



Performance evaluation of ecological governance based on public value and cost structure: empirical evidence from China

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Annotation. Based on the framework of public value and cost structure, combined with the characteristics of China's ecological policies, this study constructs an evaluation index system from four dimensions: fairness, efficiency, participation, and sustainability. Weights of indicators are determined using the analytic hierarchy process and the entropy method. Furthermore, the public value performance model, cost structure performance model, and their integrated model are applied to evaluate China's ecological governance performance from 2015 to 2024. Results show that over the decade, China's ecological governance performance has improved from "average" to "good," with all four dimensions exhibiting an upward trend. However, the overall level remains relatively low. Spatially, performance has improved across all regions, with the eastern region outperforming the northeastern, central, and western regions. The findings indicate that despite significant achievements and continuous growth in the performance index of China's ecological governance, deficiencies in fairness, participation, efficiency, and sustainability have constrained further improvement. Therefore, additional effort is needed to improve the ecological compensation system; stimulate the enthusiasm of multiple subjects for participation; clarify the rights, responsibilities, and interests of all parties; and establish a multigovernance and collaborative governance mechanism. This study clarifies the dynamic evolution characteristics and core dilemmas of China's ecological governance performance. Therefore, it provides support for promoting the green and low-carbon transformation of the economy and realizing high-quality development characterized by the coordinated coupling of economic society and ecology.

Keywords: ecological governance, public value, cost structure, performance evaluation, spatiotemporal characteristics.

JEL classification: O33, R11, Q56.

Introduction

With the steady advancement of ecological civilization construction in China, comprehensively improving the level of ecological environment governance and the modernization of governance capacity has become a consensus in academic and practical circles. However, China's current ecological governance continues to face severe challenges. It is in a critical period of advancing against heavy odds, and the structural, fundamental, and trending issues hindering effective ecological governance urgently need to be thoroughly addressed.

As China's practice of ecological civilization deepens, its ecological governance has gradually become a pivotal topic in academic research. Existing studies have focused on four aspects: the theoretical origin of governance, the construction of governance evaluation index systems, the analysis of governance dilemmas, and the exploration of governance paths. First, the theoretical origin serves as the core underpinning for research on ecological governance performance. Governance theories and conceptual connotations (Mol, Carter, 2006; Lin *et al.*, 2025), and the formation and innovation logic of Chinese-style ecological governance (Cai, Wang, 2023; Luo, Zhao, 2023) have garnered widespread attention in the academic community. These research areas have laid a theoretical foundation for exploring China's ecological governance performance. Second, constructing a scientific and rational evaluation index system is fundamental to quantifying ecological governance. Moreover, academics have established such systems from multiple perspectives based on different frameworks. At the macro level, scholars have drawn on general equilibrium theory to build index systems for evaluating ecological governance efficiency at the provincial (Han, 2017), regional (Jiang *et al.*, 2025), industrial, or enterprise levels (Wang *et al.*, 2023; Qiao *et al.*, 2024; Latella *et al.*, 2025). Researchers have also measured ecological governance efficiency using methods such as Data Envelopment Analysis (Picazo-Tadeo *et al.*, 2012; Pérez *et al.*, 2016; Lu *et al.*, 2020) and its extended approaches (Sun, Loh, 2019; Xu *et al.*, 2023; Liang, Chen, 2024), Total Factor Productivity (Lu *et al.*, 2020; Wang *et al.*, 2025), and Stochastic Frontier Analysis (Orea, Wall, 2017; Xiao, Xiao, 2021). Research at the micro level is more targeted than that at the macro level. Evaluations of governance performance in the Yellow River Basin have incorporated indicators of input (governance investment, economic development, green development, and ecological water pollution), desirable outputs, and undesirable outputs (Wang *et al.*, 2024; Liu, 2022). Meanwhile, studies on ecological governance performance in the Yangtze River Economic Belt have integrated positive indicators (e.g., capital, labor, and technology) and negative indicators (e.g., resource consumption) (Xiao *et al.*, 2020; Xiao, Xiao, 2022).

Third, analyzing governance dilemmas is a basic prerequisite for ecological governance. Practical challenges, such as the inadequate implementation of governance concepts, weak synergy among governance subjects, insufficient fulfillment of subject responsibilities, and an imperfect governance system, are the primary reasons for the low quality and insignificant performance of ecological governance (Peng *et al.*, 2024). Furthermore, the performance of environmental governance is subject to institutional factors, including environmental decentralization and environmental regulation (Cai, Guo, 2023). Finally, exploring governance paths emphasizes that multisubject synergy is the core means and key link to achieving high-quality ecological governance. Research on governance paths has transitioned from a focus on government-dominated monocentric governance to dual governance involving governments and enterprises, and further to polycentric governance with extensive social participation (Fan *et al.*, 2022; Zhao *et al.*, 2024). For instance, macrolevel ecological governance highlights policy mobilization, institutional norms and constraints, and the construction of an ecological co-governance system (Ge *et al.*, 2023; Lu *et al.*, 2025). By contrast, microlevel rural ecological governance emphasizes enhancing the awareness of governance subjects, clarifying the responsibilities and functions of multiple

subjects, and establishing a multisubject coordination system and mechanism (Liu, Leng, 2022). Additionally, with the rise and development of digital technology, some scholars have begun to explore digital technology-driven paths for ecological governance (Chen, Yin, 2025). Collectively, these studies provide targeted policy recommendations for comprehensive ecological governance in China.

Although the existing literature has made valuable explorations into China's ecological governance, most studies focus on theoretical exploration and the evaluation of ecological governance efficiency. Relatively few achievements have been made in the quantitative analysis of ecological governance performance. Most scholars construct evaluation index systems and select evaluation methods from an "input-output" perspective, leading to a relatively single perspective in indicator construction and method selection. Furthermore, although some studies have examined China's ecological governance performance, empirical measurements are mostly concentrated at the micro level (e.g., provincial regions, the Yellow River Basin, and the Yangtze River Delta Economic Belt). Research on the long-term temporal variation characteristics of ecological governance performance at the macro and meso levels has also been insufficient. Therefore, based on the basic framework of public value and cost structure, this study constructs an evaluation index system for China's ecological governance performance and measures the ecological governance performance index of China from 2015 to 2024 using the public value performance model, the cost structure performance model, and their integrated model. It also explores the characteristics of temporal dynamic change and spatial differences of China's ecological governance performance. Therefore, this work provides empirical evidence for China's ecological governance within the context of high-quality development.

The remainder of this paper is structured as follows. Section 1 presents theoretical analysis and index system. Section 2 introduces research design, including data sources, index weight calculation and model construction. Section 3 reports the results analysis, including the spatiotemporal characteristics and performance of China's ecological governance. Section 4 discusses the main findings. The final section concludes with implications, limitations, and avenues for future research.

1. Theoretical Analysis and Index System

1.1 Public Value Evaluation Index System for Ecological Governance

The concept of public value, originally articulated by Moore in 1995, refers to the collective utility, shared interests, and long-term well-being created for society as a whole and all its members by governments, public institutions, and diverse social actors through the provision of public goods, services, and policies. Its core essence lies in balancing the maximization of public interest, social fairness and justice, and the efficient allocation of resources. Public value is the fundamental standard for assessing the effectiveness and legitimacy of public sector actions. It has increasingly been applied to assess governmental performance beyond traditional efficiency metrics. In environmental governance, public value encompasses collective benefits such as ecological integrity, social inclusion, and procedural legitimacy (Bozeman, Johnson, 2015). Recently, scholars have argued that ecological governance performance should be evaluated not only in terms of output efficiency but also by its capacity to balance competing stakeholder claims and sustain long-term socio-ecological resilience (Prudence R.B., 2021; Bryson *et al.*, 2014). Drawing on this theoretical evolution, this study constructs a public value-based evaluation index system for China's ecological governance, incorporating four core dimensions: equity, efficiency, participation, and sustainability. These dimensions have been empirically validated as critical in environmental policy contexts, particularly in state-led yet multi-actor governance systems (Liang *et al.*, 2025; Yang *et al.*, 2025).

A distinctive feature of this framework lies in its stakeholder-specific disaggregation. Each of the four dimensions is assessed across three primary stakeholder groups: government entities, enterprises, and social entities (including the public and environmental NGOs). This tripartite structure reflects China's governance reality, in which the state remains the central actor in policy design and resource allocation, while enterprises execute contracted projects and social actors increasingly participate in monitoring and advocacy (Liu *et al.*, 2021). Given the divergent institutional objectives—governments focusing on regulatory compliance and public interest, enterprises emphasizing cost-effectiveness and technical feasibility, and social entities prioritizing transparency and ecological justice—the same set of indicators is applied across groups to maintain structural comparability while capturing perceptual divergences (Chen, Hu, 2023). Recent studies have demonstrated that such a disaggregated approach reveals hidden tensions and synergies among stakeholders, enabling more nuanced governance improvements (Cao, Chen, 2025).

In terms of calculation, each indicator is operationalized using quantitative and qualitative measures derived from policy documents, fiscal accounts, and survey instruments. For instance, equity is measured by distributional fairness indicators across regions and social groups using Gini coefficients adjusted for ecological expenditure; efficiency is assessed through cost-effectiveness ratios linking fiscal inputs to ecological outputs; participation is quantified by the number and diversity of stakeholder engagements in decision-making processes; and sustainability is evaluated via long-term ecological outcome indicators such as vegetation cover persistence and biodiversity indices (Du *et al.*, 2023). These indicators are standardized and aggregated using multi-criteria decision analysis methods, a common approach in public value performance studies (Tang *et al.*, 2024).

1.2 Transaction Cost Structure Index System

Transaction cost theory, foundational to institutional economics (Williamson, 1996), provides a powerful framework for understanding the frictions embedded in ecological governance implementation. Transaction costs—broadly defined as the costs of designing, managing, and enforcing agreements—are often overlooked in traditional performance evaluations, yet they substantially affect the net effectiveness and scalability of environmental interventions (McCann, Easter, 1999; Coggan *et al.*, 2010). In the context of China's top-down yet increasingly delegated governance model, transaction costs emerge at multiple stages: from initial planning and contract negotiation to on-site implementation, monitoring, and enforcement (Fan *et al.*, 2014; Liu *et al.*, 2018). Recent literature has emphasized the need for disaggregated, activity-based transaction cost measurement to improve policy design and resource allocation (Thomas *et al.*, 2024; Huang, Xu, 2024).

Following this line of inquiry, this study develops a transaction cost indicator system comprising five distinct categories, each with specific parameters and calculation methods, as summarized in *Table 1*.

(1) Search information cost (C_1) includes expenditures incurred during the pre-implementation phase to gather necessary information for decision-making. It comprises consulting fees (C_{11}) for feasibility studies and expert advice, survey and evaluation expenditure (C_{12}) for baseline environmental and social assessments, and resource exploration information expenditure (C_{13}) for identifying ecological assets. The total is calculated as $C_1 = \sum C_{1i}$, where data are sourced from project budgeting and procurement records. These costs are critical in contexts with high ecological uncertainty and fragmented institutional responsibilities (Coggan *et al.*, 2010).

Table 1. Transaction Cost Indicators for Ecological Governance: Composition , Calculation

| Indicator Name | Parameters | Calculation Method |
|--|--|-----------------------------|
| Search Information Cost (C_1) | C_{11} : Consulting fees | $C_1 = \sum_{i=1}^3 C_{1i}$ |
| | C_{12} : Survey , evaluation expenditure | |
| | C_{13} : Resource exploration info expenditure | |
| Contract Signing Cost (C_2) | C_{21} : Travel expenses | $C_2 = \sum_{i=1}^4 C_{2i}$ |
| | C_{22} : Printing expenses | |
| | C_{23} : Meeting expenses | |
| | C_{24} : Rental expenses | |
| Org. , Implementation Cost (C_3) | C_{31} : Ecological management expenditure | $C_3 = \sum_{i=1}^5 C_{3i}$ |
| | C_{32} : Disaster prevention, mitigation expenditure | |
| | C_{33} : Institutional operation expenditure | |
| | C_{34} : Equipment purchase expenses | |
| | C_{35} : Office expenses | |
| Inspection, Supervision Cost (C_4) | C_{41} : Ecological monitoring expenditure | $C_4 = \sum_{i=1}^4 C_{4i}$ |
| | C_{42} : Law enforcement , supervision expenditure | |
| | C_{43} : EIA review , supervision expenditure | |
| | C_{44} : Full-time staff labor fees | |
| Default Penalty Cost (C_5) | C_{51} : Default penalty fees (project implementation area, law enforcement) | $C_5 = C_{51}$ |

Note: compiled from the relevant literature.

Source: created by the authors.

(2) Contract signing cost (C_2) captures the administrative expenses associated with formalizing agreements among stakeholders. This includes travel expenses (C_{21}), printing expenses (C_{22}), meeting expenses (C_{23}), and rental expenses (C_{24}) incurred during negotiation and contract finalization. The calculation is $C_2 = \sum C_{2i}$. In multi-actor governance settings, high contracting costs may indicate coordination inefficiencies and information asymmetries (Liu *et al.*, 2018).

(3) Organization and implementation cost (C_3) refers to expenditures directly tied to project execution. Parameters include ecological management expenditure (C_{31}), disaster prevention and mitigation expenditure (C_{32}), institutional operation expenditure (C_{33}), equipment purchase expenses (C_{34}), and office expenses (C_{35}). Total cost is $C_3 = \sum C_{3i}$. These costs reflect the operational capacity and administrative intensity of implementing agencies, which are often underestimated in ex-ante budgeting (Mettepenningen *et al.*, 2009).

(4) Inspection and supervision cost (C_4) encompasses expenditures for monitoring, oversight, and enforcement activities essential to ensure compliance and adaptive management. It includes ecological monitoring expenditure (C_{41}), law enforcement and supervision expenditure (C_{42}), EIA review and supervision expenditure (C_{43}), and full-time staff labor fees (C_{44}). Total cost is $C_4 = \sum C_{4i}$. Effective supervision mechanisms are found to reduce long-term performance risks but require significant upfront investment (Tang *et al.*, 2024).

(5) Default penalty cost (C_5) includes penalty fees incurred due to non-compliance or underperformance in project implementation, as recorded in law enforcement and contract management systems. This category serves as an indicator of enforcement credibility and contract bindingness.

Each cost category is measured using actual expenditure data from government financial accounts, project implementation reports, and audit records. To ensure comparability across projects, costs are normalized by project area (e.g., per hectare) or duration (e.g., per year). This disaggregated, activity-based approach aligns with recent methodological advancements in environmental transaction cost measurement (Thomas *et al.*, 2022) and enables identification of cost drivers and institutional bottlenecks.

2. Research Design

2.1 Data Sources

Data for the entropy weight method in the public value performance evaluation model of China's ecological governance were collected through surveys. For the AHP, first-tier indicators were evaluated by 15 experts and scholars specializing in ecology, ecological engineering, and ecological economics. Second-tier indicators were scored by 20 civil servants (government dimension), 20 middle and senior managers (enterprise dimension), and 10 members of the public along with 10 heads of ecological and environmental NGOs (social subject dimension).

Data for the cost structure performance evaluation model using the Entropy Weight Method were sourced from publicly disclosed final accounts of *the Ministry of Natural Resources, the National Bureau of Statistics, and provincial/municipal natural resources departments*. To eliminate dimensional biases and ensure objective evaluation, all raw indicators were normalized to the [0,1] range using the Range Method. In addition, the weights for the AHP were determined through a comprehensive scoring process involving a diverse panel of stakeholders. Specifically, 15 invited experts and scholars, 20 civil servants, 20 middle and senior corporate managers, 10 members of the general public, and 10 directors of environmental non-governmental organizations (NGOs) participated in the weighting exercise.

Table 2. Classification of China's Ecological Governance Performance Evaluation Grades

| Evaluation Coefficient | <0.2 | 0.2–0.4 | 0.4–0.6 | 0.6–0.8 | >0.8 |
|------------------------|-----------|---------|---------|---------|-----------|
| Evaluation Standard | Very Poor | Poor | Average | Good | Excellent |

Source: own calculations

Drawing on existing research on ecological construction and governance policy performance, ecological civilization evaluation, and consultations with 15 interdisciplinary experts, the equal-interval grading method is employed to divide China's ecological governance performance index into five grades within the [0,1] range. The grading scheme is detailed in *Table 2*.

2.1 Index Weight Calculation

To determine the weights (m, n, k) for both the public value performance evaluation model and the cost structure performance evaluation model in China's ecological governance, this study employs a combined subjective-objective approach. Specifically, the Analytic Hierarchy Process and the entropy weight method are used together to calculate the comprehensive weight for each indicator. The core rationale for selecting this approach lies in its ability to retain the practical attributes and expert

knowledge of ecological governance policies, public value, and cost structures through AHP, while simultaneously eliminating subjective bias and fully extracting the objective information inherent in the data via the entropy weight method. As a result, the final weights balance practical relevance with data-driven rigor, making them better suited to the complex context of ecological governance performance evaluation. In terms of division of labor and internal logic, the Analytic Hierarchy Process (AHP) performs the subjective weighting function. Based on ecological governance theory, policy orientation, and expert experience, it makes structural judgments about indicator dimensions such as equity, efficiency, participation, and sustainability to determine the relative importance of indicators. The entropy weight method performs the objective weighting function. Based on the dispersion degree and information differences of actual observation data from 2015 to 2024. This allows the method to identify the discriminative power and dynamic contributions of each indicator, effectively avoiding interference from subjective preferences.

2.2.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), developed by T.L. Saaty in the mid-1970s, is a multi-criteria decision-making method primarily used for hierarchical weight analysis and decision support. This approach incorporates a degree of subjective human judgment. Its core principles are as follows: First, the decision problem is broken down into a hierarchy of indicators based on specific objectives and criteria. Second, a judgment matrix is constructed, and its eigenvalues and eigenvectors are computed to determine the indicator weights at each hierarchical level. Finally, a weighted summation is performed to aggregate the hierarchical results, yielding the weights of all indicators relative to the overall objective. The resulting comprehensive weights represent the optimal solution for the entire evaluation index system.

2.2.2 Entropy Method

The entropy method is an objective weighting approach that determines indicator weights based on variations in indicator data across different years or regions. The specific steps are as follows:

Based on the standardized values r_{ij} of China's ecological governance evaluation indicators, calculate the proportion P_{ij} of the j -th research unit's indicator value under the i -th evaluation indicator as follows:

$$P_{ij} = r_{ij} / \sum_{j=1}^m r_{ij} \quad (1)$$

Calculate the entropy value e_i of the i -th evaluation indicator as follows:

$$e_i = -k \sum_{j=1}^m P_{ij} \ln P_{ij}, \quad k = \frac{1}{\ln m} \quad (2)$$

Calculate the diversity coefficient d_i of the i -th evaluation indicator as follows:

$$d_i = 1 - e_i \quad (3)$$

Calculate the entropy weight w_i of the i -th evaluation indicator as follows:

$$w_i = d_i / \sum_{i=1}^n d_i \quad (4)$$

In these formula, $i = 1, 2, 3, \dots, n$; $j = 1, 2, 3, \dots, m$, with n representing the number of indicators and $m = 10$.

Comprehensive Weights:

$$W_i = \rho w_i^1 + (1 - \rho)w_i^2 \quad (5)$$

In these formula, W_i denotes the comprehensive weight of the indicator; w_i^1 is the weight calculated by the AHP; w_i^2 is the weight calculated by the entropy method; ρ is the adjustment coefficient, typically set to 0.5. The primarily for the following reasons: First, this value represents a neutral, compromise level that balances differences in indicator weights, thereby avoiding excessive skewness from any single indicator. Second, in the absence of significant differences in the importance of each dimension and without a clear priority basis, this coefficient objectively reflects a balanced relationship among indicators and ensures robust, reasonable evaluation results.

2.3 Model Construction

2.3.1. Public Value Performance Evaluation Model

This work draws on existing research on the performance evaluation of ecological construction policies, ecological governance policies, and desertification control policies (Liu *et al.*, 2018; Fan *et al.*, 2013; Fan, 2013). $Pstr$ and Ep denote the process performance and outcome performance of China's ecological governance, respectively. In addition, $Fair$, Eff , $Part$, and Sus represent the measurement indicators of equity, participation, efficiency, and sustainability of China's ecological governance, respectively. Accordingly, the public value performance (P_p) of China's ecological governance is defined as follows:

$$P_p = \frac{Pstr + Ep}{2} = \frac{a \cdot Fair + b \cdot Eff + c \cdot Part + d \cdot Sus + Ep}{2} \quad (6)$$

In the formula, a, b, c, d are weight coefficients.

2.3.2. Cost Structure Performance Evaluation Model

Based on research on the transaction cost composition of ecological construction policies and the transaction costs and performance evaluation of ecological governance projects (Liu *et al.*, 2018; Fan *et al.*, 2014), $Pstr$ and Ep denote the process performance and outcome performance of China's ecological governance, respectively. Trc represents the transaction cost of China's ecological governance, with En and Ex as endogenous and exogenous transaction costs, respectively. Moreover, $Cpro$ denotes the production cost of China's ecological governance, with C_g , C_e , and C_s as government investment, enterprise investment, and social subject investment in ecological governance, respectively. Tot represents the total cost of China's ecological governance. Thus, the cost structure performance (C_p) of China's ecological governance is defined as:

$$C_p = \frac{Pstr + Ep}{2} = \frac{m \cdot \left(1 - \frac{En}{Trc}\right) + n \cdot \left(1 - \frac{C_e + C_s}{Cpro}\right) + k \cdot \left(1 - \frac{Trc}{Tot}\right) + Ep}{2} \quad (7)$$

Where m, n, k are weight coefficients.

Based on the indicators in Table 2, the transaction cost Trc and endogenous transaction cost E_n of China's ecological governance are calculated as:

$$Trc = \sum_{t=1}^T (1+a)^t (C_{1t} + C_{2t} + C_{3t} + C_{4t} + C_{5t}) \quad (8)$$

$$En = C_{44} + C_{51} \quad (9)$$

In these formula, a is the discount rate, and T is the implementation period of China's ecological governance policies. C_{1t} through C_{5t} are the various cost components at time t , and C_{44} , C_{51} are specific cost indicators as defined in Table 2.

2.3.3 Integrated Model of Public Value and Cost Structure Performance

Liu *et al.* (2018) and Fan *et al.* (2014) have demonstrated the performance isomorphism between the public value and cost structure of ecological governance policies: for the same ecological governance policy in the same time period and region, the average values of public value performance and cost structure performance are equal. Thus, the integrated model of public value performance and cost structure performance for China's ecological governance in the same time period i is

$$P_{pi} = C_{pi} \quad (10)$$

That is:

$$\frac{a \cdot Fair_i + b \cdot Eff_i + c \cdot Part_i + d \cdot Sus_i + Ep_i}{2} = \frac{m \cdot \left(1 - \frac{En_i}{Trc_i}\right) + n \cdot \left(1 - \frac{C_{ei} + C_{si}}{Cprq}\right) + k \cdot \left(1 - \frac{Trc_i}{Tot_i}\right) + Ep_i}{2} \quad (11)$$

Simplifying yields:

$$a \cdot Fair_i + b \cdot Eff_i + c \cdot Part_i + d \cdot Sus_i = m \cdot \left(1 - \frac{En_i}{Trc_i}\right) + n \cdot \left(1 - \frac{C_{ei} + C_{si}}{Cprq}\right) + k \cdot \left(1 - \frac{Trc_i}{Tot_i}\right) \quad (12)$$

Interpretation of Equations (10)–(12):

Time-series performance tracking: Public value performance evaluates ecological governance performance at a single cross-section and cannot capture annual changes. Equation (10) enables the conversion of cost structure performance values into public value performance values, generating a time series of China's ecological governance performance.

Intracost structure analysis: Cost structure performance cannot directly reflect issues such as the adequacy of ecological governance compensation or the willingness and recognition of governments, enterprises, and social subjects to participate in ecological governance factors that public value performance captures. Equation (12) decomposes the internal components of ecological governance cost structure. En_i/Trc_i measures the opportunistic tendencies of various subjects in ecological governance, reflecting their satisfaction and recognition of ecological governance. $(C_{ei} + C_{si})/Cprq$ represents the proportion of enterprise and social subject investment in ecological governance

production costs, indicating the equity of ecological governance (note: ecological governance aims to restore ecosystem balance and provide ecological public goods, which primarily rely on government investment). Trc_i/Tot_i measures the “friction” of ecological governance, influenced by governance efficiency and the enthusiasm of subject participation.

$$a \cdot Fair_i = n \cdot \left(1 - \frac{C_{ei} + C_{si}}{C_{prq}}\right) \quad (13)$$

$$b \cdot Eff_i + c \cdot Part_i = k \cdot \left(1 - \frac{Trc_i}{Tot_i}\right) \quad (14)$$

$$d \cdot Sus_i = m \cdot \left(1 - \frac{En_i}{Trc_i}\right) \quad (15)$$

In summary, equity and sustainability in public value performance can be derived from Equations (13) and (14), respectively. Participation and efficiency (combined) can be derived from Equation (15).

3. Results Analysis

3.1 Isomorphism Analysis of the Model

Based on the analysis of the integrated model of public value performance and cost structure performance of China’s ecological governance, the advantages of the cost structure performance of ecological governance can be leveraged to extend the time series of the public value performance of ecological governance, thereby ensuring a measurable public value performance score for China’s ecological governance in each year. As 2024 represents the most recent year for which complete observational data is available, it offers both strong timeliness and stable data quality. This ensures an objective reflection of the actual structural characteristics of the research subjects. Accordingly, this study utilizes cross-sectional data from 2024 to conduct the isomorphism test, thereby enhancing the accuracy and reliability of the analysis.

First, a comparison was conducted between the public value performance and cost structure performance of China’s ecological governance in 2024. Given the differences in their calculation models, the resulting performance scores also varied. However, if the error between the two values was within 0.05, the performance evaluations were deemed consistent (Liu *et al.*, 2018). Based on the public value performance model, the calculated public value performance score of China’s ecological governance in 2024 was 0.5472. Based on the cost structure performance model, the calculated cost structure performance score was 0.5164. The error between the two values was 0.0308, which is less than 0.05. Therefore, the evaluations of public value performance and cost structure performance of China’s ecological governance were consistent.

Second, in accordance with Equations (13)–(15), a comparison was made between the internal structures of public value performance and the cost structure performance of China’s ecological governance. If the error of each subitem value was within 0.1, the internal structures were considered identical (Liu *et al.*, 2018).

Table 3. Comparison of Public Value Performance and Cost Structure Performance of China’s Ecological Governance, 2024

| Public Value Performance | | Cost Structure Performance | | Difference |
|----------------------------------|--------|---|--------|------------|
| $a \cdot Fair_t$ | 0.2937 | $m \cdot \left(1 - \frac{C_{ei} + C_{si}}{C_{proi}}\right)$ | 0.2401 | 0.0536 |
| $d \cdot Sus$ | 0.1735 | $n \cdot \left(1 - \frac{En_t}{Trc_t}\right)$ | 0.0982 | 0.0753 |
| $b \cdot Eff_t + c \cdot Part_t$ | 0.1426 | $k \cdot \left(1 - \frac{Trc_t}{Tot_t}\right)$ | 0.1137 | 0.0289 |

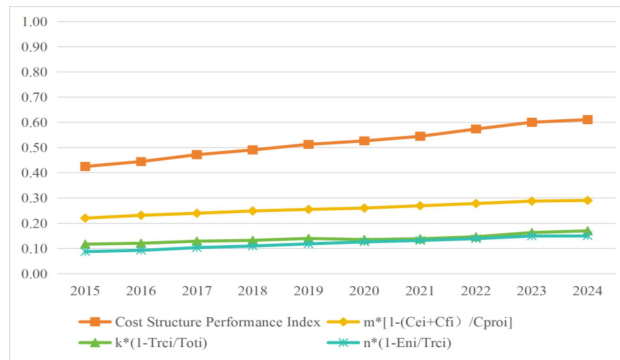
Source: own calculations.

As can be seen from Table 3, the internal structures of public value performance and cost structure performance of China’s ecological governance in 2024 passed the isomorphism test (the error of each sub-item value was less than 0.1). Therefore, in accordance with Equations (10)–(15), the public value performance and its internal structure can be inversely derived using the cost structure performance and its internal structure of China’s ecological governance.

3.2 The spatiotemporal characteristics of China’s ecological governance performance

3.2.1 Performance of Ecological Governance

Based on the cost structure performance model of China’s ecological governance and data on transaction costs, government investment, enterprise investment, and social subject investment in China’s ecological governance from 2015 to 2024, the changes in the cost structure performance and its internal structure of China’s ecological governance from 2015 to 2024 can be calculated, as shown in Figure 1.



Source: own calculations.

Figure 1. Changes in China’s Ecological Governance Cost Structure Performance and Its Internal Structure

During this period, the cost structure performance index of China’s ecological governance showed a fluctuating upward trend, rising from 0.4251 in 2015 to 0.6109 in 2024. This outcome indicates that China’s ecological governance cost structure performance improved from “average” to “good.”

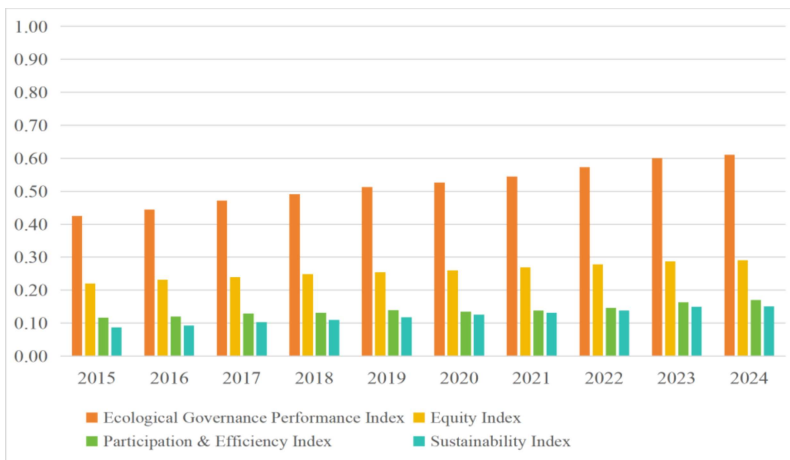
3.2.2 Temporal Changes in Ecological Governance Performance

Based on the isomorphism analysis of the internal structures of public value performance and cost structure performance of China’s ecological governance, the cost structure performance and its internal structure of China’s ecological governance from 2015 to 2024 can be used to derive inversely the public value performance and its internal structure of ecological governance during the same period. Thus, the temporal changes in China’s ecological governance performance and its internal structure from 2015 to 2024 can be obtained.

Table 4. Temporal Changes in China’s Ecological Governance Performance and Its Internal Structure

| Year | Ecological Governance Performance Index | Equity Index | Participation , Efficiency Index | Sustainability Index |
|------|---|--------------|----------------------------------|----------------------|
| 2015 | 0.4251 | 0.2203 | 0.1172 | 0.0876 |
| 2016 | 0.4446 | 0.2315 | 0.1206 | 0.0925 |
| 2017 | 0.4717 | 0.2396 | 0.1288 | 0.1033 |
| 2018 | 0.4906 | 0.2487 | 0.1321 | 0.1098 |
| 2019 | 0.5128 | 0.2549 | 0.1397 | 0.1182 |
| 2020 | 0.5265 | 0.2601 | 0.1353 | 0.1261 |
| 2021 | 0.5446 | 0.2694 | 0.1385 | 0.1317 |
| 2022 | 0.5735 | 0.2782 | 0.1464 | 0.1389 |
| 2023 | 0.6003 | 0.2878 | 0.1631 | 0.1494 |
| 2024 | 0.6109 | 0.2905 | 0.1699 | 0.1505 |

Source: own calculations.



Source: own calculations.

Figure 2. Temporal Changes in China’s Ecological Governance Performance and Its Internal Structure

As shown in *Figure 2* and *Table 4*, China’s ecological governance performance index showed a fluctuating upward trend, rising from 0.4251 in 2015 to 0.6109 in 2024. Although China’s ecological governance performance improved from “average” to “good,” the overall governance performance remained at a general level. Specifically, China’s ecological governance performance has the following characteristics:

Fairness is the main influencing factor of China's ecological governance performance, which indicates that the government's compensation or rewards for various subjects' participation in governance and the full payment of ecological compensation play an important role in ecological governance. Figure 2 demonstrates that from 2015 to 2024, the fairness index of China's ecological governance fluctuated and increased from 0.2203 to 0.2905, indicating a rise in the fairness of China's ecological governance. However, the overall fairness remained low. Research reveals that the main reasons for this phenomenon are the low compensation and rewards from the government to various subjects and the low full payment rate of ecological compensation. Therefore, in the process of ecological governance, the government needs to improve the compensation policies for ecological environment governance continuously and increase compensation or rewards for various subjects' participation in ecological governance. At the same time, ecological compensation policies and fee standards must be continuously improved, and the full payment rate of ecological compensation fees must be increased to enhance the fairness of ecological governance.

From 2015 to 2024, the participation and efficiency index of China's ecological governance fluctuated and rose from 0.1172 to 0.1699, indicating an increase in the participation and efficiency of China's ecological governance. However, the participation and efficiency remained low. On the one hand, this outcome indicates that the on-time completion rate of ecological governance projects and the on-time payment rate of ecological compensation are not high. On the other hand, it indicates that the participation of government subjects, enterprises, and social subjects in the planning, implementation, management, and maintenance of ecological governance projects is not high. Therefore, in the process of ecological governance, the marine ecological compensation policies and systems must be continuously improved to ensure the on-time payment of ecological compensation fees. Furthermore, the participation of enterprises and social subjects in ecological governance projects must be enhanced through incentive means. These developments can promote all subjects to complete various governance projects actively, thereby improving the participation and efficiency of ecological governance.

During the same period, the sustainability index of China's ecological governance rose from 0.0876 to 0.1505, indicating an increase in the sustainability of China's ecological governance. According to research and interviews, the investment of government subjects, enterprises, and social subjects in ecological governance has increased. Moreover, the construction of the government's relevant ecological management organizational systems has been improved. Meanwhile, the satisfaction of enterprises and social subjects with ecological compensation, their understanding of the responsibility for maintaining ecological governance achievements, and the necessity of ecological governance have been enhanced, thus improving the sustainability of ecological governance. However, Figure 2 demonstrates that the sustainability of ecological governance around China remained at a low level from 2015 to 2024. Therefore, in the process of ecological governance, the government needs to increase investment in ecological governance, strengthen the construction of ecological management organizational systems, improve ecological compensation policies and systems, and enhance the awareness of ecological protection and governance of enterprises and social subjects. These solutions can help improve the sustainability of ecological governance.

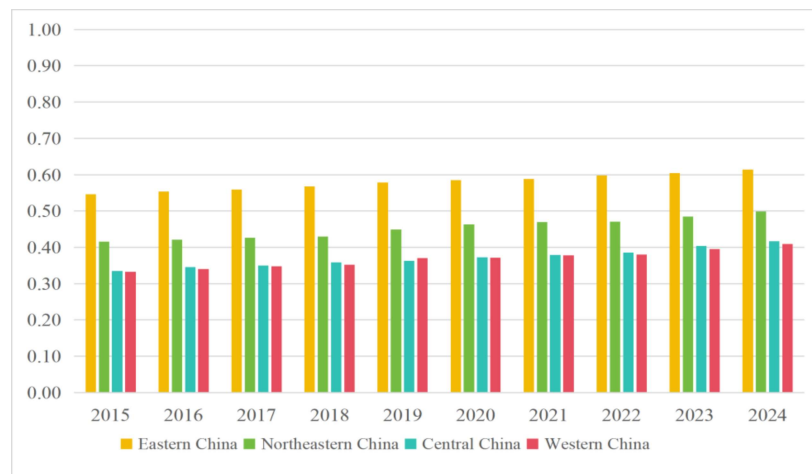
3.2.3 Spatial Differences in Ecological Governance Performance

The spatial comparison results of ecological governance performance in different regions of China can be obtained by analyzing the regional ecological governance performance index of China, as shown in Figure 3.

From 2015 to 2024, the ecological governance performance of all regions in China showed an overall upward trend, consistent with the national ecological governance performance change trend. However, the range of change was small. Overall, the ecological governance performance of various regions in China has particularities and differences, which are specifically reflected in the following aspects:

The ecological governance performance in Eastern China is significantly higher than that in Northeast, Central, and Western China. From 2015 to 2024, the ecological governance performance index in Eastern China rose from 0.5461 to 0.6138. Additionally, the performance of ecological governance improved from general to good.

The ecological governance performance in Northeast China is average, but the growth rate is higher than that in Eastern China. From 2015 to 2024, the ecological governance performance index in Northeast China rose from 0.4154 to 0.4987, and the ecological governance performance remained at a general level. The growth rate of ecological governance performance reached 20.05%, higher than 12.93% in Eastern China.



Source: own calculations.

Figure 3. Spatial Differences in China's Ecological Governance Performance

The ecological governance performance in Central and Western China is the same and generally low. However, the growth rate is rapid. From 2015 to 2024, the ecological governance performance indexes in Central and Western China rose from 0.3346 and 0.3325 to 0.4163 and 0.4091, respectively, and the ecological governance performance improved from a low to a general level. The growth rates of ecological governance performance reached 24.41% and 23.02%, respectively.

4. Discussion

This study establishes a well-founded evaluation index system, determines indicator weights by integrating the AHP and Entropy Method, and assesses the performance of China's ecological

governance through three analytical frameworks: the Public Value Performance Model, Cost Structure Performance Model, and Integrated Model. The detailed findings are presented below.

First, compared to the central and western regions and the northeastern region, the ecological governance performance in eastern China is higher. The main reasons for this phenomenon are as follows. (1) Eastern China has a high level of economic development and abundant local fiscal revenue, enabling local governments to increase capital investment continuously in key links of ecological governance, such as the construction of pollution control facilities, ecological restoration projects, and the upgrading of regulatory equipment (Sun, 2019). (2) As a frontier of reform and opening up and an economic core area, Eastern China has a higher implementation efficiency of ecological and environmental protection policies in various provinces and cities, a more complete environmental supervision system, and stricter law enforcement than other regions (Liang , Chen, 2024). These characteristics can effectively promote the implementation of governance responsibilities. (3) Eastern China is concentrated with high-tech industries, leading in the research, development, and application capacity of environmental protection technologies (Han, 2017). Moreover, it has more mature and efficient pollution control technologies than other regions. At the same time, the proportion of high-pollution and high-energy-consuming industries in the industrial structure is low, thus reducing governance pressure from the source. (4) Eastern China has a high population density and overall high education level, with strong public awareness of environmental protection and clear demands for ecological environment quality. These features force local governments and enterprises to attach importance to governance and form a positive interaction.

Second, the ecological governance performance in Northeast China is average, but the growth rate is higher than that in the eastern region. The core reasons for this phenomenon are as follows. (1) the initial performance index in Northeast China is much lower than that in Eastern China at a low starting point, with great “marginal space” for governance improvement. Therefore, a high proportion of growth can be achieved with the same governance investment. (2) As an old industrial base, Northeast China had a large ecological debt in the early stage. In recent years, the state has intensively introduced special policies for the revitalization of Northeast China and ecological protection and restoration. These policies increased support in funds, technologies, and projects, driving the rapid improvement of governance performance (Han, 2017). (3) Northeast China has focused on promoting the transformation and upgrading of traditional high-energy-consuming and high-pollution industries; closing and eliminating backward production capacity; and increasing investment in key areas such as mine restoration, black soil protection, and river basin governance, with targeted governance measures and evident short-term effects (Sun, 2019). (4) The environmental protection infrastructure and supervision system in Northeast China were relatively weak in the early stage. With the increase of environmental protection investment and the improvement of supervision, the governance capacity at the basic level has been quickly supplemented, directly promoting the steady rise of the performance index and forming a high growth rate.

Finally, the ecological governance performance in central and western regions of China is basically stable and overall low, but the growth rate is relatively fast. The main reasons for this phenomenon are as follows. (1) In recent years, the state has attached great importance to ecological and environmental protection in Central and Western China, issued a series of relevant policies, and provided policy guarantee and financial support for ecological governance in these regions. Central and Western China have also actively responded to national policies and increased the investment and promotion of ecological governance (Han, 2017). (2) Central and Western China are important ecological security

barriers in China. However, the ecological environment is relatively fragile. The fragility and importance of the ecological environment have driven Central and Western China to have a strong sense of urgency and initiative in ecological governance, prompting them to accelerate the governance pace and promote the rapid improvement of performance. (3) In the process of economic development, Central and Western China have gradually realized the damage of traditional high-pollution and high-energy-consuming industries to the ecological environment. Moreover, they have accelerated the pace of industrial structure adjustment and upgrading. At the same time, they have actively introduced advanced ecological governance technologies and experiences from Eastern China and foreign countries. These regions have also implemented innovative applications in combination with their own actual conditions, thus improving the efficiency and effectiveness of ecological governance. (4) With the development of the economy and society and the improvement of education levels, the public's awareness of environmental protection in Central and Western China has gradually increased (Jiang *et al.*, 2025). Their requirements for ecological environment quality have continued to increase, thus prompting the government and enterprises to pay added attention to ecological governance, increase investment, and promote the improvement of ecological governance performance.

Conclusions and Recommendations

Conclusions

Based on four dimensions and from three perspectives, this study constructs an evaluation index system for ecological governance performance, assesses the level of China's ecological governance performance from 2015 to 2024, and comparatively analyses the changes and main factors of ecological governance performance in different regions of China. The main conclusions are as follows:

From the perspective of temporal characteristics, China's ecological governance performance has continued to rise, showing a good trend of ecological governance over the past 10 years. From the perspective of various dimensions, the fairness, participation, efficiency, and sustainability of China's ecological governance have all shown an upward trend. Among them, the growth of the fairness index has contributed the most to China's ecological governance performance. Although the contributions of participation, efficiency, and sustainability are relatively small, their indexes are also growing steadily.

From the perspective of spatial differences, the ecological governance performance of all regions in China has continued to rise, showing an overall trend of decreasing from Eastern China to Northeast, Central, and Western China. Specifically, the ecological governance performance in Eastern China is better than that in Northeast, Central, and Western China. Moreover, it remains at a relatively high level overall. Eastern China's comprehensive advantages in resource investment, policy implementation, technical support, and other aspects have driven its leading ecological governance performance. Although the ecological governance performance in Northeast China is generally good, it is better than that in Central and Western China. Moreover, its growth rate is higher than that in Eastern China. Northeast China has a low base, late policy implementation, and large governance space. It has also achieved a high growth rate by adopting targeted governance measures. The ecological governance performance in Central and Western China is the same and generally low. However, their growth rate is higher than that in Eastern and Northeast China. Central and Western China have a low base and a late start in ecological governance. At the same time, they have achieved rapid growth under the combined effect of policy promotion, capital investment, industrial transformation, and the improvement of public awareness.

This study still has several limitations that warrant further improvement. First, data availability is constrained by official public fiscal accounts and statistical yearbooks. Certain detailed transaction cost items at the micro-project level cannot be fully separated from aggregated expenditure, and long-term, continuous data on public participation and subjective satisfaction remain relatively scarce, restricting more refined measurement. Second, the indicator dimensions are limited to fairness, efficiency, participation, and sustainability. Emerging factors such as digital governance, cross-regional coordination, the application of green technology, and the prevention of ecological risks are not yet included. Therefore, the index system could be expanded to reflect the evolving requirements of modern ecological governance. Third, this study covers a 10-year period from 2015 to 2024. In the future, researchers can conduct longer time-series analyses by collecting historical data prior to 2015, which would help identify long-term trends, structural changes, and the dynamic evolution of ecological governance performance.

Managerial and Policy Implications

According to the temporal changes and regional differentiation characteristics of ecological governance performance, China needs to focus on the four goals of fairness, participation, efficiency, and sustainability and break through the predicament of ecological governance through differentiated policy combinations.

In the dimension of fairness, efforts must be made to improve the ecological compensation mechanism and focus on fairness. The horizontal ecological protection compensation mechanism and the realization mechanism of ecological product value should be enhanced. Furthermore, a scientific ecological value accounting system should be established, and the losses and contributions of the public and enterprises should be scientifically quantified. At the same time, the use channels of ecological compensation funds should be expanded while promoting the transformation of ecological compensation from “blood transfusion” to “hematopoiesis.” Ecological governance policies should balance intergenerational equity and intergenerational equity, and the rights and interests of vulnerable groups should be protected. Moreover, the balance of interests between regions can be realized through ecological compensation. Payments and other mechanisms can also be transferred to ensure that the achievements of ecological governance can benefit all subjects.

In the dimension of participation, efforts must be made to encourage public participation and promote multisubject cooperation. Attention should also be given to strengthening publicity and education, improving the public’s awareness of ecological and environmental protection, and encouraging the public to participate actively in ecological governance. Furthermore, policy transparency and decision-making scientificity should be improved through information disclosure and public supervision. This development can turn the public into an important force in ecological governance. The roles of the government, enterprises, and social subjects form a pattern of multigovernance. The government should strengthen guidance and supervision, and enterprises should fulfill their social responsibilities. Meanwhile, the public and environmental protection organizations should actively participate in supervision and governance to promote ecological governance work jointly.

In the dimension of efficiency, efforts must be made to optimize policy implementation and promote technological innovation. Furthermore, the intensity and effectiveness of policy implementation should be strengthened while establishing and improving a policy evaluation system. Policy effects and compliance should also be quantitatively assessed. Policy measures need to be adjusted and optimized promptly to ensure that ecological governance policies can achieve the expected results. Investment in

environmental monitoring and governance technologies should be increased, and big data, artificial intelligence, and other technologies should be employed to improve the efficiency of environmental monitoring and governance. At the same time, the large-scale applications of green innovative technologies need to be promoted, and the technological content of ecological governance should be improved.

In the dimension of sustainability, efforts should be made to clarify long-term goals and establish a dynamic adjustment mechanism. The goals of ecological governance policies should be aligned with national strategic planning. Furthermore, policy design should cover the three dimensions of economy, society, and ecology to achieve their coordinated development and ensure the sustainability of ecological governance. A dynamic adjustment mechanism can be introduced according to environmental changes and policy effects. Additionally, policies should be regularly evaluated while adjusting and optimizing ecological governance policies promptly to ensure the scientificity and effectiveness of policies.

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Author contributions

Bei Ma is responsible for the paper's conceptualization, investigation, writing of the original draft, and Writing-Review & Editing. Shuang Liu is responsible for visualization and data curation. Rongshan Qiu provided critical feedback and helped shape the research, analysis, and manuscript.

EKOLOGINIO VALDYMO EFEKTYVUMO VERTINIMAS REMIANTIS VIEŠĄJA VERTE IR SĄNAUDŲ STRUKTŪRA: EMPIRINIAI KINIJOS DUOMENYS

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Santrauka. Remiantis viešosios vertės ir sąnaudų struktūros sistema bei Kinijos ekologinės politikos ypatybėmis, tyrimo metu buvo sukurta vertinimo indeksų sistema remiantis keturiomis dimensijomis: teisingumo, efektyvumo, dalyvavimo ir tvarumo. Rodiklių svoriai nustatyti per analitinės hierarchijos procesą ir taikant entropijos metodą. Tyrime Kinijos ekologinio valdymo veiklos rezultatai 2015–2024 m. vertinti taikant viešosios vertės našumo modelį, sąnaudų struktūros našumo modelį ir integruotą jų modelį. Rezultatai parodė, kad per dešimtmetį Kinijos ekologinio valdymo veiklos rezultatai pagerėjo nuo vidutinio iki gero lygio, o visose keturiuose dimensijose fiksuota augimo tendencija. Tačiau bendras lygis išliko santykinai žemas. Erdviniu požiūriu veiklos rezultatai pagerėjo visuose regionuose, tačiau geriausi rodikliai nustatyti rytiniame regione, kuris apėmė šiaurės rytų, centrinį ir vakarinį regionus. Nepaisant reikšmingų pasiekimų ir nuolatinio Kinijos ekologinio valdymo veiklos indekso augimo, teisingumo, dalyvavimo, efektyvumo ir tvarumo trūkumai riboja tolesnį tobulėjimą. Todėl būtina tobulinti ekologinio kompensavimo sistemą, didinti įvairių subjektų motyvaciją dalyvauti šiame procese, aiškiai apibrėžti visų suinteresuotųjų šalių teises, pareigas ir interesus bei plėtoti daugiašaliu bendradarbiavimu pagrįstus valdymo mechanizmus. Šiame tyrime analizuojami Kinijos ekologinio valdymo raidos dinamikos ypatumai ir pagrindinės problemos, todėl jo rezultatai gali prisidėti prie žaliosios ir mažo anglies dioksido intensyvumo ekonomikos transformacijos skatinimo bei aukštos kokybės vystymosi, paremto suderinta ekonomikos, visuomenės ir ekologijos plėtra, įgyvendinimo.

Reikšminiai žodžiai: ekologinis valdymas; viešoji vertė; sąnaudų struktūra; veiklos vertinimas; erdvėlaikio charakteristikos.