

Exploring the Path of Watershed Ecological Product Value Realization to Boost Regional High-Quality Development: From the Perspective of Big Data Drive

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Abstract: This paper closely aligns with the strategic orientation of national green development and regional coordinated development, taking the Taihu Lake Basin as a typical case to explore the in-depth integration of watershed ecological product value realization and regional high-quality development driven by big data, which holds significant significance for regional green transformation and national ecological economic development. By integrating multi-dimensional data, it systematically analyzes the enabling mechanisms and transformation paths of big data in such links as the confirmation of rights, accounting, and transaction of ecological products, and reveals the core mechanism of converting ecological advantages into economic advantages. The research clarifies the feasible paths for regional high-quality development, condenses a replicable and promotable coordinated development model, and provides solid theoretical support and feasible practical plans for relevant practices.

Keywords: Watershed Ecological Products; Regional High-Quality Development; Value Realization; Big Data.

1. Introduction

The Fourth Plenary Session of the 20th Central Committee of the Communist Party of China proposed accelerating the comprehensive green transformation of economic and social development and building a beautiful China. The "Recommendations of the Central Committee of the Communist Party of China on Formulating the 15th Five-Year Plan for National Economic and Social Development" clearly optimizes the regional economic layout, promotes coordinated development and comprehensive green transformation, and emphasizes further advancing the construction of a Digital China and deepening the development and utilization of data resources. Under this policy orientation, converting watershed ecological value into momentum for regional high-quality development through market-oriented and industrialized means has become a major practical issue in implementing the national green development strategy and achieving harmonious coexistence between humans and nature. With its rigorous value, technical, and practical logic, big data analysis plays a significant enabling role in the realization of ecological product value, providing new momentum and space for the green transformation of production methods and the strengthening of technical support for ecological products. Moreover, in the regional "nature-economy-society" coupling system, there is an inherent positive feedback relationship between ecological product value realization and high-quality economic development[1-4]. The in-depth integration of the two with big data technology is not only an innovative practice of Chinese-style modernization featuring harmonious coexistence between humans and nature but also an important path to promote regional high-quality development.

2. Methods, and Materials

2.1. Research Methods

This paper adopts a comprehensive evaluation method combining the Analytic Network Process (ANP), Factor Analysis, and the CRITIC method to evaluate the value realization of ecological products in the Taihu Lake Basin.

Analytic Network Process (ANP): Construct a network structure model including criterion layers such as "ecological resources—value transformation—regional development". By inviting experts in the field to make pairwise comparison judgments, the weights of each element and their influence paths are calculated. Thus, the key factors and core paths driving the value realization of watershed ecological products and then promoting regional high-quality development are identified, so as to solve the complex feedback and dependency relationships among various elements in the system of ecological product value realization and regional high-quality development[5-7].

1) Construct the unweighted matrix W_s :

$$W_s = \begin{pmatrix} W_{11} & W_{12} & \cdots & W_{1n} \\ W_{21} & W_{22} & \cdots & W_{2n} \\ \vdots & \vdots & & \vdots \\ W_{n1} & W_{n2} & \cdots & W_{nn} \end{pmatrix} \quad (1)$$

2) Construct the weighted matrix A_s :

$$A_s = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{2n} \\ \vdots & \vdots & & \vdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{pmatrix} \quad (2)$$

3) Multiply the weighted matrix A_s by the unweighted matrix W_s to obtain the weighted matrix. The calculation formula is as follows:

$$W_s^\omega = A_s \times W_s \quad (3)$$

4) Find the limit supermatrix

$$W_A^j = \lim_{k \rightarrow \infty} W_s^{\omega k} \quad (4)$$

Entropy Weight Method: Calculate the information entropy of the index data after standardization. A smaller entropy value indicates a greater degree of dispersion of the index, which means it provides more information and thus has a higher weight. The specific calculation steps are as follows: **1)** Perform data standardization (using the corresponding formula for positive indicators) **2)** Calculate the proportion of each indicator **3)** Calculate the entropy value **4)** Calculate the difference coefficient as the objective weight.

1) Data standardization (for positive indicators)

$$Z_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \quad (5)$$

2) Indicator proportion

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^n z_{ij}} \quad (6)$$

3) Entropy value

$$h_j = -\frac{1}{\ln n} \times \sum_{i=1}^n p_{ij} \times \ln p_{ij} \quad (7)$$

4) Objective weight

$$V_j = \frac{1 - h_j}{\sum_{j=1}^m (1 - h_j)} \quad (8)$$

Combined Weight and Value Accounting: The multiplication synthesis method is used to calculate the combined weight, which incorporates both the ANP subjective weight and the objective weight from the entropy value method. Based on the GEP accounting formula, we calculate the value of material products, regulating services, and cultural services separately, then sum them up to obtain the total value of watershed ecological products and the comprehensive benefit score.

Combined weight

$$W_j^* = \frac{W_j \times V_j}{\sum (W_j \times V_j)} \quad (9)$$

2.2. Data Sources

Except for a small amount of data collected through field investigations, expert consultations, and authoritative literature, all other original data used in this paper are derived from publicly available information released by the People's Government of Jiangsu Province and the People's Government of Shanghai Municipality. These data include the "Taihu Lake Basin Soil and Water Conservation Bulletin", "China Ecological Environment Bulletin", "Environmental Quality Annual Report", and other relevant publications, covering various statistical information from relevant departments such as the Bureau of Statistics, the Bureau of Ecology and Environment, and the Bureau of Culture and Tourism [8-9].

3. Results

In this study, the internal connection between watershed ecological product value realization and regional high-quality development is not isolated but presents a dynamic relationship of "ecological supply—value transformation—development feedback". This relationship takes "big data drive" as the core link: on the one hand, through data tools such as dynamic monitoring of ecological background and precise identification of industrial opportunities, it not only

consolidates the foundation for watershed ecological protection and restoration but also cultivates value carriers such as ecological agriculture and green manufacturing; on the other hand, the upgrading of industrial structure and the expansion of value realization channels empowered by data transform ecological value into development dividends such as economic benefits and residents' income increase, ultimately forming a closed loop of "ecological optimization—industrial upgrading—development coordination". Therefore, as a whole, this paper studies the core issue of watershed ecological product value realization boosting regional high-quality development.

3.1. Types and Supply Status of Ecological Products

The abundant and diverse ecological resources in the Taihu Lake Basin are the primary prerequisite for promoting the value realization of ecological products and empowering regional high-quality development. Located in the core area of the Yangtze River Delta, the Taihu Lake Basin boasts Taihu Lake, a large freshwater lake, as well as numerous river networks, wetlands, agricultural lands, and other ecological spaces. It has a unique ecological endowment of "interconnected rivers and lakes, dense river networks, and interleaved fields", and is an important ecological barrier and resource supply area in the Yangtze River Delta. Its ecological environment quality directly affects regional ecological security and high-quality development. The proportion of ecological conservation areas in the basin is significant, and the types of ecological resources are rich and diverse.

3.2. Value Realization Models and Effects

By establishing a weight system and accounting model, this study conducts a comprehensive quantitative analysis of the value realization of ecological products in the Taihu Lake Basin, clearly presenting its core effectiveness in promoting high-quality regional development and providing precise data support for path optimization.

From the perspective of subjective weights, the regulatory service value accounts for the highest proportion in the criterion layer, followed by material product value and cultural service value. This reflects that in the expert consensus, the regulatory function of the ecosystem is the core support for ensuring the sustainable development of the watershed, which is consistent with the current strategic orientation of "ecological priority and green development". At the indicator layer, the output value of agriculture, forestry, animal husbandry and fishery products, utilization value of freshwater resources, and water conservation value emerge as the core focus indicators, indicating that policies should prioritize three key areas: improving the quality of agricultural ecological products, efficient utilization of water resources, and ecological protection and restoration.

The objective weight results show that the water conservation value ranks first in weight, followed by carbon sequestration value and soil conservation value. This is highly consistent with the core ecological functions of the watershed ecosystem and confirms the objective importance of regulatory services in the watershed value system. As the core indicator of material products, the output value of agriculture, forestry, animal husbandry and fishery products still occupies an important position, reflecting the dual significance of production and ecological functions.

Table 1. Results of ANP Subjective Weight Analysis

CRITERION LAYER	CRITERION LAYER WEIGHT	INDICATOR LAYER	INDICATOR LAYER WEIGHT	COMPREHENSIVE SUBJECTIVE WEIGHT
MATERIAL PRODUCT VALUE	0.350	1. Output value of agricultural, forestry, animal husbandry and fishery products	0.450	0.1575
		2. Freshwater resource utilization value	0.300	0.1050
		3. Ecological energy output value	0.250	0.0875
ADJUST SERVICE VALUE	0.450	4. Water conservation value	0.220	0.0990
		5. Carbon sequestration value	0.200	0.0900
		6. Soil retains value	0.180	0.0810
		7. Air purification value	0.150	0.0675
		8. Water purification value	0.150	0.0675
		9. Flood storage value	0.100	0.0450
CULTURAL SERVICE VALUE	0.200	10. Leisure tourism income	0.300	0.0600
		11. Landscape value-added value	0.250	0.0500
		12. Agricultural product brand premium	0.150	0.0300
		13. Ecological satisfaction	0.150	0.0300
		14. Number of people driven by employment	0.100	0.0200
		15. Narrowing rate of urban-rural income gap	0.050	0.0100
TOTAL	1.000		3.000	1.0000

Table 2. Results of Entropy Method Objective Weight Analysis

AIR PURIFICATION VALUE	0.802	0.198	0.077	6
FRESHWATER RESOURCE UTILIZATION VALUE	0.815	0.185	0.072	7
AGRICULTURAL PRODUCT BRAND PREMIUM	0.768	0.232	0.090	8
LEISURE TOURISM REVENUE	0.827	0.173	0.067	9
FLOOD STORAGE VALUE	0.841	0.159	0.062	10
LANDSCAPE VALUE-ADDED VALUE	0.835	0.165	0.064	11
ECOLOGICAL ENERGY OUTPUT VALUE	0.863	0.137	0.053	12
ECOLOGICAL SATISFACTION	0.856	0.144	0.056	13
EMPLOYMENT DRIVES THE NUMBER OF PEOPLE	0.871	0.129	0.050	14
THE NARROWING RATE OF THE INCOME GAP BETWEEN URBAN AND RURAL AREAS	0.889	0.111	0.043	15

Table 3. Results of Combined Weight Analysis

RANKING	INDICATORS	COMBINATION WEIGHTS
1	Water conservation value	0.2343
2	The output value of agricultural, forestry, animal husbandry and fishery products	0.1415
3	Carbon sequestration value	0.1170
4	Soil retains value	0.0993
5	Freshwater resource utilization value	0.0799
6	Water purification value	0.0571
7	Air purification value	0.0549
8	Ecological energy output value	0.0490
9	Leisure tourism revenue	0.0425
10	Landscape value-added value	0.0338
11	Flood storage value	0.0295
12	Agricultural product brand premium	0.0285
13	Ecological satisfaction	0.0178
14	Employment drives the number of people	0.0106
15	The narrowing rate of the income gap between urban and rural areas	0.0045
TOTAL		1.0000

The combined weight integrates the dual advantages of subjective judgment and objective data, ultimately identifying water conservation value, output value of agriculture, forestry, animal husbandry and fishery products, and carbon sequestration value as the three core driving indicators for the

value of watershed ecological products. This result clarifies the focus of path optimization: priority should be given to increasing investment in the protection of ecological regulatory functions such as water conservation and carbon sequestration, while strengthening the ecological and brand

transformation of material products such as agriculture, forestry, animal husbandry and fishery. The overall value can be enhanced through the two-wheel drive of "ecological quality improvement + industrial efficiency enhancement".

Based on the comprehensive benefit growth rate, the future value growth trend is predicted as follows:

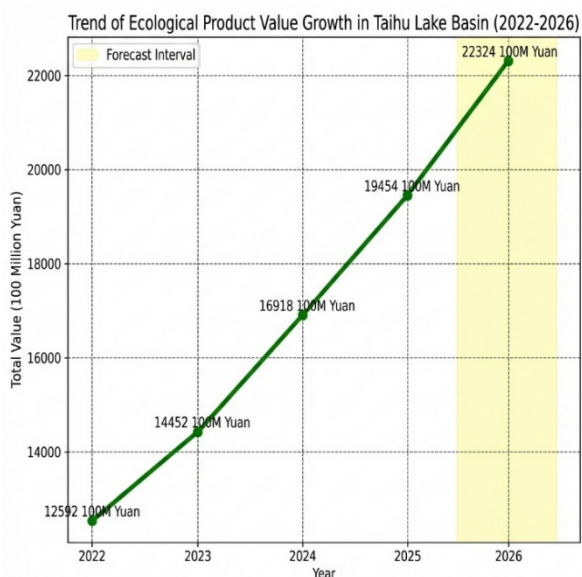


Figure 1. Value Accounting Results and Forecasting Analysis

The data indicates that the value of ecological products in the watershed shows a sustained and rapid growth trend: the total value increased from 10,845.21 hundred million yuan in 2022 to 14,572.83 hundred million yuan in 2024, a growth of 34.4% over two years with a compound annual growth rate of 16.4%. Among them, the growth rate in 2024 increased to 17.06% compared with 2023, showing a continuous enhancement of the momentum for value realization. This is closely related to the implementation of policies such as ecological protection and restoration and industrial green transformation in the Taihu Lake Basin in recent years. It is predicted that a stable growth rate of 15.00% will be maintained from 2025 to 2026, and the total value is expected to exceed 1,900 billion yuan in 2026, fully confirming the enormous potential and sustainability of the value realization of ecological products in the Taihu Lake Basin. This growth trend provides an important basis for long-term policy planning: it is necessary to continuously increase policy support for ecological protection and industrial integration to consolidate the momentum of value growth, while proactively addressing potential structural issues in the growth process through optimized policies.

3.3. Innovative Models of Watershed Ecological Product Value Boosting Regional High-Quality Development Based on Big Data

Innovative Application of Big Data in Intelligent Management Services and "Internet +" Culture-Tourism Integration

The Dayangdang water system in Changxing implemented "Internet +" water governance, ensuring the water ecological environment through the informatization system of the "river chief system" and an intelligent platform. At the same time, focusing on the 4A-level Tuying Wetland Cultural Park, it built a water culture corridor. The corridor introduces the

characteristic aquatic plants and animals of Taihu Lake through visible and tangible artistic images and popular science exhibition boards, and tourists can also learn about Taihu Lake Lougang culture through relevant digital carriers. Its digital ticketing and guest room management system helped the scenic spot achieve a revenue of 900 million yuan in half a year.

Innovative Application of Big Data in the Whole Chain of Green Finance and Property Rights Transactions

Xinchang County, Zhejiang Province launched the nation's first "Soil and Water Conservation Common Prosperity Loan". By accessing the watershed soil and water conservation digital management platform, banks obtained real-time ecological governance data and ecological product value evaluation results of 6 towns and townships, and finally achieved targeted credit of 500 million yuan. This fund is specifically used to support small watershed governance and rural industrial development, and the loan interest rate is linked to the increase or decrease of the soil and water conservation rate of small watersheds, realizing two-way constraints and empowerment of finance and ecology through digital data linkage.

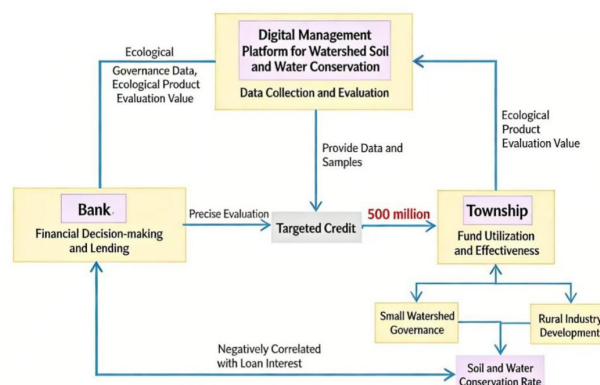


Figure 2. Diagram of the Operational Mechanism of the 'Water Conservation and Common Prosperity Loan'

4. Discussion

This study holds significant theoretical and practical significance. Theoretically, addressing the research gap in the integration of watershed ecological product value realization and regional high-quality development, it constructs a systematic path system empowered by big data, extracts a universal logical framework and factor configuration model. These can be adaptively applied to various ecological scenarios, filling relevant research gaps, expanding the scope of application, and enriching the theories of technological empowerment and regional coordinated development in the field of ecological economics. Meanwhile, by deeply integrating modern development elements, it systematically explores diverse paths and practical paradigms, improving the theoretical framework for ecological product value transformation from the perspective of high-quality development. Practically, through technologies such as big data and satellite remote sensing, it provides actionable solutions to the "difficulties in measurement, transaction, monetization, and mortgage" of ecological products, promoting the conversion of ecological advantages into development advantages. Additionally, it activates the vitality of technological innovation, strengthens the effectiveness of ecological protection and restoration, and achieves a win-win situation for both watershed economy and ecology through

characteristic paths, injecting lasting momentum into the green low-carbon transformation and high-quality development of the Yangtze River Delta and similar regions[10].

This study has certain limitations: focusing on the unique ecological and data conditions of the Taihu Lake Basin, the cross-regional generalizability of its conclusions needs verification; access to some microdata is restricted, the quantification of non-market values is insufficient, and uncertain factors have not been fully considered; it does not involve ethical risks of digital technology, policy differences across administrative levels, or long-term dynamic effects, and the discussion on the practical constraints and social impacts of model implementation is not in-depth enough, so the operability needs further optimization.

5. Conclusion

Under the strategic guidance of national green development and regional coordinated development, the in-depth integration of watershed ecological product value realization and regional high-quality development has become a major practical issue. Taking the Taihu Lake Basin as the research object, this paper explores the mechanism, paths, and guarantee system for their coordinated development from the perspective of big data-driven, and draws the following conclusions: (1) There exists a dynamic closed-loop of "ecological supply - value transformation - development feedback" between the two, big data can address the "four difficulties" (measurement, transaction, monetization, and mortgage) of ecological products; (2) the Taihu Lake Basin has formed four types of value realization models with remarkable results, but still faces multiple challenges; (3) big data empowers watershed development through three major paths and spawns a variety of innovative transformation models.

To promote in-depth integration, optimization suggestions are put forward:(1) improve the multi-source data integration and technology empowerment system, break data silos, and strengthen talent training; (2) improve institutional policies and market mechanisms, clarify the ownership of property rights of ecological products such as cultural services and village-level micro-units, build a trans-watershed horizontal ecological protection compensation mechanism, and improve transaction regulations and green financial systems;(3) strengthen industrial and regional collaborative governance, promote the in-depth integration of industries, establish a cross-regional collaborative governance platform, and optimize the assessment and supervision mechanism. These suggestions aim to activate the potential of big data empowerment, address development bottlenecks, and provide support for the green transformation and high-quality development of the Taihu Lake Basin and similar regions.

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