Principle of Environmental Replacement Cost Method

The environmental replacement cost method is a method for comprehensively assessing the cost of restoring an ecosystem after it has been damaged. This method not only focuses on the physical restoration of the ecosystem, but also takes into account the need for long-term maintenance and protection, as well as the development opportunities that have been foregone in order to protect the ecosystem. The environmental replacement cost method divides the measurement of the value of ecological products into three levels of cost: restoration, maintenance, and strategy.

The restoration costs are the costs of the technical measures and measures taken to restore the damaged ecosystem to its original state. The maintenance costs are the costs of the continuous maintenance work that must be carried out to maintain the function and health of the ecosystem after it has been restored. The strategic costs are more related to the macro-level decisions and sacrifices made to protect the ecosystem.

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By assessing potential environmental damage and the corresponding replacement costs, policymakers and the public can be made more aware of environmental protection and take effective measures to avoid environmental damage.

2.2. Steps of Environmental Replacement Cost Method

2.2.1. Ecological Restoration Layer Cost

The cost of ecological restoration of the wetland park refers to the total cost of various technical methods and means actually used in the process of restoring or re-acquiring the wetland park to its original (ideal) state in accordance with the ecological service functions of the wetland park before it was damaged. According to the relevant laws and regulations such as *the Environmental Protection Law of the People's Republic of China* and *the Technical Specification for National Ecological Status Survey* and *Assessment - Assessment of Ecosystem Service Functions* issued by the Ministry of Ecology and Environment of China in 2021, this paper selects several key on-site park ecosystem service function evaluation indicators.

(1)Water purification

This paper selects water conservation capacity U_w as the evaluation index, and uses R_w to measure the value of restoration after damage. The total amount of conservation is measured by the amount of precipitation stored.

$$U_w = 10S \times (P - E - Q) \tag{1}$$

$$R_w = U_w \times R \tag{2}$$

$U_w\,(m^3/a)$ represents annual regulated water volume; $R_w\,(yuan/a)$ represents annual regulated water volume value; $S\,(hm^2)$ represents wetland area; $P(mm)$ represents precipitation; $E(mm)$: represents average evapotranspiration of the wetland; $Q(mm)$ represents Wetland surface rapid net flow; $R(yuan/m^3)$ represents price of tap water;

(2)Carbon sequestration and oxygen release

This article selects U_{CO_2} (the amount of carbon fixed) and U_{O_2} (the amount of oxygen released) as a measure of this function. According to the formula for photosynthesis: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ can be obtained that plants fix 1.63 grams of carbon dioxide and release 1.19 grams of oxygen for every gram of dry matter produced. Thus, the formula is:

$$U_{CO_2} = 1.63C_t \times S \times N \tag{3}$$

$$U_{O_2} = 1.19 \times S \times N \tag{4}$$

$$R_{CO_2} = F_{CO_2} \times P_{CO_2} \tag{5}$$

$$R_{O_2} = F_{O_2} \times P_{O_2} \tag{6}$$

$U_{CO_2}, U_{O_2}\,(t/a)$ represents the annual amount of carbon dioxide diluted and oxygen released by the wetland park; $R_{CO_2}, R_{O_2}\,(yuan/a)$ represents the value of fixed carbon dioxide and released oxygen; C_t represents the carbon content in carbon dioxide, the content is 27.27%; $S\,(t/hm^2)$

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represents the wetland area, $N(t/hm^2)$ represents the net productivity of the forest; $P_{CO_2}, P_{O_2}(yuan/t)$ represents the price of carbon sequestration, oxygen respectively.

In summary, the total value of the restoration layer cost of the wetland park is:

$$R = R_w + R_{CO_2} + R_{O_2} \tag{7}$$

2.2.2. Ecological Maintenance Layer Cost

The maintenance layer cost of the wetland park is the cost of restoring the condition to its original state by artificial means and continuing to maintain it. Over time, some landscape relics will oxidize and be eroded by rain, etc., at which time human intervention will be required to maintain them to a certain extent. The value of ecological maintenance layer cost is :

$$M = M_y + M_j + M_h \tag{8}$$

M_y is the cost of maintaining tourism resources, M_j is the cost of maintaining landscape art, M_h is the cost of maintaining the ecological environment. All units are yuan.

2.2.3. Ecological Strategic Layer Cost

The measurement of strategic cost is conducive to a deeper understanding of the potential value of ecological resources. The strategic cost adopts the opportunity cost method. In terms of ecology, opportunity cost is considered to be the economic income forgone by the provider of ecosystem services in favor of the protection of natural assets. In order to estimate the strategic cost of the wetland park, this paper refers to the research conclusions of Ma Hongwei (2014) and uses the per capita disposable income of urban residents and the per capita disposable income of residents as a reference. The calculation formula is:

$$S = (L_1 - B_1) \times H + (L_2 - B_2) \times H \tag{9}$$

S represents opportunity cost; L_1 represents the national per capita disposable income of urban residents; L_2 represents the national per capita income of rural residents; B_1 represents the per capita disposable income of urban residents in the study area; B_2 represents the per capita income of rural residents in the study area; H represents the population of the study area.

Table 1. Three-tier cost measurement composition table for the ecological product value of the wetland park

Cost type	Specific classification	Itemized
Ecological restoration layer(R)	Water purification	Annual regulated of water volume value(R_w)
	Carbon sequestration and oxygen release	CO_2 absorption value(R_{CO_2})
		O_2 release value(R_{O_2})
Ecological maintenance layer(M)	Maintenance of tourism resources	Cost of maintaining tourism resources(M_y)
	Landscape art maintenance	Cost of maintaining landscape art(M_j)
	Ecological environment maintenance	Cost of maintaining the ecological environment(M_h)
Ecological strategic layer(S)	Strategic cost	Opportunity cost(S)
Sum(Z)	$Z = R + M + S$	

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2.3. Data Source

The data used in this thesis comes from the information disclosure of Nanjing Binjiang Park Management Co. from 2020 to 2023. The above detailed records of Nanjing Binjiang Park's main accounting data and financial indicators, as well as the implementation of the annual financial budget and production and operation.

3. Results and Discussion

3.1. Evaluation Findings of Environmental Replacement Cost Method

After calculating the total cost of ecological products in Nanjing Yuzui Wetland Park in 2023, it is compared with the comprehensive income of Nanjing Yuzui Wetland Park to determine whether the value of ecological products has been realized.

As a 4A-level tourist attraction, the main source of economic income for Nanjing Yuzui Wetland Park is the tourism-related income brought by tourists, such as comprehensive expenses for scenic area tickets, food and beverage, transportation, and entertainment. Therefore, the degree of realization of the value of ecological products in Nanjing Yuzui Wetland Park is measured by the tourism revenue brought by the scenic area. According to the public information of Nanjing Binjiang Park Management Co., Ltd., the total operating income of the company in 2023 was 121 million yuan, an increase of 14 million yuan over the previous year's 107 million yuan, an increase of 13.08%. Compared with the cost of ecological products, there is a large gap, and the value is not realized.

Table 2. Financial data of Nanjing Binjiang Park Management Co.
(Unit: 10,000 yuan)

Numble	Revenues	Operating Profits	Net Profits
2020	15094.87	398.20	341.83
2021	14888.13	599.95	451.39
2022	10737.02	936.03	32.94
2023	12100.00	800.00	600.00

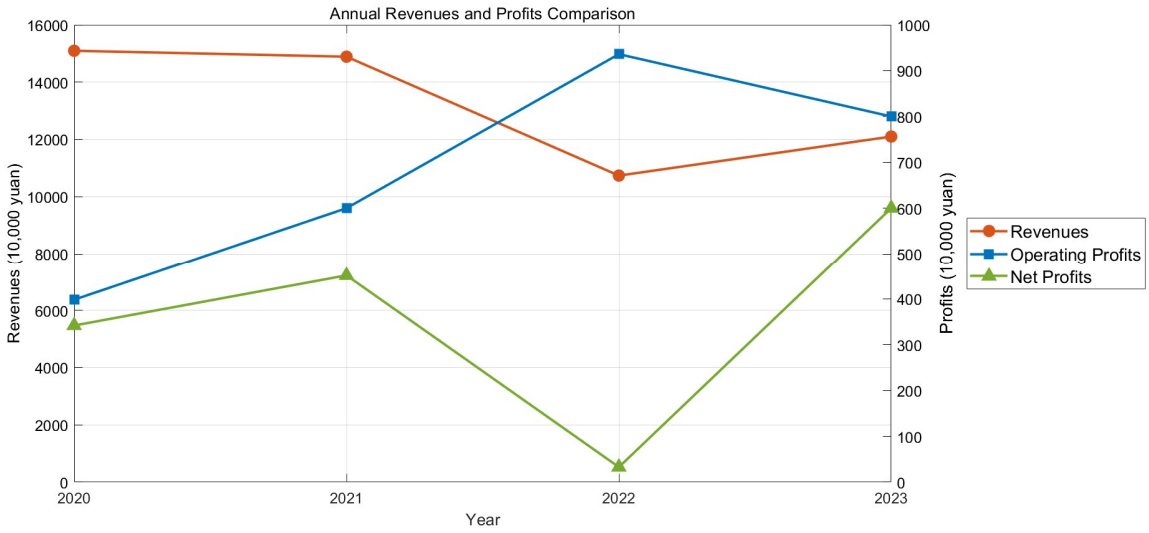

Figure 2. Trend chart of financial data of Nanjing Binjiang Park Management Co.

Although the operating income of Nanjing Binjiang Park Management Co., Ltd. has been on the rise in recent years, it totaled 65.6053 million yuan in the first half of 2024, an increase of

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3.5108 million yuan over the 62.0945 million yuan of the same period last year, an increase of 5.65%. The total operating income for the whole year of 2023 was 121 million yuan, an increase of 14 million yuan over the 107 million yuan of the previous year, an increase of 13.08%. However, the increase is relatively slow, and the gap with the actual cost still exists, which is still not enough to cover the cost of ecological products calculated in the early stage. Moreover, Nanjing Binjiang Park Management Co., Ltd. is responsible for the operation and management of tourism services and green spaces in the eight parks in Hexi District. The ecological product value of Nanjing Yuzui Wetland Park is only a small part of it and cannot be measured separately.

According to the field survey, the park has not been fully developed. In addition to the green space squares at the two ends, there is only one greenway in the middle for visitors to walk on. The infrastructure is not perfect and there is no profit point. At the same time, considering that Nanjing Yuzui Wetland Park is an open park that does not charge admission fees and only relies on retail shops in the park to make a profit, it is obviously impossible to realize its ecological product value.

Therefore, it can be concluded that the ecological product value of Nanjing Yuzui Wetland Park has not been realized so far.

3.2. Discussion on the Innovation of the Manuscript

In terms of research subjects, current research on wetland parks is mainly conducted from the perspectives of biodiversity and wetland landscape, and the subjects of most of the research are confined to general ecological protection. There are very few research results based on the value of ecological products, and there are even fewer studies on the measurement of the value of ecological products. In the face of these problems, this paper classifies the forms of ecological product value in Yuzui Wetland Park, sorts and calculates the replacement cost at different levels, and finally obtains the ecological product value of Yuzui Wetland Park.

In terms of research perspective, previous scholars' researches on wetland parks often focused on the biodiversity, pollutant characteristics, ecological restoration, of wetland parks,etc. Although they all have their own unique research perspectives, they have neglected the ecological product value of wetland parks. This paper puts the research perspective on the realization of the ecological value of wetland parks, and takes Nanjing Yuzui Wetland Park as an example to analyze the realization path of the ecological product value of the whole wetland park from a macro perspective, and also has a specific case analysis.

In terms of the measurement method,there is also a lack of scientific and effective, easy-to-popularize, systematic measurement methods for the value of ecological products. The lack of measurement methods is not conducive to the development of wetland parks and the realization of the value of ecological products. This paper considers the restoration of the ecological environment from the perspective of its function, improves the research method, and measures the actual cost of restoring and maintaining the ecological environment once it has been damaged. It is somewhat innovative.

4. Conclusion

The main findings of this paper are as follows:

(1) The ecological product value of Nanjing Yuzui Wetland Park has not been fully realized under the current economic model. Although the operating income of Nanjing Binjiang Park Management Co., Ltd. has continued to grow in recent years, the increase is still insufficient to cover the cost of ecological products, especially when no admission fees are charged and the park mainly relies on retail shops for profits, the ability to realize the value of ecological products is limited.

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(2) The environmental replacement cost method, as a scientific method for evaluating the value of ecological products, can more comprehensively reflect the true value of the ecological products of the wetland park by measuring the costs of the restoration layer, maintenance layer and strategic layer. The measurement model constructed in this study proves the operability and feasibility of this method and provides a scientific basis for evaluating the value of ecological products in wetland parks.

(3) This study not only focuses on the direct economic value of the wetland park, but also fully considers its ecological and cultural value. Through multi-level cost analysis, we reveal the ecological functions of the wetland park in maintaining biodiversity, purifying water quality, and sequestering carbon and releasing oxygen, as well as its cultural value in history, culture, and urban development.

In summary, this study not only reveals the current situation of the ecological product value of Nanjing Yuzui Wetland Park, but also provides practical suggestions for its future sustainable development. We hope that the results of this study will attract the attention of more scholars and decision-makers to the ecological product value of wetland parks and jointly promote the protection and development of wetland parks.

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