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Research on performance evaluation of ecological product value realization under the “Dual Carbon Goals”

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Introduction: To measure the performance level of ecological product value realization, this article selects 16 indicators from four aspects: high-quality development, urban-rural regional coordination, ecological environment governance, and institutional mechanism construction to construct a performance evaluation index system for ecological product value realization mechanism. The entropy weight method is used to calculate the performance level of the whole country and 30 provinces (municipalities) from 2012 to 2022.

Methods: The innovation of this article lies in the first use of the whole country as the research object, constructing a long-term panel data model covering the period of 2012–2022, and quantitatively analyzing the performance differences and dynamic evolution laws of ecological product value realization in each province through entropy weight method. This national provincial scale research design not only fills the gap in macro level performance evaluation, but also reveals the differences in location characteristics and institutional responses in the transformation of ecological product value in different regions.

Results: The results show that the performance of the national ecological product value realization mechanism has been increasing year by year, showing explosive growth in 2015, and the growth rate has fluctuated since then.

Discussion: It is suggested to formulate a performance evaluation policy for the realization mechanism of ecological product value based on the goal of building a beautiful China, promote the establishment of ecological product value realization methods and paths with the characteristics of each province (city), conduct performance evaluations on pilot demonstrations and base creation in the national ecological product value realization, and further optimize and improve relevant institutional mechanisms.

KEYWORDS

value realization of ecological products, index system, performance evaluation, entropy weight method, regional differences

1 Introduction

Guided by the scientific theory of Xi Jinping’s ecological civilization, China has achieved remarkable results in the field of ecological civilization construction, which has attracted worldwide attention. This achievement has become a significant symbol of the historic achievements and changes of the Communist Party of China and the national cause in the new era. “Clear water and green mountains are golden hills and silver mountains” concept is an important content of xi ecological civilization thought. On this basis, the

concept of “realizing the value of ecological products” with Chinese characteristics has emerged. This concept defines the various benefits that “green mountains and clear waters” provide to humanity as ecological products, and through specific value realization pathways, transforms “green mountains and clear waters” into “golden mountains and silver mountains,” ultimately achieving the ideal state of harmonious coexistence between humans and nature.

“Ecological products” refer to the sum of material products, services, and ecological rights that are naturally generated by ecosystems or reasonably developed and utilized by humans, and can provide wellbeing for humans. They have both ecological and economic attributes, emphasizing the characteristic of being directly utilized by humans and achieving value transformation through market mechanisms. In the context of China, its composition includes: material products, regulatory service products, and cultural service products.

In August 2016, the General Office of the CPC Central Committee and The General Office of the State Council issued the Opinions on Establishing a Unified and Standardized National Ecological Civilization Pilot Zone and the Implementation Plan of the National Ecological Civilization Pilot Zone (Fujian), which officially put forward the concept of realizing the value of ecological products (). In April 2021, the General Office of the CPC Central Committee and The General Office of the State Council issued and implemented the Opinions on Establishing and Improving the Value Realization Mechanism of Ecological Products, which put forward six mechanisms to realize the value of ecological products from the perspective of top-level design. In March 2022, the National Development and Reform Commission and the National Bureau of Statistics jointly studied and issued the “Standard for the Total Value Accounting of Ecological Products (Trial)” [Development and Reform Foundation (2022) No. 481] document to standardize the value accounting of ecological products. At this point, a large number of effective practices have been carried out in promoting the realization of the value of ecological products across the country. Because its mechanism construction is still in the initial stage of exploration, there are still some bottleneck problems that have not been broken. Therefore, evaluating the current performance of realizing the value of ecological products from the Angle of result orientation and goal orientation is the basic work to further improve the mechanism of realizing the value of ecological products, and is of great significance to further improve the policy design of realizing the value of ecological products.

2 Research progress and review

2.1 Concept proposal

The “ecological products” originally proposed by the academic circle refers to healthy, natural, and green high-grade products, whose production process consumes less resources or is more friendly to the environment (Ren and Yuan, 1992). With the iteration of society and technological innovation, humans have become increasingly aware that the process of survival and development has a profound impact on the natural ecological environment, and the quality of life is increasingly constrained

by the state of the ecological environment. Therefore, seeking a dynamic balance between economic and social development and natural ecological protection has become an inevitable choice. After American scholar Costanza et al. put forward the view that the products and services provided by the ecosystem for human beings are valuable (Chen and Zhong, 2023; O'Connor and Kenter, 2019), the academic community began to explore how to calculate and measure the value of the ecosystem. The international community has carried out a series of theoretical studies, such as the Millennium Ecosystem Assessment (MA) and the Environmental and economic Accounting system-Experimental Ecosystem Accounting (SEEA-EEA), with a view to obtaining the recognition of all sectors of society, so as to establish a responsibility mechanism for all mankind to build, share and jointly protect (Gaodi and Zhiqin, 2024). With the continuous advancement of Chinese ecological civilization construction strategy, domestic scholars have given new connotations to “ecological products” based on the concept of ecosystem services. Ecological products are no longer emphasized as eco-friendly commodities circulating in the market, but more emphasis is placed on the functional role of natural ecosystems for human survival and development. Such as providing fresh air, clean water, pleasant climate, etc. (Zeng et al., 2014), using the form of ecological products to make the hidden value of natural ecosystems explicit (Xuelian and Binli, 2024).

2.2 Research progress

According to the literature search in WOS database, some scholars began to discuss the paid use mechanism of ecosystem as early as 1980s and 1990s, but the number of literature was only in single digits. As shown in Figure 1, from 2006 to 2010, the number of relevant literature gradually increased. Since 2011, the topic of paying ecosystem has become a hot topic, and the number of relevant literature has increased year by year. Searching the relevant literature on “value realization of ecological products” in the CNKI database, it is found that scholars began to study the value realization mechanism of ecological public goods in 2005, and the number of relevant literature began to increase in 2018, and the number of literature will increase sharply after 2020, and the accounting methods, realization mechanism, and transformation path models of the value of ecological products will gradually increase.

In recent years, some scholars have explored and studied the realization of the value of ecological products from the perspective of effectiveness, and evaluated the performance of the realization of the value of ecological products by quantitative methods. As shown in Figures 2, 3, Xuelian et al. (2024) selected 16 indicators from three aspects of ecological benefit, economic benefit, and social benefit to build an evaluation system for the value realization of ecological products, and evaluated the value realization of ecological products in 11 provinces (municipalities) along the Yangtze River Economic Belt with entropy value method. Wenjing (2023) established the evaluation index system of the realization effect of the value of ecological products, and evaluated the realization effect of the value of ecological products in key ecological functional areas of the

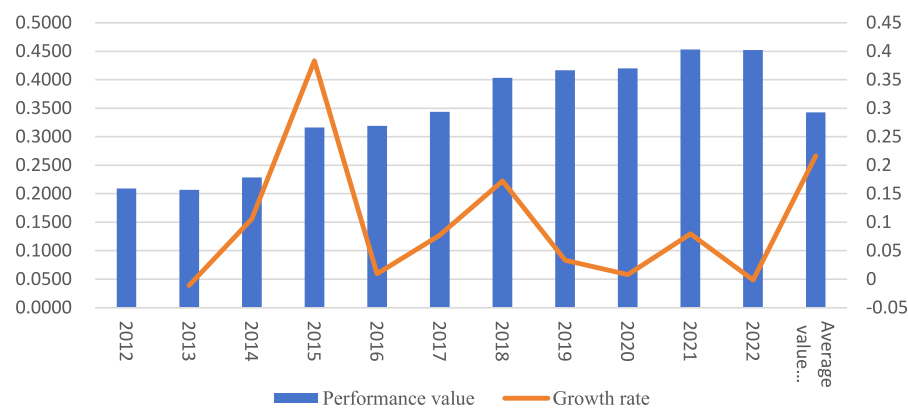


FIGURE 1
Performance evaluation value of ecological product value realization mechanism from 2012 to 2022.



FIGURE 2
Top 10 provinces in terms of performance of ecological product value realization mechanism.

Yellow River Basin with the principal component analysis method. [Lei et al. \(2022\)](#) built an evaluation system for the practical effect of the value transformation of ecological products from three aspects: the effect of ecological product protection, the effect of value transformation and the guarantee mechanism, and evaluated the effect of realizing the value of ecological products in 37 cities in the Yangtze River Basin. [Wu \(2023\)](#) evaluated the total level, structural conversion rate, and sustainability of ecological product value realization in Chishui River Basin of Guizhou Province from three indexes: gross value evaluation index, structural evaluation index, and dynamic evaluation index. Some scholars have established an evaluation index system for the transformation effect of “clear water and green mountains are golden hills and silver mountains,” and have conducted evaluation studies on key cities such as Zhejiang Province and Yangtze River Economic Belt ([Lin and Yu, 2022](#); [Chongyang et al., 2020](#)).

2.3 Research review

The realization of the value of ecological products, as an original concept under the strategic framework of China’s ecological civilization construction, aims to promote a positive interaction between ecological environment protection and economic and social development, and is a Chinese path toward the modernization of harmonious coexistence between humans and nature. Many domestic experts and scholars have discussed the concept types, value accounting methods, implementation mechanisms, transformation paths, and case summaries of ecological products ([Chen and Zhong, 2023](#); [Hui et al., 2024](#); [Minghao et al., 2024](#); [Jiangyi and Degang, 2020](#); [Xiaolu et al., 2023](#); [Linbo et al., 2019](#)), with the ultimate goal of establishing relevant mechanisms to realize the transformation of green mountains into gold and silver mountains.

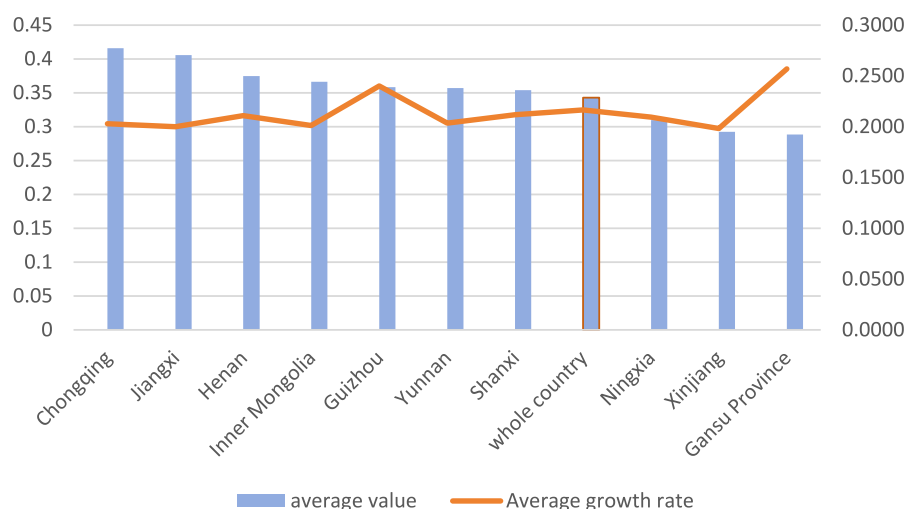


FIGURE 3

Top 10 provinces in terms of performance growth rate of ecological product value realization mechanism.

In general, most of the research objects of scholars focus on key cities or certain ecological types in a certain province or a certain river basin, and the research scale is relatively specific, and few carry out performance evaluation from the provincial scale. In terms of the evaluation content, they pay more attention to ecological benefits, economic benefits, and social benefits. In the index design, the system and mechanism of realizing the value of ecological products are not considered much, and there is still a lack of quantitative reference for how to further improve the relevant mechanism. In view of this, this paper attempts to evaluate the performance of realizing the value of ecological products in 31 provinces (autonomous regions and municipalities) in order to provide references for implementing the spirit of the Third Plenary Session of the 20th CPC Central Committee and further improving the relevant mechanisms.

3 Evaluation model design

Improving the mechanism for realizing the value of ecological products is an innovative reform practice. From the perspective of strategic value, its core lies in promoting new driving forces for high-quality economic development, building a new trend of coordinated development between urban and rural areas, leading a new trend of ecological protection and restoration, and constructing a new paradigm of harmonious coexistence between humans and nature. This paper takes the strategic value orientation as the goal orientation to design the performance evaluation model.

3.1 Construction principles

First, it reflects the goal orientation and serves the goal of “further improving the realization mechanism of the value of

ecological products.” The evaluation indicators of the system and mechanism should be fully considered, and the overall performance of the realization of the value of ecological products should be measured from the effectiveness of the construction of the guarantee mechanism.

Second, pay attention to the classification of regions. The natural ecological endowments in different regions of the country are quite different, and the corresponding functional positioning is not the same. Regional differences should be fully considered, and ratio indicators rather than absolute indicators should be used as far as possible in the evaluation design.

Third, scientific authority should be considered. In principle, the data should be used as much as possible to the National Bureau of Statistics, the Ministry of Ecology and Environment, the Development and Reform Commission and other ministries and departments of the provinces of the open data, or through authoritative data calculation, to ensure consistent and comparable caliber.

3.2 Constructing theory

The theory of “Two Mountains” is based on dialectical materialism and historical materialism as philosophical foundations, deeply reflecting the dialectical unity of the relationship between humans and nature. It regards ecological protection and economic development as a contradictory unity of opposites, and through practice reveals the objective laws of the transformation from green mountains and clear waters to golden mountains and silver mountains. It affirms the material foundation role of nature for human beings and emphasizes the subjective initiative of human beings to transform nature, achieving the value creation of humanized nature while respecting the laws of nature.

3.3 Construction ideas

Based on the above mentioned, the target layer of the performance evaluation index system for the realization of ecological product value is the performance index. The criterion layer is designed from the four strategic value orientations, and specific evaluation indicators are selected considering data availability, comparability, continuity, and other factors.

First, in terms of cultivating new driving forces for high-quality economic development, it follows the principle of “protecting the ecological environment is protecting productivity, improving the ecological environment is developing productivity,” regards ecology as an emerging productive force, and makes it an inexhaustible driving force to support economic development, forming a virtuous circle of protecting ecology, relying on ecology, and developing ecology.

Second, in building a new trend of coordinated development between urban and rural areas, based on the differentiated characteristics of residents’ demand for a better life in urban and rural areas and different functional zones, we promote the coordinated optimization of the development pattern between urban and rural areas through the supply of precise products and service systems. In this process, relying on the endowment of rural ecological resources to drive the improvement of development momentum, gradually narrowing the urban-rural development gap, promoting a relatively balanced standard of living for all residents, and steadily moving toward the goal of common prosperity.

Third, in guiding the new trend of ecological and environmental protection and restoration, the main task is to resolve the “misalignment” of cost sharing and benefit distribution in maintaining ecosystem functions, restoring the environment, and improving the environment. We will establish a benefit-oriented mechanism in which environmental protection benefits, users pay, and vandals pay, and encourage all parties to take the initiative to improve the supply capacity and level of ecological products. To form a conscious mind and conscious action to jointly participate in ecological and environmental protection.

Fourth, in creating a new plan for harmonious coexistence between man and nature, we will give full play to the institutional advantages of socialism with Chinese characteristics in concentrating resources to accomplish major tasks, create a system with Chinese characteristics to realize the value of ecological products, and find a way to promote and complement each other in ecological and environmental protection and economic development, and create a new plan for harmonious coexistence between human beings and nature.

3.4 Performance evaluation index system

To comprehensively consider the performance of ecological product value realization from multiple dimensions. Indicators such as the construction land output rate in the dimension of high-quality development can measure the efficiency of resource utilization and the quality of economic development; Indicators such as income of urban and rural residents in the dimension

of urban-rural regional coordination can reflect the balance of development; Indicators such as the number of days with good air quality in the dimension of ecological environment governance can reflect the effectiveness of ecological protection; The indicators of institutional construction in the dimension of institutional mechanism construction can evaluate policy guarantees and management capabilities. These indicators take into account the economic, social, ecological, and institutional levels, with both positive indicators for measuring effectiveness and negative indicators for reflecting problems, forming a comprehensive and targeted evaluation system. This paper constructs the three-level ecological product value realization performance evaluation index system as shown in [Table 1](#).

4 Data and methods

4.1 Data sources

This study takes 30 provinces (urban areas) in China from 2012 to 2022 as the research object. Tibet, Hong Kong, Macao, and Taiwan are not covered in this study for the time being due to the lack of data. The data mainly come from China Statistical Yearbook, China Environmental Statistical Yearbook, relevant provincial (urban) statistical yearbook, National Bureau of Statistics website and wind database, etc. The missing data were replaced by the nearest year.

4.2 Research methods

Aiming at the historical evaluation of the value of ecological products at the provincial scale in China, this study adopted the comprehensive index evaluation method to make a comprehensive evaluation by transforming multiple indicators into one comprehensive index according to different weights. The entropy weight method objectively assigns weights based on the degree of data variation, avoiding subjective bias and meeting the objective needs of evaluating the indicators of ecological product value realization mechanism. It can eliminate the influence of dimensional differences in indicators, reflect the information value of indicators through information entropy, and assign higher weights to key indicators with large variations such as ecological environment governance and resource utilization efficiency. It can accurately reflect the actual contribution of multi-dimensional performance of ecosystems, making it more suitable for indicator evaluation in this field ([Runzhe et al., 2021](#)).

4.2.1 Standardization of index data

First of all, the index matrix is constructed $C = [c_{i,t}]_{n \times m}$. In order to eliminate the influence of different dimensions of indicators, the linear change method is adopted to standardize the indicator variables. Positive indicators are processed according to [Equation 1](#), and negative indicators are processed according to

TABLE 1 Performance evaluation index system of ecological product value realization.

Target layer	Guideline layer	Indicator codes	Indicator name	Units	Indicator properties
Ecological product value realization mechanism performance evaluation index system A	High-quality development B1	C1	Production rate of construction land	Ten thousand yuan/hectare	Positive
		C2	Water yield rate	Yuan/ton	Positive
		C3	Energy output rate	Ten thousand yuan/ton standard coal	Positive
		C4	GDP per capita	Ten thousand yuan	Positive
	Rural-urban regional coordination B2	C5	Ratio of per capita disposable income of urban and rural residents	%	Negative
		C6	Per capita consumption expenditure ratio of urban and rural residents	%	Negative
		C7	Growth rate of per capita income of rural residents	%	Positive
		C8	Urbanization rate	%	Positive
	Improving the ecological environment B3	C9	Proportion of days with good air quality	%	Positive
		C10	Surface water is better than Class III ratio	%	Positive
		C11	Harmless treatment rate of household waste	%	Positive
		C12	Carbon emissions per unit of GDP	Tons/ten thousand yuan	Negative
	Institutional building B4	C13	Institutional development	–	Positive
		C14	Pilot projects to demonstrate the effectiveness of construction	–	Positive
		C15	The proportion of local fiscal funds spent on environmental protection	%	Positive
		C16	Number of burst environment times	Times/year	Negative

Equation 2.

$$\text{Positive indicators : } C_{it} = \frac{[x_{it} - \min(x_i)]}{[\max(x_i) - \min(x_i)]} \quad (1)$$

$$\text{Contrarian indicator : } C_{it} = \frac{[\max(x_i) - x_{it}]}{[\max(x_i) - \min(x_i)]} \quad (2)$$

Where, x_{it} is the statistical value of the i indicator in the t year, $\min(x_i)$ represents the minimum value of the indicator, $\max(x_i)$ represents the maximum value of the indicator, C_{it} represents the standardized value of the i indicator in the t year, and obtains the matrix $C' = (C_{i,t})_{m \times n}$ ($i = 1, 2, 3, \dots, m$; $t = 1, 2, 3, \dots, n$).

4.2.2 Calculate indicator information entropy and weight

Equations 3–5 are used to calculate the specific weight and information entropy of each indicator (Yueying et al., 2024).

$$w_i = \frac{(1 - e_i)}{\sum_{i=1}^n (1 - e_i)} \quad (3)$$

$$e_i = \frac{1}{\ln n} \sum_{t=1}^n (p_{ij} \ln p_{it}) \quad (4)$$

$$p_{it} = \frac{c_{it}}{\sum_{i=1}^m c_{it}} \quad (5)$$

Where, w_i is the weight of indicator i , e_i is the information entropy of indicator i , and $p_{i,t}$ is the value of indicator matrix C after standardized processing, namely the matrix C' mentioned above.

4.2.3 Weight of ecological product value realization performance evaluation index

Through dimensionless standardized processing of the original data, entropy weight method is used to determine the corresponding weights of high-quality development, urban-rural

and regional coordination, ecological environment governance, and institutional and mechanism construction, and the results are shown in Table 2.

Based on the weight calculated by panel data, this paper calculates the performance value of ecological product value realization mechanism in 30 provinces and the whole country from 2012 to 2022, and the results are shown in Table 3.

From the results in the Table 4, it can be seen that high scoring provinces such as Beijing have outstanding high-quality development indicators such as economic development, construction land output rate, and well-established institutional mechanisms, such as high local financial investment in environmental protection; Fujian and Zhejiang have excellent ecological environment governance indicators and strong ability to convert the value of ecological products such as forest carbon sinks. Low scoring provinces such as Gansu and Xinjiang have weak economic foundations, lagging energy output rates and other indicators, and are located in ecologically fragile areas in the northwest, making it difficult to control air quality. At the same time, there are many sudden environmental incidents in the construction of institutional mechanisms, and local environmental protection financial investment is insufficient, resulting in low comprehensive performance.

5 Results and discussion

Judging from the overall evaluation results, the performance of the value realization mechanism of ecological products increased year by year, and the growth rate fluctuated slightly. 2015 showed an explosive growth, corresponding to the rapid increase in the number of relevant academic papers in 2015 as mentioned above. The main driving factor is that in 2015, the Political Bureau of the CPC Central Committee formally wrote “clear waters and

green mountains are gold and silver mountains” into important documents such as the Central Committee and The State Council to promote ecological civilization construction and ecological civilization system reform. It has become an important thought for Chinese ecological civilization construction (2024b). In September of the same year, the CPC Central Committee issued the first comprehensive document on ecological civilization construction, the Overall Plan for the Reform of the Ecological Civilization System, and successively issued six supporting plans. The idea that “clear waters and lush mountains are gold and silver mountains” has become an important driving force for the realization of the value of ecological products.

The growth rate in 2012 was -0.011084 , showing negative growth, or due to the lack of systematic mechanisms for realizing the value of ecological products, policy and practical paths to be explored, and limited implementation effects. In 2013, the growth rate turned positive to 0.105514 due to the central government’s proposal of “building a beautiful China,” the inclusion of ecological civilization in the national strategy, and local pilot projects such as ecological compensation. In 2014, the growth rate reached 0.383104 , which was the peak of the stage, due to the issuance of the “Opinions on Accelerating the Construction of Ecological Civilization,” which clarified the requirements for realizing the value of ecological products, accelerated the implementation of local ecological red lines and other policies, and the increase in academic research publications providing support for practice. In 2016, the growth rate was 0.077040 . Based on the policies of 2015, the supporting policies of the Overall Plan for Ecological Civilization System Reform began to take effect, and the pilot program for ecological product value accounting was launched. In 2017, the growth rate was 0.172556 , and the implementation of GEP accounting and other practices has been promoted, resulting in significant achievements in policy implementation. In 2018, the growth rate was 0.032949 , or due to the implementation

TABLE 2 Weight of performance evaluation index of ecological product.

High-quality development B1		Urban-rural and regional coordination B2		Ecological and environmental governance B3		Improving institutions and mechanisms B4	
C1	0.0550376	C5	0.0372166	C8	0.0368375	C12	0.0420891
C2	0.0750078	C6	0.0480885	C9	0.0712459	C13	0.0403968
C3	0.0657259	C7	0.0411965	C10	0.0692466	C14	0.0378203
C4	0.0623953	C8	0.2314333	C11	0.0511722	C15	0.0350906

TABLE 3 Results of performance evaluation of ecological product value.

Nationwide	Beijing	Fujian	Zhejiang	Guangdong	Jiangsu	Shanghai	Tianjin	
0.3426	0.5299	0.4656	0.4647	0.4627	0.4508	0.4437	0.4326	
Hainan	Chongqing	Jiangxi	Hubei	Anhui	Sichuan	Hunan (Province)	Shandong	
0.4188	0.416	0.4056	0.4022	0.402	0.3922	0.3879	0.3856	
Shaanxi	Hebei	Henan	Ji Lin	Guangxi	Inner Mongolia	Guizhou	Yunnan	
0.3832	0.3814	0.3747	0.3741	0.3669	0.3663	0.3584	0.3567	
Shanxi	Liaoning	Qinghai	Heilongjiang	Ningxia	Xinjiang	Gansu (Province)		
0.3541	0.3357	0.3226	0.3148	0.3095	0.2924	0.2883		

TABLE 4 Evaluation results of performance sub-indexes of ecological.

Index name B	High quality development B1	Urban-rural and regional coordination B2	Ecological and environmental governance B3	Improving institutions and mechanisms B4
Nationwide	0.0547	0.0888	0.0961	0.103
Anhui	0.052	0.0996	0.1007	0.1497
Beijing	0.1644	0.1217	0.0908	0.153
Fujian	0.0891	0.111	0.1152	0.1503
Gansu	0.0205	0.0564	0.0891	0.1223
Guangdong	0.0783	0.1043	0.1258	0.1542
Guangxi	0.0351	0.089	0.1106	0.1322
Guizhou	0.0399	0.0655	0.1033	0.1497
Hainan (Province)	0.0473	0.0976	0.1344	0.1396
Hebei	0.0426	0.1014	0.0837	0.1537
Henan	0.0569	0.0938	0.0848	0.1392
Heilongjiang	0.018	0.1129	0.0922	0.0918
Hubei	0.0643	0.1078	0.1013	0.1288
Hunan	0.0651	0.0938	0.1075	0.1215
Ji Lin	0.0283	0.1042	0.0926	0.1489
Jiangsu	0.0869	0.1178	0.0961	0.15
Jiangxi	0.0492	0.103	0.1029	0.1506
Liaoning	0.035	0.1002	0.0939	0.1066
Inner Mongolia	0.0367	0.0997	0.0877	0.1422
Ningxia	0.0164	0.0938	0.0802	0.1192
Qinghai	0.0286	0.0849	0.1018	0.1074
Shandong	0.0607	0.0972	0.0875	0.1402
Shanxi	0.0416	0.0932	0.0596	0.1597
Shaanxi	0.0658	0.0834	0.0923	0.1417
Shanghai	0.1304	0.129	0.1005	0.0838
Sichuan	0.0503	0.0934	0.1064	0.142
Tianjin	0.081	0.1379	0.0879	0.1258
Xinjiang	0.0195	0.081	0.0828	0.109
Yunnan	0.0479	0.0645	0.1103	0.134
Zhejiang	0.0889	0.1243	0.1046	0.147
Chongqing	0.0724	0.101	0.1016	0.141

of the mechanism entering an adjustment period, some pilot projects entered the adjustment stage. The growth rate in 2019 was 0.007848, close to stagnation, which may be affected by insufficient policy implementation depth. The growth rate in 2020 was 0.079452, with a slight rebound. With the continuous promotion of ecological civilization construction, local understanding and implementation of mechanisms have been strengthened. The growth rate in 2021 was 0.001475, slightly decreasing again, possibly due to marginal diminishing effects of some policies. The growth rate of 0.216344 in 2022 has significantly rebounded, which may be related to the deepening of the “dual carbon” target and the

further improvement of the mechanism for realizing the value of ecological products, and the enhancement of policy synergy.

Judging from the average situation and change trend of the provinces in the past 11 years, the top 10 provinces in the performance of ecological product value realization mechanism (Figure 4) are higher than the national average level, and have greater advantages. However, from the average growth rate, the growth rate of these provinces is lower than the national average growth rate. In terms of growth rate, 70% of the top 10 provinces with average growth rate are above the national average, and three provinces are below the national average (see Figure 5).

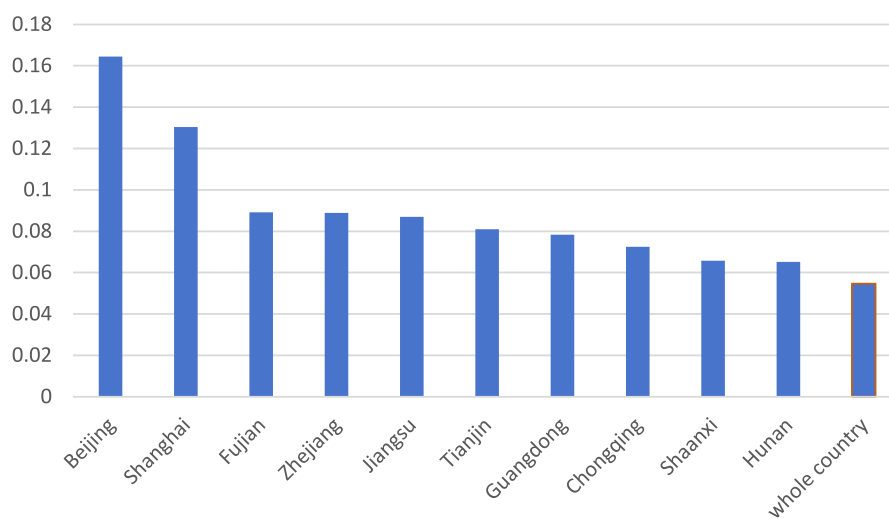


FIGURE 4
Indicator B1 "High Quality Development" - Top 10 provinces.

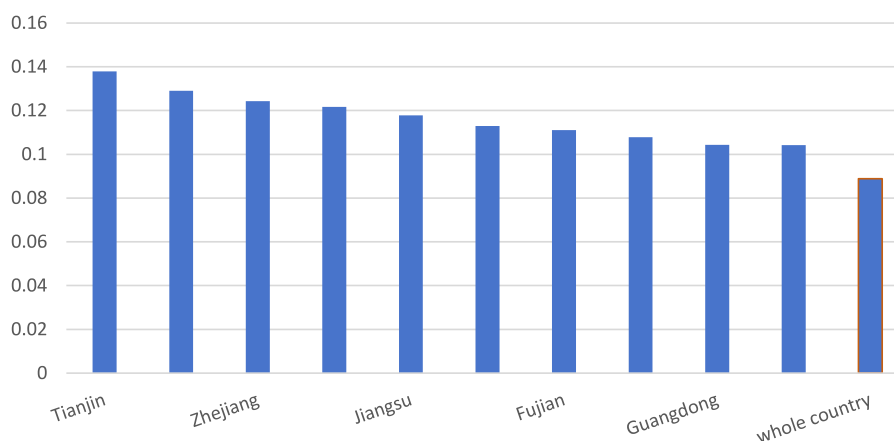


FIGURE 5
Indicator B2 "Urban Rural Regional Coordination" - Top 10 provinces.

In terms of the change trend of each sub-index, Beijing ranks first in the country in terms of high-quality development, which is three times higher than the national average (see Figure 6). In terms of specific indicators, the main reason why Beijing is much higher than other places is that the "water resource production rate" is different from that of other provinces. For example, in 2022, Beijing's water resources output rate is 1,038.52 yuan/ton, but Shanghai, Fujian, and Zhejiang are respectively 423.93 yuan/ton, 308.31 yuan/ton, and 465.2 yuan/ton.

In terms of rural-urban regional coordination, there is not much difference between the top 10 provinces. Except for Hubei, which is a central province, the remaining nine provinces are all located in the eastern region (Figure 7). In terms of the coordinated development of urban and rural areas, the gap between the east, central, and western regions is huge. From another perspective, it

can be argued that the realization of the value of ecological products in the central and western provinces will be promising. In terms of ecological environmental governance, the top 10 provinces are all located in the south. From the analysis of specific indicators, in addition to a good ecological background, environmental quality such as air, water, and solid waste are also important indicators reflecting the effectiveness of ecological environmental governance. It can be seen that the overall level of ecological environmental governance in southern provinces is higher than that in northern provinces. In terms of institutional and institutional construction, 17 provinces have issued guidance documents on the top-level design of the mechanism for realizing the value of ecological products at the provincial level, among which the top 10 provinces are all among them, and there are a certain number of state-level pilot demonstrations of "lucid waters and lush mountains are gold

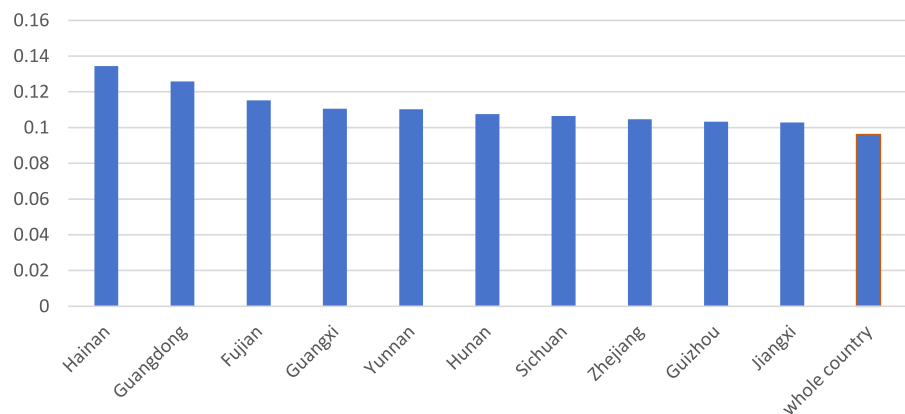


FIGURE 6
Indicator B3 "Ecological Environment Governance" - Top 10 provinces.

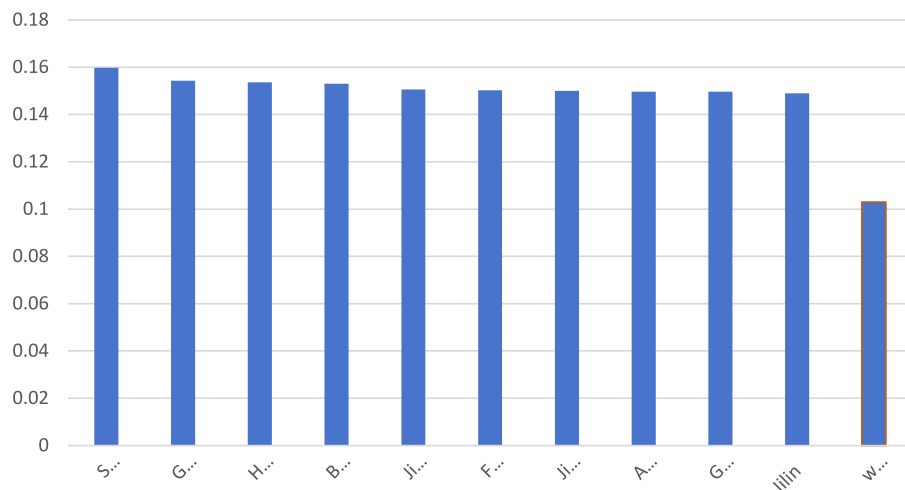


FIGURE 7
Indicator B4 "Institutional Mechanism Construction" - Top 10 provinces.

hills and silver mountains” in the province, successfully exploring the practical path of transforming the value of ecological products into economic value.

6 Policy suggestions

To sum up, it is suggested to improve the value realization mechanism of ecological products from the following aspects. First, in view of the strong guidance of the policy on the realization of the value of ecological products, it is suggested that the national level should introduce the performance evaluation policy of the realization mechanism of the value of ecological products in accordance with the construction goal of beautiful China, so as to gather policy synergy for the construction of beautiful China. Second, it is suggested that each province (urban area) introduce the top-level design scheme of the value realization mechanism of

ecological products, increase the summary and condensation of the existing cases of the value realization of ecological products in the province, and determine the way and path of the value realization of ecological products with the characteristics of the province. The third is to carry out performance and effectiveness evaluation in combination with the pilot demonstration and base creation of various national departments in ecological civilization construction or “clear waters and lush mountains are golden hills and silver mountains,” so as to provide reference for further optimization and improvement of relevant work.

When implementing policy recommendations for the realization mechanism of ecological product value, foreseeable challenges mainly lie in the difficulty of policy adaptation caused by regional heterogeneity. There are significant differences in ecological endowment, economic foundation, and institutional environment between the eastern, central, and western regions of China. For example, the ecological environment governance

scores of southern provinces are generally higher than those of northern provinces, while the energy structure transformation pressure of northern provinces is greater. Unified performance evaluation policies are prone to implementation deviations, and cross departmental data barriers and coordination obstacles are prominent. The realization of ecological product value involves multi departmental data, but the collection standards are not unified, there are “information islands,” and the quantitative standards for institutional mechanism construction indicators lack standardization, which may lead to distorted evaluation results. In addition, the construction of long-term mechanisms faces the dilemma of interest coordination, and the contradiction between the redistribution of interests of ecological protectors and beneficiaries is prominent. The cost-benefit mismatch between the upstream protected areas of the Yangtze River Economic Belt and the downstream developed areas, coupled with insufficient grassroots implementation capacity and technical support in some underdeveloped areas, a lack of professional talents and technical tools, makes it difficult to accurately apply quantitative methods, resulting in performance evaluation becoming a mere formality. To overcome these challenges, a policy adaptation mechanism of “classification guidance + dynamic adjustment” can be established. Differentiated evaluation index weights can be formulated according to ecological functional zones, and an annual dynamic adjustment mechanism can be established. At the same time, a cross departmental data platform and technology empowerment system can be created. The National Development and Reform Commission will lead the integration of data, unify standards, develop automation tools, and form expert teams to provide technical training. Innovative cross regional interest coordination and market-oriented incentive mechanisms can be established, and a performance-based ecological compensation transfer payment system can be established. Pilot experiences such as Zhejiang’s “Two Mountains Bank” can be promoted, linking performance with market-oriented transactions. It is also necessary to establish a “performance policy practice” closed-loop optimization mechanism, publish a blue book to publicly disclose provincial rankings, and set up innovation funds to support grassroots exploration of characteristic transformation models. This will promote the mechanism for realizing the value of ecological products from pilot exploration to systematic improvement.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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