

Ecosystem Service Value Assessment of Aha Lake National Wetland Park in Guiyang City, 2017

Rong Li^{1,2*}

¹ School of Karst Science, Guizhou Normal University, Guiyang, China

² State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University, Guiyang, China

Email Address

1121555372@qq.com (Rong Li)

*Correspondence: 1121555372@qq.com

Received: 5 July 2025; **Accepted:** 9 August 2025; **Published:** 20 August 2025

Abstract:

National wetland parks are an important part of China's wetland conservation system, and the assessment of their ecosystem service value not only helps to enhance the public's awareness of wetland conservation, but also provides a scientific It can also provide scientific decision-making basis for the construction and management of wetland parks. This paper takes Aha Lake National Wetland Park in Guiyang City as the research object, and quantitatively evaluates the value of its ecosystem services in 2017 based on the methods of market value method, alternative engineering method and shadow price method. The results showed that the total value of ecosystem services of this wetland park was 650,877,000 CNY/year, of which the highest value was for regulating services (644,192,600 CNY/year), the second highest was for supporting services (440,0000 CNY/year), and the lowest was for cultural services (2,215,100 CNY/year). Among the sub-functions, flood storage, maintenance of biodiversity and recreation were the major contributors to each category, respectively. The study suggests that in the construction of wetland parks, hydropower should be rationally developed, flood storage function should be maintained, wildlife habitat protection should be strengthened, and scientific research and tourism and recreation potentials should be fully explored in order to achieve a win-win situation in the coordination between economic development and ecological protection, which provides a quantifiable reference basis for the value assessment and management of urban wetlands..

Keywords:

National Wetland Parks, Ecosystem Services, Value Assessment, Wetland Conservation

1. Introduction

Wetlands are one of the most important ecosystems on which human beings depend for their survival and are known as the “kidneys of the earth”, “air humidifiers” and “biological supermarkets”. Rivers, lakes, ponds, marshes, coastal salt marshes and

man-made canals and reservoirs are all part of wetlands. Wetlands provide direct or indirect benefits to people with their rich ecological functions. People and wetlands have truly formed a community of destiny and a symbiotic relationship that is closely dependent on each other [1]. Globally, wetlands contribute to climate regulation, water purification, flood mitigation, shoreline protection, nutrient cycling, and biodiversity conservation, while also serving as critical habitats for numerous rare and endangered species. According to the Ramsar Convention on Wetlands (2021), approximately 35% of global wetlands have been lost since 1970, primarily due to anthropogenic disturbances such as urban expansion, agricultural intensification, and infrastructure development. This degradation has severely reduced the capacity of wetlands to deliver ecosystem services, thereby threatening both ecological integrity and human well-being. February 2, 2024 is the 28th World Wetlands Day in the world, and the theme of the day is “Wetlands and Human Well-being”, which is aimed at highlighting the importance of wetlands to the survival and development of human beings, and to call on the whole society to understand the wetlands, recognize the wetlands, protect the wetlands, and protect the wetlands. It also calls on the whole society to understand wetlands, recognize wetlands and protect wetlands. Wetlands are one of the three major ecosystems on earth, together with oceans and forests, and have made important contributions to the economic and social development of mankind. Due to the influence of climate change, water pollution and unreasonable human activities (agricultural irrigation, lake reclamation), wetlands are dying out at an accelerated rate globally. The destruction of wetlands will disturb the natural ecological balance, increase the emission of greenhouse gases, and then amplify the destructive nature of droughts and floods and other meteorological disasters, posing a serious threat to the survival and development of human beings [2]. Therefore, it is especially important to have a correct understanding of the wetland ecosystem and to make a scientific assessment of its service value, and then to develop and utilize or restore it in a reasonable way [3].

Ecosystem services refer to the various service benefits that people obtain from ecosystems (including natural and anthropogenically modified ecosystems), and direct, indirect, tangible and intangible benefits should be regarded as ecosystem services, which can be classified into four major categories of regulating, cultural, provisioning, and supporting services according to the differences in the types of services [4,5]. Currently, scholars at home and abroad mostly use the market value method, alternative engineering method and shadow price method to assess the value of ecosystem services [6,7]. These monetized valuation methods intuitively reveal the contribution of ecosystems to human interests and help promote ecological protection and management. In this context, this paper chooses Aha Lake National Wetland Park, which is located in the central area of the city and has diverse ecological functions, as the research object, aiming to quantify the value of its ecosystem services, and to provide a scientific basis for the protection and rational utilization of urban wetlands [8].

In recent decades, wetland conservation and restoration have gained increasing attention from the scientific community, policy-makers, and the public. Numerous valuation studies have been conducted worldwide, using diverse approaches such as contingent valuation, benefit transfer, and market-based methods to quantify the ecological and economic contributions of wetlands. These assessments have demonstrated that the monetary value of wetland ecosystem services often exceeds that of alternative land uses, thereby providing strong economic justification for their

protection. For instance, the Everglades in the United States and the Okavango Delta in Botswana have been extensively studied to evaluate their carbon sequestration capacity, hydrological regulation, and recreational value. However, regional differences in ecological characteristics and socio-economic contexts mean that localized assessments remain essential for informing effective management strategies.

In China, wetlands cover approximately 5.6% of the national territory and are recognized as a vital component of the country's ecological security system. Over the past two decades, the Chinese government has enacted a series of wetland conservation policies, including the establishment of national wetland parks, restoration programs, and strict land-use regulations. These measures have contributed to slowing wetland loss and enhancing ecological resilience. Nevertheless, pressures from rapid urbanization, industrial pollution, and climate variability continue to pose significant challenges to wetland conservation. As part of the country's ecological civilization initiative, there is an urgent need for comprehensive, site-specific evaluations that integrate ecological and economic perspectives.

Aha Lake National Wetland Park, located in Guiyang, Guizhou Province, represents an important freshwater wetland in southwest China. The Park serves multiple ecological functions, including flood regulation, water quality improvement, climate moderation, and habitat provision for aquatic and terrestrial species. In addition, it holds cultural and educational significance for the surrounding communities, offering opportunities for recreation, environmental education, and ecotourism. While existing studies on Aha Lake have focused on hydrology, biodiversity, and vegetation dynamics, relatively few have systematically quantified the total ecosystem service value (ESV) of the Park using integrated valuation approaches.

To address this research gap, the present study employs a combination of the market value method, the equivalent factor method, and the carbon tax method to estimate the ESV of Aha Lake National Wetland Park for the year 2017. This comprehensive assessment not only quantifies the contributions of different ecosystem service categories—such as regulating, supporting, and cultural services—but also identifies priority areas for management and policy intervention. By linking ecological functions to their corresponding economic values, the study provides a robust scientific basis for wetland conservation planning, sustainable resource utilization, and the development of ecosystem-based management strategies in southwest China and beyond.

2. Research Area and Methodology

2.1. Overview of the research area

Aha Lake National Wetland Park is located in the southwest of Guiyang city center, Guizhou Province (E106°37'03"~106°40'39", N26°30'38"~26°33'55") [9], with a total planning area of 1024.71hm², of which the wetland area is 473.93hm². Aha Lake National Wetland Park is a natural park. Aha Lake National Wetland Park is a natural park, and the main protection object is the reservoir pond-river composite wetland ecosystem; at the same time, because of its special location, it also carries the main function of providing urban leisure and green space and improving the urban taste. Aha Reservoir, the main water body of this wetland park, is a medium-sized reservoir mainly for urban water supply and flood control [9]. (Figure 1)

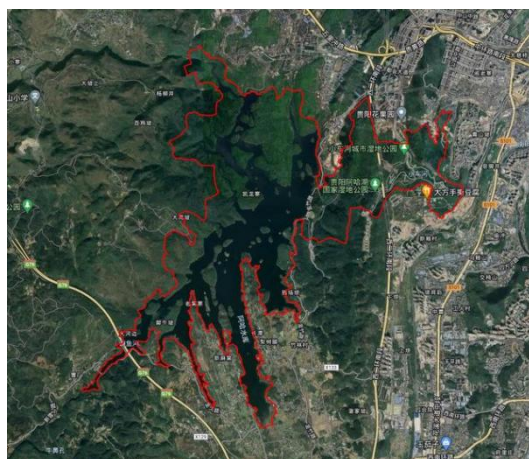


Figure 1. Lake Ahab Wetland Park (Photo credit: <https://baijiahao.baidu.com/s/>).

The existing wetland area of the park is 437.93 hm², accounting for 42.74% of the total area of the park, which is divided into three major wetland categories, namely riverine wetland, marsh wetland and artificial wetland, and five wetland types, namely permanent river, karst cave wetland, herbaceous marsh, reservoir pond wetland and paddy field wetland [10]. For animals, there are 497 species in 184 families, including 34 species of animals and 228 species of birds. Aha Lake National Wetland Park has a variety of habitats and rich biodiversity, with a woodland area of 559.38 hm², and 932 species of plants in 583 genera of 208 families have been identified, among which there are 3 species of wild plants of national second-class protection, 5 species of national first-class protection plants, 4 species of national second-class protection plants, and 1 species of bryophytes of new record in Guizhou Province [11].

2.2. Data Sources

The data used in this study were obtained from multiple sources to ensure accuracy and comprehensiveness. Hydrological and meteorological data for the year 2017 were collected from the Guiyang Hydrological Bureau and the Guiyang Meteorological Bureau, respectively. Land use and vegetation cover data were derived from high-resolution remote sensing imagery (Landsat 8 OLI/TIRS) and validated through field surveys conducted in the summer of 2017. Statistical data on agricultural production, aquaculture, and tourism were obtained from the Guiyang Statistical Yearbook and relevant government reports. Carbon price data were sourced from the China Certified Emission Reduction (CCER) market. In addition, literature data, including ecosystem service equivalent factors and valuation parameters, were obtained from national and international studies to enhance comparability with other research.

2.3. Evaluation index system and evaluation method

The valuation of ecosystem services in Aha Lake National Wetland Park was conducted following the classification framework proposed by the Millennium Ecosystem Assessment (MEA, 2005), which divides ecosystem services into four broad categories: provisioning, regulating, supporting, and cultural services. Given the ecological characteristics of the study area, this research focused on three categories—regulating, supporting, and cultural services—while provisioning services were excluded due to the minimal direct extraction of wetland products in the Park, and the ecosystem service value of Aha Lake National Wetland Park is classified into three categories of regulating function, supporting function, and cultural function

value with a total of nine items, in which the regulating service contains The regulating services include five categories, namely, climate regulation, water purification, flood storage, water conservation, and carbon sequestration and oxygen release; the cultural services include two categories, namely, recreation and scientific research values; and the supporting functions include two categories, maintaining biodiversity and providing habitats. Three complementary methods were used:

Market Value Method (MVM)-applied to services with well-defined market prices, such as tourism and aquaculture. Equivalent Factor Method (EFM)-used to estimate non-market services based on the standardized value per unit area, adjusted for local ecological conditions. Carbon Tax Method (CTM)-applied to quantify the economic value of carbon sequestration, using the carbon storage capacity of wetland vegetation and the prevailing carbon market price [6,7,12,13]. (Table 1)

Table 1. Valuation system for ecosystem services of Aha Lake Wetland Park.

Service Function Category	Function Type	Assessment Method
Regulatory function	Climate regulation	Alternative cost method
	Water purification	Cost analysis method
	Flood storage	Shadow price method
	Water conservation	Shadow price method
	Oxygen sequestration	Industrial Oxygen Production, Afforestation Cost Method
Cultural functions	Recreation	Travel cost approach
	Scientific research value	Outcome parameter approach
Support functions	Maintaining biodiversity	Opportunity cost approach
	Habitat provision	Market value approach

3. Results and Analysis

3.1. Regulation Function

3.1.1. Climate regulation

Guiyang belongs to subtropical monsoon humid climate, with plateau and monsoon climate characteristics, the average annual temperature is 15.3°C. In the subtropical region of China, the evaporation of lake water surface is generally 600~900mm, according to the characteristics of the Aha Lake Wetland Park area with no summer heat, the value of evaporation of water body is selected to be 600mm, and the water surface area of Aha Lake Wetland Park is 473.93hm², and the evaporation of Aha Lake Wetland Park is calculated to be 2.843636 million m³; the substitution cost refers to the cost needed to be spent in order to provide the same climate regulation service, assuming that artificial sprinkler irrigation is used to replace the evaporation of the water body, the cost of irrigation per cubic meter is about 0.5-0.83 CNY, so the calculation concludes that the climate regulation value of Aha Lake National Wetland Park is 1,421,800 CNY.

3.1.2. Carbon Sequestration and Oxygen Release

For every 1kg of plant dry matter produced, 1.62kg of CO₂ can be fixed and 1.20kg of O₂ can be released. China's Ministry of Finance suggests that the price of carbon tax in China is RMB 40 CNY/t; China's industrial cost of oxygen production is RMB 400 CNY/t. The area of forested land in Lake Ahabu National Wetland Park amounts to 559.38 hm², so the value of the carbon tax for sequestration of carbon in the

forested land of Lake Ahabu National Wetland Park is calculated to be 3.6248 million CNY/year, the value of oxygen release is 26.8522 million CNY/year, and the total value of carbon sequestration and oxygen release is 30.47 million CNY/year.

3.1.3. Flood storage

Flood storage function means that the wetland ecosystem has certain hydrological-physical attributes and has the function of water storage. Aha Reservoir in Aha Lake Wetland Park site has the ability of flood storage, with a total capacity of 86.58 million m³; normal water storage level of 1110m, the corresponding capacity of 54.2 million m³, the water surface area of Aha Reservoir is 4.5km², the average depth of water is 11m, after calculation, the Aha Reservoir can store water amounting to 049.5 million m³, by applying the shadow engineering method, the cost of the unit capacity of the reservoir is taken as 12.15 CNY/m³, the value of flood storage is calculated to be 601 million CNY.

3.1.4. Water Quality Purification

Water quality purification function refers to the process of ecosystem adsorption, transformation and other treatments for pollutants entering the water body so that the ecological function of the water body is partially or completely restored. Aha Lake National Wetland Park has a total of 473.93hm² of wetlands, and according to the relevant literature, the purification amount of wetland ecosystems for COD, total nitrogen, and total phosphorus is 110.43^{t/km²}, 8.56^{t/km²}, and 8.56^{t/km²}, respectively, and the cost of COD, total nitrogen, and total phosphorus treatment in the wetland ecosystems of Aha Lake is calculated to be 1,400 CNY/t, 1,750 CNY/t, and 2,800 CNY/t, respectively, which results in the cost of COD, total nitrogen, and total phosphorus treatment of Aha Lake, 2800 CNY/t, resulting in a value of 848,300 CNY for atmospheric purification of a city ecosystem.

3.1.5. Water conservation

The function of water conservation is that the ecosystem intercepts and stores precipitation through the forest canopy, dead wood layer, root system and soil layer, and enhances soil infiltration and accumulation, thus effectively storing soil moisture and replenishing groundwater. Aha Lake National Wetland Park has 559.38hm² of forested land, and the capacity of forests to store precipitation is about 100mm, equivalent to 1,000t/hm², which shows that the total amount of water stored in 559.38hm² of forested land is 560,000m³. Aha Lake National Wetland Park has a total of 473.93hm² of wetlands, and the volumetric water content of soil can be up to 60% or more, and the difference of the groundwater level is calculated according to 1m, which means that the amount of stored water is up to 1m. Calculated by 1m difference of groundwater level, its water source is 2,843,600m³, according to the current cost of the reservoir 3.071 CNY/m³, the water source of Aha Lake National Wetland Park is worth 10,452,500 CNY/year.

3.2. Cultural Functions

3.2.1. Recreation

Guiyang City in Guizhou Province is rich in ecotourism resources. According to the 2017 Guiyang City National Economic and Social Development Statistics Bulletin, Guiyang City received a total of about 148,365,900 domestic tourists in 2018.

Calculated on the basis of 15% of the total number of tourists in Guiyang City, the annual number of tourists received by Aha Lake National Wetland Park is expected to be approximately 22.255 million. According to the data center of the Ministry of Culture and Tourism, in 2017, the number of domestic tourists was 5.001 billion, and the total tourism input was 4.57 trillion CNY, and the per capita consumption of domestic tourism was 914 CNY, which calculates the value of recreation and entertainment function of Aha Lake National Wetland Park to be 2,034,100 CNY/year.

3.2.2. Scientific research value

According to the references and data, the average scientific research value of wetland ecosystem per unit area in China is 3,820 CNY/hm², referring to this value, since the natural wetland area of Lake Ahabu National Wetland Park is 473.93hm², the value of scientific research function of Lake Ahabu National Wetland Park is calculated to be 181,000 CNY/year.

3.3. Supporting functions

3.3.1. Maintaining biodiversity

The average value of forests for biodiversity conservation is 2884.6 CNY/hm²; the average value of water bodies for biodiversity conservation is 2203.3 CNY/hm². The land use types of Lake Ahab National Wetland Park are mainly forests and water bodies along the shoreline, so the value of maintaining biodiversity can be measured by combining the average annual value of forests and water bodies for biodiversity conservation. The annual average value of forests and water bodies for biodiversity conservation can be measured. The shoreline forest area of Lake Ahab National Wetland Park is 559.38hm², and the wetland area of water body is 401.35hm², which calculates the value of maintaining biodiversity to be 2.5 million dollars.

3.3.2. Providing Habitat

Costanza's ecological benefit to the wetland for providing habitat function on average per year, which is equivalent to RMB1,979.95/hm². The total area of the shoreline forest and water body of Aha Lake National Wetland Park is 960.73hm², and its value of providing habitat is calculated to be 1.9 million CNY/year.

4. Conclusion and Discussion

This study provides a comprehensive evaluation of the ecosystem service value (ESV) of Aha Lake National Wetland Park, revealing that regulating services overwhelmingly dominate the total ESV, accounting for more than 99% of the annual value. Within this category, flood regulation, water purification, and climate regulation emerged as the most significant contributors, underscoring the wetland's role as a critical ecological safeguard in Guiyang. Supporting and cultural services, although contributing a smaller proportion in monetary terms, remain indispensable for biodiversity conservation, habitat provision, recreation, and environmental education. (Figure 2)

Table 2. Ecosystem service values of Aha Lake National Wetland Park in 2017, categorized by service type. Values are expressed in units of $\times 10^4$ CNY per year, with corresponding proportions (%) of the total estimated ecosystem service value.

Service Category	Value ($\times 10^4$ CNY/year)	Percentage (%)
Regulating Services	64,419.26	99.0
Supporting Services	440.00	0.68
Cultural Services	221.51	0.34

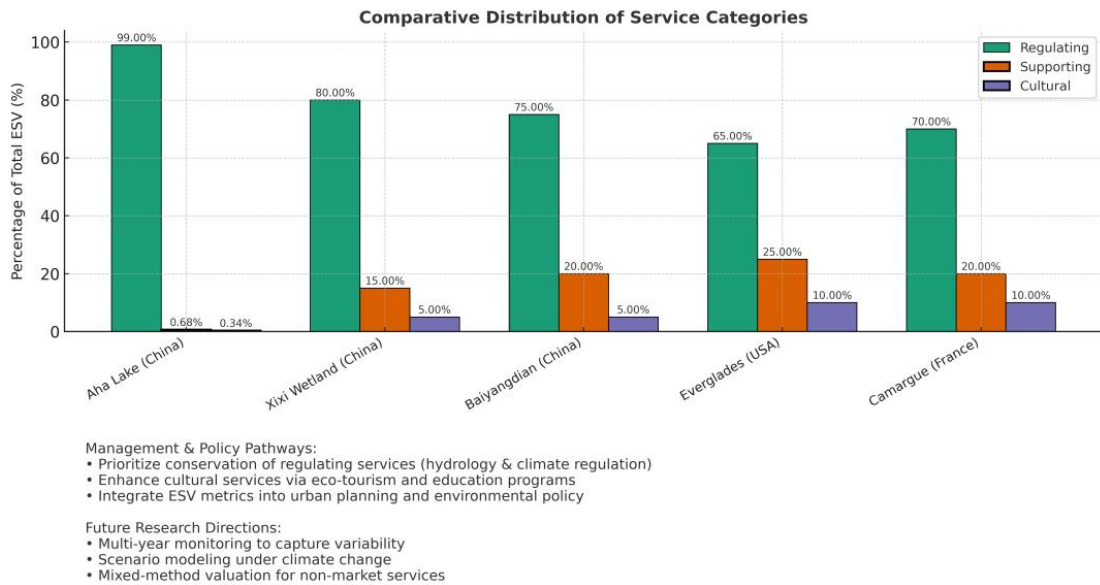


Figure 2. Comparative distribution of ecosystem service categories (Regulating, Supporting, and Cultural) for five wetland ecosystems across China, USA, and France. Data are expressed as percentages of total ecosystem service value (ESV).

4.1. Interpretation of Findings and Comparative Insights

The high proportion of regulating services aligns with findings from both domestic and international wetland studies. For example, similar patterns have been observed in Baiyangdian Wetland (China), Poyang Lake Wetland (China), the Everglades (USA), and the Okavango Delta (Botswana), where hydrological regulation and climate-related functions dominate ecosystem value. However, Aha Lake's per unit area ESV surpasses that of many urban wetlands, attributable to its hydrological connectivity, vegetation diversity, and effective flood storage capacity. This suggests that targeted management to maintain these ecological attributes can significantly enhance urban wetland value.

4.2. Policy and Management Implications

From a policy perspective, the results provide strong economic justification for integrating wetland conservation into urban planning and regional development strategies. The degradation of such ecosystems would likely lead to increased flood risk, reduced water quality, and heightened greenhouse gas emissions, all of which carry substantial economic and social costs. Recommended measures include:

Strengthening hydrological monitoring to optimize seasonal water level management in support of biodiversity and flood mitigation.

Implementing stricter pollution controls in upstream catchments, combined with the promotion of sustainable agricultural practices.

Integrating ESV assessments into land-use planning and environmental impact evaluations for infrastructure development.

Promoting ecotourism and environmental education to foster public engagement and generate sustainable funding for conservation.

4.3. Methodological Reflections

The integrated use of the market value method, equivalent factor method, and carbon tax method enabled the quantification of both market and non-market services. However, each approach carries inherent limitations. Market-based methods may overestimate values when market distortions exist; equivalent factor methods rely on generalized coefficients that may not fully capture local ecological conditions; and carbon-based valuations depend on fluctuating carbon market prices. Future studies should incorporate stated-preference techniques such as contingent valuation (CV) or choice experiments (CE) to better capture intangible cultural values.

4.4. Limitations and Future Research Directions

Several limitations should be acknowledged. First, this study analyzed data from a single year (2017), limiting its ability to capture interannual variability. Second, provisioning services were not monetized due to their limited presence in the Park, potentially underestimating the total value. Third, cultural ecosystem services remain underrepresented in monetary terms due to methodological constraints.

Future research should therefore:

Conduct multi-year monitoring to assess temporal trends and the resilience of wetland functions.

Incorporate social and cultural valuation to represent non-market benefits more comprehensively.

Apply ecosystem service trade-off analysis to evaluate the implications of different management strategies.

Use scenario modeling to project climate change impacts on wetland hydrology and service provision.

4.5. Broader Significance and Final Remarks

The findings from Aha Lake National Wetland Park contribute to the growing body of global evidence that urban wetlands are indispensable ecological infrastructures. Delivering ecosystem services valued at over 650 million CNY annually, Aha Lake exemplifies how conserving and enhancing wetland ecosystems is not only an environmental necessity but also an economically sound investment. Integrating ESV into environmental decision-making can help align urban development objectives with ecological sustainability, supporting both national ecological civilization goals and international biodiversity conservation commitments.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

References

- [1] Hao, C.Y. Analysis on wetland ecological restoration and protection measures in nature reserves. *New Agriculture*, 2023, 18, 40-41.
- [2] Qi, Y.J.; Liu, X. Wetlands and human well-being. *Ecological Economy*, 2024, 40(4), 5-8.
- [3] Tang, E.L. Valuation of ecosystem service functions of the wetland around Chaohu Lake. *Journal of Hebei Academy of Environmental Engineering*, 2023, 33(1), 55-61.
- [4] Assessment, M.E. Ecosystems and Human Well-being. Washington DC: Island Press, 2005.
- [5] He, Z.J.; Cheng, J.H.; Liu, Y.J.; Zhang, Y.J. Impacts of land use and climate change on the regulation services of the Qinghai-Tibet Plateau from 1990 to 2020. *Journal of Glaciology and Geocryology*, 2023, 45(5), 1616-1628.
- [6] OuYang, Z.Y.; Wang, R.S.; Zhao, J.Z. Ecosystem service functions and their ecological-economic value assessmen. *Chinese Journal of Applied Ecology*, 1999, 10(5), 635-640.
- [7] Zhou, G.M.; Qin, H.L.; Ren, B.; Zou, Y.A.; Deng, Z.M.; Huang, L.A.; Liu,, P.; Xiu, .C.; Chen, C.B. Valuation of ecosystem service functions of Huayange National Wetland Park in Suining, Hunan. *Hunan Forestry Science and Technology*, 2019, 46(6), 49-58.
- [8] Li, Y.T.; Du, Z.Y.; Wang, X. et al. Valuation of wetland ecosystem service functions in the Yellow River Delta Nature Reserve. *Marine Environmental Science*, 2019, 38(5), 761-768.
- [9] Tan, H.Y.; Gao, Y.P.; Hou, T.W. Study on the structure of aquatic plant communities in Xiaochehe section of Guiyang Aha Lake National Wetland Park. *Modern Agricultural Science and Technology*, 2023, 22, 101-105.
- [10] Deng, L.B.; Yan, W.; Wang, G.Q. Current status and protection of wetland resources in Guiyang Aha Lake National Wetland Park, Guizhou. *Journal of Agronomy*, 2014, 4(7), 37-40.
- [11] Guiyang Forestry Bureau. 2023.
- [12] Cui, L.J. Wetland value assessment. Beijing: Science Press, 2001.
- [13] Cui, L.J. Monetary valuation of Zhalong Wetland. *Journal of Natural Resources*, 2002, 17(4), 451-456.



© 2025 by the author(s); licensee International Technology and Science Publications (ITS), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (<http://creativecommons.org/licenses/by/4.0/>)