

Article

Evaluation of Perceived Effectiveness in Ecological Products Value Realisation: A Case Study of the Beijing–Tianjin–Hebei (BTH) Region

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Abstract

A scientifically robust evaluation system for ecological products value realisation is urgently needed in China. Approaches that rely solely on objective indicators face significant challenges due to data limitations and regional heterogeneity. This study innovatively constructed an experts' perceived effectiveness evaluation scale for ecological products value realisation, establishing a dual mechanism of "objective data + expert experience calibration" and covering the entire chain of "ecological background–economic conversion–social well-being–benefit feedback". This framework was applied to the Beijing–Tianjin–Hebei (BTH) region, with results indicating that the perceived effectiveness index for value realisation of material-supply-oriented ecological products (MSEPs), regulatory service-oriented ecological products (RSEPs), and cultural service-oriented ecological products (CSEPs) was 0.7054, 0.6482, and 0.6052, respectively. Significant regional differences exist. Beijing holds a central and leading role, while effectiveness in the northern mountainous areas of Hebei Province is stronger than in the central and southern regions. Regions with weaker performance should prioritise leadership strategies over comprehensive development, as disparities arising from regional differentiation call for more sophisticated coordination mechanisms. The study offers new insights for policy decision-making and optimisation, enhancing both the applicability and precision of evaluation methods. Nonetheless, the designed scales remain exploratory and warrant verification through a broader empirical basis.

Keywords: ecological products value realisation; perceived effectiveness; evaluation scale; the Beijing–Tianjin–Hebei region



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1. Introduction

'Ecological products value realisation' is a term jointly proposed and continuously refined by the Chinese government and scholars. Unlike the internationally extensively researched ecosystem service value accounting systems (such as the Millennium Ecosystem Assessment (MEA) [1], the System of Environmental–Economic Accounting—Ecosystem Accounting (SEEA-EA) [2], and Gross Ecosystem Product (GEP) [3]) or payments for ecosystem services [4], it constitutes a comprehensive framework from natural ecosystem

to ecological products to economic returns [5], and is designed to integrate three core components—enhancing the quantity and quality of ecological products, monetizing their multi-dimensional values, and optimizing the supporting policy instruments. As an embodiment of the Chinese leadership’s concept that “lucid waters and lush mountains are invaluable assets,” these mechanisms have become widespread practices across China [6] and are an integral part of deepening ecological civilisation reform [7]. Consequently, government authorities and the general public pay particular attention to the effectiveness of these policy measures.

In the definitions provided by the National Development and Reform Commission (NDRC) and the National Bureau of Statistics (NBS) of China [8], there are three categories of ecological products—material-supply-oriented ecological products (MSEPs), regulating-service-oriented ecological products (RSEPs), and cultural-service-oriented ecological products (CSEPs)—which constitute the goods and services provided by ecosystems for use in economic and other human activities. The inherent complexity of its value realisation mechanism—characterised by multi-stakeholder involvement, dynamic processes, and context-specific attributes—manifests in effectiveness that exhibits multidimensional characteristics with significant heterogeneity across different types of ecological products and regions. Developing effective evaluation methods remains an ongoing challenge for the field. Lei et al. [9], Du and Chang [10], and Wen et al. [11] explored the effectiveness of ecological products value realisation at a regional level. Zhou et al. [12] analysed the value of ecological products delivered by forest ecosystems. Wang et al. [13] conducted effectiveness evaluations focusing on local pilot cases of ecological product value realisation. He et al. [14] and Wu et al. [15] analysed the economic effects of the realisation of ecological products value. Fu et al. [16] and Yang et al. [17] proposed the concept of “degree of ecological products value realisation” and applied it to evaluations in desert areas. Kong et al. [18] and Wang et al. [19] put forward the concept of “efficiency of ecological products value realisation” and provided corresponding measurement methods.

However, existing studies have obvious limitations. First, due to data availability constraints, the current quantitative indicator system cannot fully capture the long-term benefits and implicit values of ecological products (e.g., long-term contributions of ecosystem regulatory functions). Second, purely quantitative metrics are inherently limited in their ability to fairly evaluate regional performance. For instance, forest coverage may naturally reach 90% in southeastern China yet remain as low as 10% in northwestern regions—a disparity rooted in divergent ecological baselines rather than variations in the efficacy of value realisation efforts; the value realisation of pollution purification services is more pronounced in heavily polluted areas, whereas it cannot be realised or quantified in pollution-free regions. Third, insufficient attention has been paid to the heterogeneous characteristics of different types of ecological products, which limits the accuracy and relevance of the effectiveness evaluation results. Notably, the Ministry of Ecology and Environment (MEE) of China has developed an effectiveness evaluation system for the realisation of ecological products value, including both quantitative and qualitative indicators, for the pilot demonstration projects it launched [20]. This expert-scoring system, though widely applied in some regions, proves difficult to implement when a common national set of indicators is used across different tiers of areas. Existing studies rarely focus on the construction logic of the evaluation system, the indicator screening process, or the verification of its rationality, making it challenging to develop systematic solutions that can directly inform policymaking. The academic community urgently needs to innovate existing effectiveness evaluation systems to further enhance the universality and accuracy of evaluation methods.

This study, therefore, employs an objective-strategy-measurement (OSM) analytical framework to innovatively design a scale for evaluating the perceived effectiveness of value realisation across different types of ecological products. This scale, developed through a dual mechanism of ‘objective data + expert calibration’, aims to provide scientific support for practical decision-making and policy optimisation. To verify the usability and adaptability of the scale, this study used the Beijing–Tianjin–Hebei (BTH) region as a case study to implement and test its effectiveness. The remainder of this paper is organised as follows: Section 2 constructs a framework for evaluating perceived effectiveness; Section 3 introduces the study area and data sources; Section 4 presents the evaluation results from applying the scale to the BTH region; and Section 5 briefly summarises and discusses the core findings.

2. Analytical Framework

2.1. OSM Analysis

OSM is an analytical framework that originates in classical management thinking and has been refined, summarised, and standardised in recent years through the internet and digital operations practices as a versatile strategic planning tool. The principle is to decompose overarching objectives into corresponding strategies and specific, implementable, and measurable actions, thereby ensuring that the implementation plan does not deviate from the overall direction [21]. With its clear hierarchy and progressive structure, it is highly suitable for deconstructing systemic initiatives such as ecological products value realisation in the BTH region. Hence, it was used specifically to evaluate the perceived effectiveness of value realisation across all three ecological products categories (Figure 1).

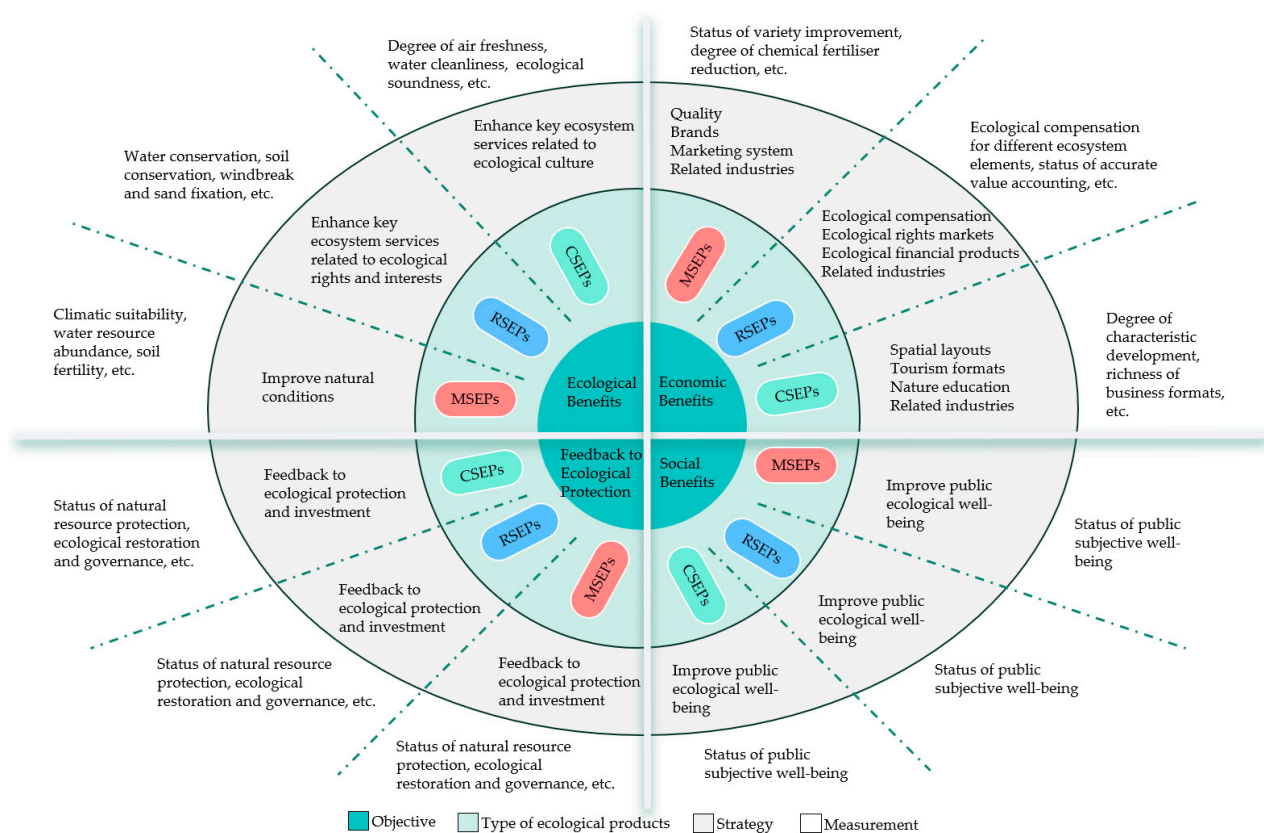


Figure 1. OSM framework.

The “O” (objective) addresses the directional question of “why we are doing this.” The three ecological products categories are fundamentally aligned in their objectives. In

addition to delivering ecological, economic, and social benefits, there is a crucial fourth dimension—leveraging economic returns to further ecological protection, creating a self-reinforcing cycle of conservation.

The “S” (strategy) tackles the pathway question of “how we achieve the objective,” and the “M” (measurement) answers the evaluation question of “how we assess performance.” Their concrete applications vary notably across the three ecological products categories.

- (1) MSEPs value realisation. The key strategy for achieving ecological benefits is to improve natural environmental factors for products growth, including climate, water, and soil. Four strategies can be adopted to achieve economic benefits—first, enhancing products quality through quality improvement and green input; second, building ecological brands based on regional or product characteristics and promotion; third, optimising the production and marketing operation systems, such as the operation and logistics systems; and fourth, driving the development of related industries, especially agriculture and rural development. Strategies for achieving social benefits and providing feedback for ecological protection primarily involve improving public ecological well-being, implementing ecological protection measures, and investing in funds. These can be measured based on the public’s subjective well-being, the status of natural resource protection, and the progress of ecological restoration and governance.
- (2) RSEPs value realisation. The key strategy for achieving ecological benefits is to enhance the ecosystem services currently recognised by the market for trading rights, such as water conservation, water purification, and carbon sequestration. Four strategies can be adopted to achieve economic benefits—first, improving various types of ecological compensation systems; second, fostering the ecological rights trading market throughout the entire process; third, innovatively designing new types of ecological financial products, such as ecological credit loans, securities, and funds; and fourth, driving the development of related industries, which can be measured using indicators such as market scale and the income of market entities. The strategies for achieving social benefits and feeding back into ecological protection were the same as those for MSEPs value realisation.
- (3) CSEPs value realisation. The key strategy for achieving ecological benefits is to enhance ecosystem services that are closely associated with ecological and cultural experiences, such as fresh air, clean water bodies, and beautiful landscapes. Four strategies can be adopted to achieve economic benefits—first, optimising the spatial layout and routes of ecotourism; second, innovating and developing tourism formats, such as rural tourism, sports tourism, and study tourism; third, strengthening efforts in promotion and nature education; and fourth, driving the development of related industries. The strategies for achieving social benefits and feeding back into ecological protection were the same as those for MSEPs value realisation.

A detailed breakdown of the OSM framework is available in Supplementary Materials S1.

2.2. Design of the Evaluation Scales

Through the OSM analysis, with reference to relevant policy documents (see Supplementary Materials S2), and under the guidance of the principles of scientificity, systematicity, guidance, and feasibility, an initial set of three distinct scales was designed for categorical evaluation—the perceived effectiveness index of value realisation for MSEPs (PEM) evaluation scale, the perceived effectiveness index of value realisation for the RSEPs (PER) evaluation scale, and the perceived effectiveness index of value realisation for CSEPs (PEC) evaluation scale.

Subsequently, the preliminary scale was refined through a structured Delphi process. This involved a multidisciplinary panel of professionals from relevant backgrounds, including ecology, public administration, ecological economics, and agricultural economics. All panel members possessed over eight years of professional experience and were affiliated with institutions such as national research academies, and university departments. An iterative process of two consultation rounds was conducted to converge toward a consensus on the final item set (see Supplementary Materials S3).

Finally, the PEM evaluation scale and sub-indices for the different objectives (denoted as PEME, PEMB, PEMS, and PEMF) were determined (Table 1), totalling 18 evaluation items.

Table 1. The PEM evaluation scale.

Index Name	Sub-Index Name	Item No.	Item
PEM	PEME	1	Climatic suitability
		2	Water resource abundance
		3	Soil fertility
	PEMB	4	Status of variety improvement
		5	Effectiveness in chemical fertilizer reduction
		6	Development level of green production technologies
		7	Development of cold chain logistics system
		8	Effectiveness of regional brand building
		9	Effectiveness of products brand building
		10	Effectiveness of enterprise brand building
		11	Status of business entity development
		12	Development level of agricultural socialized services
	PEMS	13	Contribution to rural household income improvement
		14	Contribution to urban-rural coordinated development
		15	Residents' sense of gain
		16	Residents' sense of happiness
	PEMF	17	Feedback to sustainable natural resource management
		18	Feedback to investment in ecological restoration and governance

Note: In the actual evaluation questionnaire, all the above items are presented under a unified question framework to ensure consistent evaluation criteria while maintaining clarity and ease of understanding for expert respondents. For example, the complete question for "Climatic suitability" would be "To what extent does the climatic suitability in this area impact the value enhancement of MSEPs?" The other two scales adhere to the same structural framework.

The PER evaluation scale and sub-indices under different objectives (denoted as PERE, PERB, PERS, and PERF) were determined (Table 2), with a total of 18 evaluation items.

The PEC evaluation scale and its subindices under the different objectives (PECE, PECB, PECS, and PECF) were determined (Table 3), totalling 19 evaluation items.

Table 2. The PER evaluation scale.

Index Name	Sub-Index Name	Item No.	Item
PER	PERE	1	Water conservation function
		2	Soil conservation function
		3	Windbreak and sand fixation function
		4	Water purification function
		5	Carbon sequestration function
	PERB	6	Element-based compensation mechanism
		7	Regional/watershed compensation mechanism
		8	Ecological products value accounting
		9	Natural resource rights confirmation
		10	Ecological rights trading mechanism
		11	Green credit products
		12	Green securities products
	PERS	13	Income of participating entities
		14	Farmers' ecological well-being
		15	Residents' sense of gain
		16	Residents' sense of happiness
	PERF	17	Feedback to sustainable natural resource management
		18	Feedback to investment in ecological restoration and governance

2.3. Scoring of Evaluation Items, Determination of Weights, and Calculation of Indices

For each item, an expert scoring method was adopted, and a 1-to-5 Likert scale was developed, where 1 point indicated “very little impact” and 5 points indicated “very significant impact.” In rare instances, a score of 0 was reserved for items judged to have a severely detrimental effect, such as when scenic area development causes significant ecological damage. For each item, detailed information on the development status and effectiveness of the evaluation area was collected to enable experts to make fair judgments (see Supplementary Materials S4–S6). The scoring process involved two stages—first, independent evaluation by six experts specialising in ecological civilisation construction, ecological product value realisation, and protection-development coordination; second, a structured workshop for in-depth discussion, which led to a convergent set of consensus scores for each item. This very process of reaching consensus inherently ensures the internal consistency of the final scores in terms of content and validity.

An analytic hierarchy process (AHP) was adopted to determine the indicator weights. This method combines quantitative and qualitative analyses, utilising decision-makers' experiences to assess the relative importance of criteria for achieving each measurement objective and to assign reasonable weights to each criterion within each decision-making scheme. It then uses these weights to derive the priority ranking of different schemes, and is effectively applied to research topics that are difficult to solve using quantitative methods [22].

Table 3. The PEC evaluation scale.

Index Name	Sub-Index Name	Item No.	Item
PEC	PECE	1	Air quality
		2	Water quality
		3	Landscape quality
		4	Biodiversity richness
	PECB	5	Spatial layout of ecological scenic spots
		6	Planning of ecotourism routes
		7	Construction of ecological scenic spots
		8	‘Ecology + rural leisure’ tourism
		9	‘Ecology + health and wellness’ tourism
		10	‘Ecology + study tours’ tourism
		11	‘Ecology + sports’ tourism
		12	‘Smart tourism
		13	Ecotourism festival activities
	PECS	14	Development of related industries
		15	Nature education and cultural inheritance
		16	Residents’ sense of gain
		17	Residents’ sense of happiness
	PECF	18	Feedback to sustainable natural resource management
		19	Feedback to investment in ecological restoration and governance

The specific operation steps were as follows: (1) for the index and sub-index layers, Yaahp 10.3 software was used to design the weight questionnaire; (2) professionals who participated in the scale optimisation were invited to conduct pairwise comparisons of items at different levels and sort them by importance, with the importance divided into 17 grades (from 1, least important, to 17, most important); (3) the professionals’ scoring results were aggregated to obtain the average score; and (4) the Yaahp 10.3 software was used to test the consistency of the professionals’ scores (Table 4), and calculate the importance of each item based on the values in the matrix, thereby deriving weights (Table 5).

Table 4. Results of the consistency test.

Judgment Matrix	CR	Judgment Matrix	CR	Judgment Matrix	CR
PEM	0.0931	PER	0.0701	PEC	0.0909
PEME	0.0707	PERE	0.0691	PECE	0.0954
PEMB	0.097	PERB	0.094	PECB	0.0871
PEMS	0.0912	PERS	0.0954	PECR	0.0705
PEMF	—	PERF	—	PECF	—

Table 5. Index weights.

PEM		PER		PEC	
Item No.	Item Weight	Item No.	Item Weight	Item No.	Item Weight
1	0.0264	1	0.0311	1	0.0729
2	0.1385	2	0.0475	2	0.0375
3	0.0605	3	0.0985	3	0.1376
4	0.0109	4	0.1391	4	0.0158
5	0.1701	5	0.1760	5	0.0843
6	0.1062	6	0.0062	6	0.0354
7	0.0249	7	0.0086	7	0.0271
8	0.0232	8	0.0069	8	0.0977
9	0.0567	9	0.0381	9	0.0513
10	0.0639	10	0.0357	10	0.1427
11	0.0357	11	0.0212	11	0.0448
12	0.0151	12	0.0170	12	0.0196
13	0.127	13	0.0426	13	0.0129
14	0.0111	14	0.0185	14	0.0562
15	0.0384	15	0.0098	15	0.0072
16	0.0218	16	0.0050	16	0.0243
17	0.058	17	0.1988	17	0.0115
18	0.0116	18	0.0994	18	0.0404
				19	0.0808
Total	1		1		1

Based on the expert scores and index weights, the value of each index is calculated using the following formula:

$$PEM = \sum_{i=1}^{18} M_i \times w_i$$

$$PER = \sum_{i=1}^{18} R_i \times u_i$$

$$PEC = \sum_{i=1}^{19} C_i \times v_i$$

where M_i , R_i , C_i represent the scores of the i -th item of the three types of effectiveness indices, and w_i , u_i , v_i represent the weights of the i -th item of the three types of effectiveness indices.

To enhance the intuitiveness of result presentation and reflect a specific region's relative position among all evaluated subjects, a unitisation method (also known as Min-Max scaling) was applied to each index and sub-index, rescaling their values to the range 0 to 1. The formula is as follows:

$$X'_{ij} = \frac{X_{ij} - \min_{X_{ij}}}{\max_{X_{ij}} - \min_{X_{ij}}}$$

In the formula, X'_{ij} denotes the standardised value of the i -th item in the j -th region, X_{ij} denotes the actual value of the i -th item in the j -th region, and $\max_{X_{ij}}$ and $\min_{X_{ij}}$ represent the maximum and minimum values of the j -th region, respectively.

Municipal-level administrative units usually possess the comprehensive capacity to coordinate all three ecological products value realisation models, necessitating an evaluation of their synergistic development effectiveness. Therefore, the coordinated coupling degree (CCD) of the three indices (PEM, PER, and PEC) for each region was calculated to analyse the comprehensive effectiveness of regional ecological products value realisation. The CCD model can explain the interdependencies, associations, and relationships among different systems [23]. The formula is as follows:

$$C = 3 \times \left[\frac{PEM \times PER \times PEC}{(PEM + PER + PEC)^3} \right]^{\frac{1}{3}}$$

$$T = \gamma_1 PEM + \gamma_2 PER + \gamma_3 PEC$$

$$D = \sqrt{C \times T}$$

where C and D are the coupling and coordination degrees of PEM , PER and PEC , respectively. T is the comprehensive coordination value of PEM , PER and PEC , γ_1 , γ_2 and γ_3 are the weight coefficients. In view of the equal importance of the three indices, $\gamma_1 = \gamma_2 = \gamma_3 = 1/3$.

3. Study Area and Data Sources

3.1. Study Area

The scales were applied to evaluate the perceived effectiveness of ecological products value realisation in the BTH region (Figure 2). Geographically and culturally connected, the BTH region forms an integrated area with a total area of 216,000 km². Its landforms are characterised by mountainous areas in the northwest (approximately 60% of the total area), plains in the southeast, and coastal zones along the Bohai Sea. Comparing the 13 cities, this region has a population of over 100 million. In 2014, the BTH-coordinated development strategy was established as a national strategy. Currently, its total economic output exceeds 10 trillion yuan and is gradually becoming one of the most dynamic, open, and innovative regions of China's economy.

Ecological coordination is a key component of the coordinated development of the BTH region. Regions within the BTH region have promoted collaborative development across multiple fields, including joint prevention and control of air and water pollution, the construction of ecological security barriers (with forest coverage increasing from 21% in 2014 to 26% in 2022), and the transition to green, low-carbon practices. They also explored cross-regional ecological compensation and ecological rights trading mechanisms, with cumulative compensation funds exceeding 15 billion yuan since 2018, making the BTH region highly representative of the realisation of ecological products value.

3.2. Data Sources

The data for index calculation were derived from expert scores. Multiple data sources were employed to ensure that experts could make well-informed judgments, including (1) official statistics and departmental data, such as statistical yearbooks, bulletins, and data/reports from agricultural, environmental, and natural resources departments at various levels; (2) openly accessible geospatial data; (3) other social data platforms, social media, and platform information; and (4) academic research literature. This integrated system combines macro-level statistics with micro-level evidence, and objective records

with subjective perceptions, providing comprehensive support for the scale evaluations (see Supplementary Materials S4–S6).

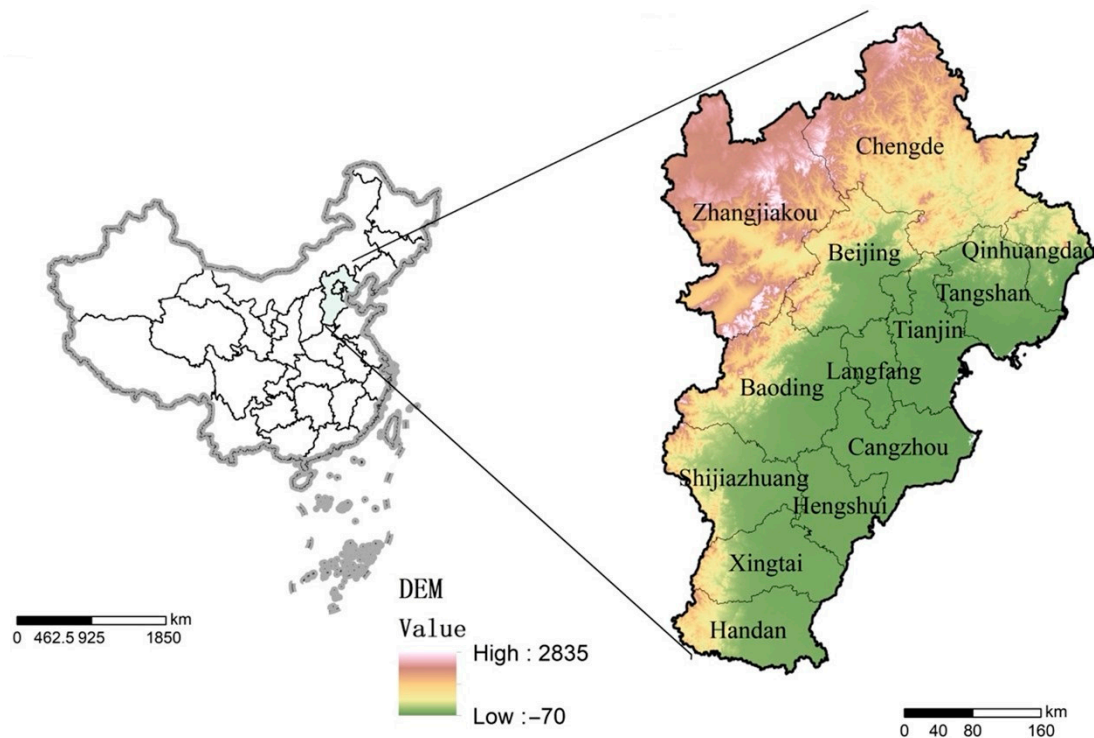


Figure 2. The location of the BTH region.

4. Results

4.1. Evaluation Results of PEM, PER and PEC

The evaluation results of the perceived effectiveness of ecological products value realisation in the BTH region are presented in Figure 3. Compared to relying solely on objective indicators, the study reveals new insights into less tangible dimensions, such as “institutional effectiveness” and “perceived value,” that are difficult to quantify.

The average PEM value of the BTH region was 0.7054, whereas that of Hebei Province was 0.6871, both falling within the above-average level. There were significant differences between cities, presenting an evident gradient distribution. Beijing ranks first with a PEM value of 0.8492, the only city to exceed 0.8. This is primarily attributed to Beijing’s substantial investment in ecological protection and active trading markets. The second echelon consists of five cities, namely Chengde (0.7857), Tianjin (0.7629), Baoding (0.7502), Shijiazhuang (0.7298), and Handan (0.7279), with PEM values ranging between 0.7 and 0.8. These cities possess unique ecological advantages—northern cities are rich in forest resources, while central and southern cities have extensive cultivated land, leading to good effectiveness in realising the value of MSEPs. An additional seven cities—Langfang (0.6796), Tangshan (0.6723), Qinhuangdao (0.6531), Zhangjiakou (0.6529), Cangzhou (0.6505), Xingtai (0.6454), and Hengshui (0.6113)—presented PEM values between 0.6 and 0.7. Most of these cities focus on industrial development, and some are located on the eastern coastal plains, both of which are unfavourable for cultivating high-quality ecological elements and producing ecological material products. Despite sharing similar ecological foundations, Chengde and Zhangjiakou have pursued divergent pathways in brand development and market mechanisms, resulting in big differences in their perceived effectiveness outcomes.



Figure 3. Spatial Distribution of PEM, PER and PEC in the BTH Region.

The average PER value of the BTH region was 0.6482, whereas that of Hebei Province was 0.6303, both at medium levels. There were significant differences between cities, showing an evident gradient distribution. Tianjin ranked first with a PER value of 0.7595, followed by Beijing (0.7343), Chengde (0.7571), and Zhangjiakou (0.7506), which also performed well. This is primarily due to the abundant forest resources in these areas and their extensive practices in the cross-regional coordinated allocation of water resources, as well as the positive results achieved in water rights trading, trans-basin ecological compensation, carbon sink trading, and other fields. The second echelon comprised four cities—Baoding (0.6949), Shijiazhuang (0.6667), Handan (0.6186), and Qinhuangdao (0.6247)—with PER values ranging between 0.6 and 0.7. These cities have achieved good results in terms of the quantitative monetisation of ecological rights. Five cities, namely Langfang (0.5372), Tangshan (0.6093), Cangzhou (0.5836), Hengshui (0.5119), and Xingtai (0.5788), had PER values below 0.6, among which Hengshui had the lowest. Most of these cities focus on industrial development (which significantly interferes with ecological regulatory services) or have incomplete ecological rights-trading mechanisms, resulting in poor performance in the quantitative monetisation of ecological rights. Additionally, although Tangshan and Tianjin share a similar industrial foundation, the marked divergence in their PER scores underscores how the “market mechanism maturity”—a critical soft dimension—leads to varied effectiveness in ecological products value realization.

The average PEC value for the BTH region was 0.6052, whereas that for Hebei Province was only 0.5755, ranking lowest among the three types of ecological products. The BTH region remains a key area for the national prevention and control of air pollution, water pollution, and other environmental issues, and is also frequently affected by sand and dust weather. These factors have posed obstacles to the realisation of the value of ecological and cultural services. Only Beijing (0.8360) presented a PEC value exceeding 0.8, which benefits from its diverse forms of ecological and cultural services, well-developed eco-tourism industry, and highly effective value realisation. Three cities—Baoding (0.7385), Zhangjiakou (0.7362), and Tianjin (0.7003)—had PEC values between 0.7 and 0.8, showing good effectiveness in value realisation. Qinhuangdao (0.6632), Shijiazhuang (0.6505), and Chengde (0.6425) presented PEC values ranging from 0.6 to 0.7, with moderate effectiveness in value realisation. Six cities, Handan (0.5546), Xingtai (0.5448), Tangshan (0.5410), Langfang (0.4516), Cangzhou (0.4351), and Hengshui (0.3730), had PEC values below 0.6. These cities still have significant room for improvement in aspects such as the supply quality of ecological and cultural services, market promotion, and integrated development with other industries.

The CCD results of the PEM, PER, and PEC in the BTH region are presented in Table 6. Overall, the CCD in the BTH region exhibits a “high in the north and low in the south” pattern, with significant differences in *D*-values across cities. Beijing had a *D*-value as high as 0.9776, reflecting its comprehensive advantages. Tianjin (0.8725) and Shijiazhuang (0.7551) also have relatively high *D*-values, benefiting from their developed economies and markets that drive coupled development through the realisation of economic value. Chengde (0.8635), Baoding (0.8334), and Zhangjiakou (0.7161) rely on their abundant forest and cultivated land resources, promoting coupled development with ecological advantages. Handan (0.6614), Qinhuangdao (0.6108), and Tangshan (0.5793) had moderate *D*-values, indicating that the comprehensive effectiveness of ecological products value realisation still needs improvement. Xingtai (0.4991), Cangzhou (0.4387), Langfang (0.4222), and Hengshui (0.1) showed poor overall effectiveness due to limited forest resources, underdeveloped economies, and small populations. Among these cities, the *D*-value of Hengshui is much lower than that of the other cities. Strategic prioritisation is imperative for optimising the value realisation of ecological products in regions constrained by limited resource endowments and underdeveloped foundations.

Table 6. Results of CCD in the BTH region.

<i>D</i> -Value Range	Number of Cities	City (Value)
0.9–1.0	1	Beijing (0.9776)
0.8–0.9	2	Tianjin (0.8725), Chengde (0.8635)
0.7–0.8	3	Baoding (0.8334), Shijiazhuang (0.7551), Zhangjiakou (0.7161)
0.6–0.7	1	Handan (0.6614)
0.5–0.6	2	Qinhuangdao (0.6108), Tangshan (0.5793)
0.4–0.5	3	Xingtai (0.4991), Cangzhou (0.4387), Langfang (0.4222)
0–0.4	1	Hengshui (0.1)

4.2. Evaluation Results of PEM Sub-Indices

Due to the varying scores of each item, the actual contribution rates of the different sub-indices to PEM differ. Based on the perceived effectiveness evaluation results (Table 7), the contribution rate of PEME ranged from 17.87% to 23.62%, with an average of 20.52%, which was lower than its fixed weight (22.54%). This indicates that high-quality ecological elements are not sufficiently reflected in the value of ecological products. The contribution rate of PEMB varied between 40.12% and 54.94% with an average of 47.18%, which was

below its fixed weight (50.67%). This suggests that further improvements in quality and efficiency are required to realise economic benefits. The contribution rate of PEMS ranged from 17.37% to 28.52%, averaging 23.82%, which was higher than its fixed weight (19.83%). This demonstrates that the BTH region has achieved positive results by increasing the income of ecological protectors and enhancing residents' sense of gain and happiness. The contribution rate of the PEMF ranged from 6.83% to 10.66%, with an average of 8.49%, exceeding its fixed weight (6.96%). This reflects the feedback effect of ecological products value gains on ecosystems.

Table 7. Results of contribution rates of PEM sub-indices in the BTH Region. Unit: %.

	Beijing	Tianjin	Shijiazhuang	Chengde	Zhangjiakou	Qinhua- ngdao	Tangshan	Langfang	Baoding	Cangzhou	Hengshui	Xingtai	Handan
PEME	19.91	17.87	23.62	19.42	18.66	20.65	23.42	18.64	22.98	18.14	18.21	22.83	22.35
PEMB	52.50	49.67	45.67	54.94	45.88	45.09	40.12	47.88	45.28	48.76	46.71	43.96	46.84
PEMS	20.76	24.85	23.08	17.37	24.80	23.95	28.52	25.62	22.47	24.89	25.60	24.58	23.15
PEMF	6.83	7.60	7.63	8.27	10.66	10.30	7.94	7.85	9.28	8.20	9.49	8.63	7.65

Based on the perceived effectiveness evaluation results, the spatial distribution of PEM sub-indices in the BTH region is presented in Figure 4. The PEME was relatively high in the central cities but low in the coastal areas. PEMB was higher in cities surrounding Beijing and relatively low in central and southern cities. PEMS was higher in central cities but lower in the northern and southern regions, and PEMF was higher in northwestern cities but lower in southeastern areas. As the core city of the BTH region, Beijing has obvious advantages in all four subindices. This also indicates that the realisation of ecological products value requires the integration of ecological elements with multiple factors, such as the economy, market, and technology, to achieve maximum benefits. Cities surrounding Beijing, including Tianjin, Shijiazhuang, Baoding, and Langfang, have relatively high performance in PEMS and PEMF, with outstanding results in driving people's well-being and feedback benefits. However, their PEMB remained at a medium level, indicating that the economic value of material-supply-type ecological products warrants further exploration. In northwestern mountainous areas, such as Zhangjiakou, Chengde, and Qinhuangdao, PEMF outperforms other regions, indicating that these cities have achieved remarkable results in channelling benefits back into ecological protection, which is conducive to forming a closed loop of the ecological products value chain. The PEME of Zhangjiakou was relatively backward, indicating that its ecological environment has remained fragile. Tangshan and Cangzhou, located in the eastern coastal area, showed outstanding performance in the PEMS, with significant results in promoting people's well-being. Nevertheless, their PEMB is relatively low, indicating a need to enhance their ability to convert economic benefits. Their PEME is at a medium level, requiring further consolidation of the foundation for ecological elements. Hengshui, Xingtai, and Handan in the southern plains had high PEMS and PEMF values, but their PEME and PEMB values were generally low. Restricted by insufficient natural conditions and underdeveloped markets, these cities perform poorly in terms of factor input for material-supply-type ecological products and economic conversion capacity. In summary, the observed regional differentiation reveals distinct path dependencies in ecological products value realisation, necessitating the construction of region-specific implementation pathways, while the resulting development disparities must be addressed through enhanced regional coordination.

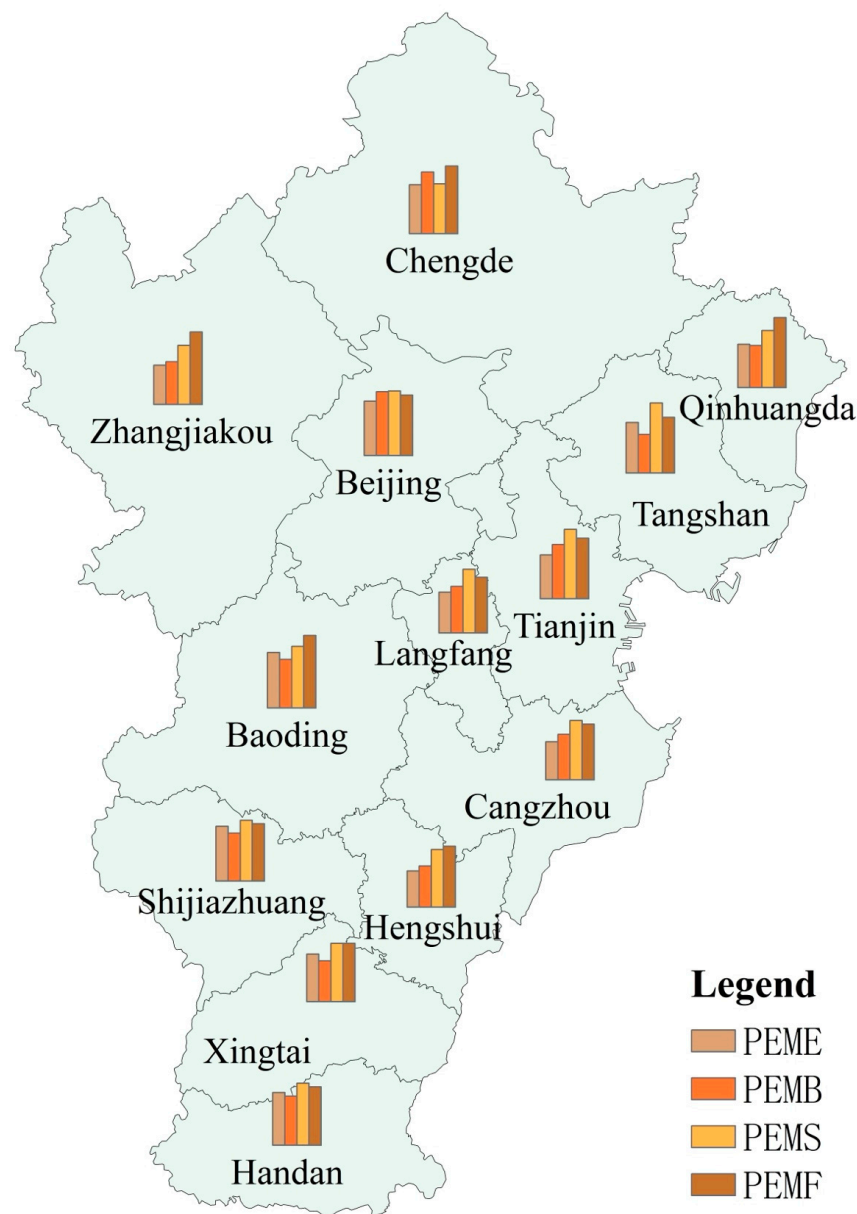


Figure 4. Spatial Distribution of PEM sub-indices in the BTH Region.

4.3. Evaluation Results of PER Sub-Indices

Similarly, the actual contribution rates of the different sub-indices to the PER vary. Based on the perceived effectiveness evaluation results (Table 8), the contribution rate of PERE ranged from 13.24% to 18.76% with an average of 15.83%, which was lower than its fixed weight (17.23%). This suggests that the input of ecological regulatory functions is not adequately reflected in the RSEP values. The contribution rate of PERB ranged from 38.56% to 49.87%, averaging 43.21%, which was below its fixed weight (45.12%). This suggests that further improvements in quality and efficiency are required to realise economic value. The contribution rate of PERS ranged from 15.67% to 26.34% with an average of 20.89%, whereas the contribution rate of PERF varied between 8.92% and 12.54% with an average of 10.07%. Both values were higher than their respective fixed weights (18.95% and 9.68%, respectively). This demonstrates that, through the quantitative monetisation of ecological rights, farmers who previously suffered economic losses from engaging in ecological protection now obtain tangible benefits. This has effectively increased their enthusiasm for participating in ecological protection, playing a positive role in enhancing

people's well-being and promoting the sustainable implementation of ecological protection and restoration.

Table 8. Results of contribution rates of PER sub-indices in the BTH Region. Unit: %.

	Beijing	Tianjin	Shijiazhuang	Chengde	Zhangjiakou	Qinhuangdao	Tangshan	Langfang	Baoding	Cangzhou	Hengshui	Xingtai	Handan
PERE	47.81	46.39	44.30	53.90	51.38	56.64	51.28	52.44	50.43	52.92	65.36	57.24	53.55
PERB	16.44	15.94	17.02	13.17	11.25	12.44	13.90	11.19	11.93	12.36	10.95	9.87	13.99
PERS	8.67	8.00	6.87	4.92	2.94	3.34	7.64	4.30	4.26	5.20	4.27	5.41	6.76
PERF	27.07	29.67	31.81	28.01	34.43	27.58	27.19	32.07	33.38	29.52	19.42	27.48	25.71

Based on the perceived effectiveness evaluation results, the spatial distribution of PER sub-indices in the BTH region is presented in Figure 5. Overall, the spatial distribution of PERE follows a pattern in which northern cities have higher values than central cities, and central cities have higher values than southern ones. Large cities in the northern and western regions had relatively high PERB values, whereas other cities had slightly lower values, showing significant spatial differences. In terms of the PEMS, Beijing and Tianjin stand out prominently, whereas the other cities have low values with substantial disparities. PERF presented a pattern of high values in the northwest and low values in the southeast.

As two megacities in the BTH region, Beijing and Tianjin lead both the PERB and PERS. They explored various innovative models in ecological compensation, ecological rights trading, and green financial product design, taking the forefront of realising the economic value of regulatory service-type ecological products and driving people's well-being. Shijiazhuang performed well in both PERB and PERF, demonstrating a strong ability to convert regulatory services into economic benefits and feed these benefits back into ecological protection. Chengde and Zhangjiakou, located in the northwestern mountainous areas, led other regions in PERE and PERF. Benefiting from their vast forest areas, these two cities have achieved remarkable results in terms of input into regulatory services and the use of benefits to support ecological protection. Cities such as Qinhuangdao, Baoding, Langfang, Cangzhou, and Xingtai share a similar sub-index structure with Chengde and Zhangjiakou, but with lower values. There is an urgent need for these cities to explore the value conversion pathways for regulatory-service-type ecological products in farmland ecosystems. Tangshan and Handan had relatively similar PERE and PERB values, which were slightly higher than their PEMS and PERF values. This indicates a relatively balanced performance in input into regulatory services and the realisation of economic value. However, there is still room for improvement in enhancing people's well-being and providing ecological benefits. Hengshui has only a medium-level PERE, whereas its other subindices rank the lowest among all regions. This suggests that the overall effectiveness of value realisation for regulatory-service-type ecological products in Hengshui is relatively weak.

4.4. Evaluation Results of PEC Sub-Indices

From the perspective of the actual contribution rates of the PER sub-indices (Table 9), the contribution rate of PECE ranged from 17.99% to 38.76%, with an average of 25.56%, which was slightly lower than its fixed weight (26.38%). This indicates that the supporting role of a high-quality ecological environment on the value of CSEPs was not prominently reflected within the region. The contribution rate of the PECB ranged from 39.60% to 54.72%, averaging 47.68%, which is below its fixed weight (51.58%). This suggests that the ability to convert CSEPs into economic benefits needs to be strengthened. The contribution rate of the PECS varied between 7.83% and 14.49%, with an average of 10.79%, which was slightly higher than its fixed weight (9.92%). This demonstrates that specific achievements have been made in increasing the income of ecological protectors and enhancing the

residents’ sense of gain and happiness. The contribution rate of PECF ranged from 12.58% to 21.47%, averaging 15.97%, which was higher than its fixed weight (12.12%). This reflects the feedback effect of the benefits of the CSEPs on ecosystem protection and development.

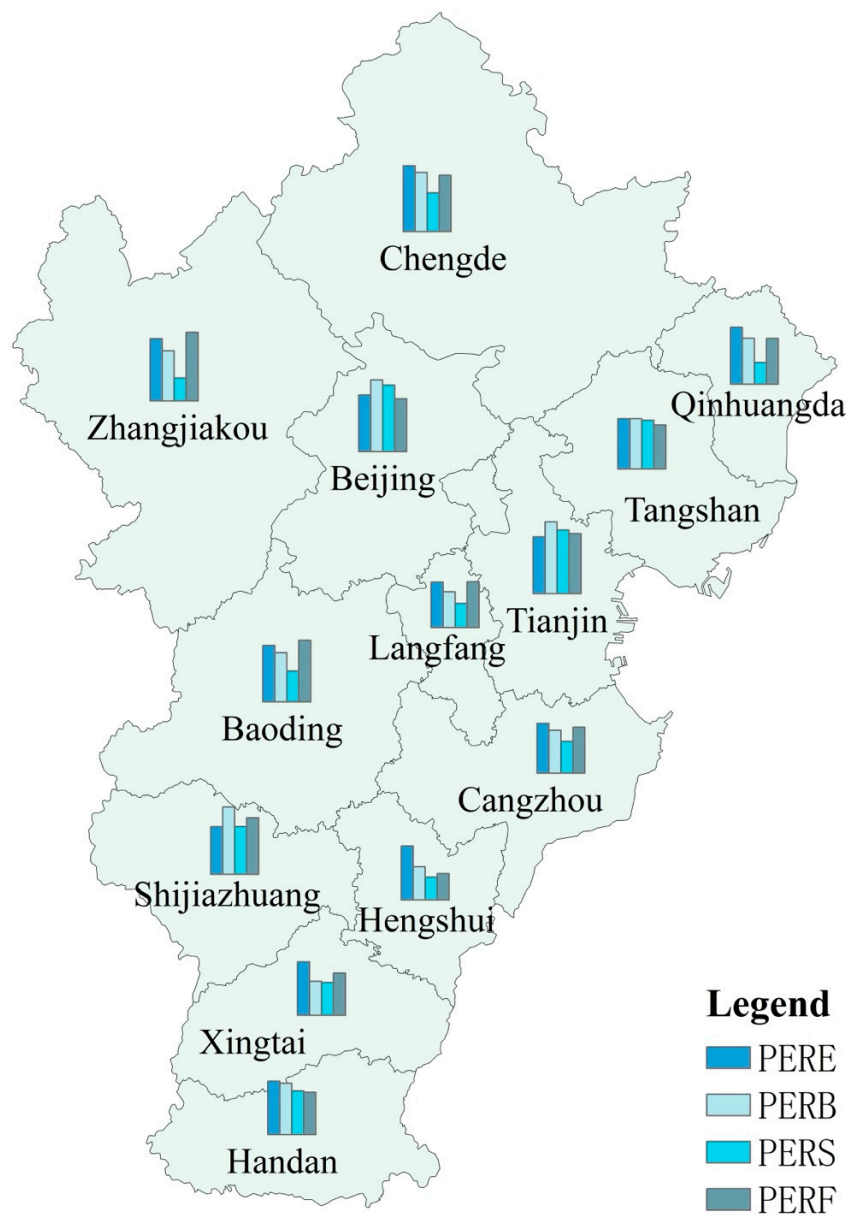


Figure 5. Spatial distribution of PER sub-indices in the BTH Region.

Table 9. Results of contribution rates of PEC sub-indices in the BTH Region. Unit: %.

	Beijing	Tianjin	Shijiazhuang	Chengde	Zhangjiakou	Qinhua- ngdao	Tangshan	Langfang	Baoding	Cangzhou	Hengshui	Xingtai	Handan
PECE	20.83	19.25	23.56	38.76	31.99	29.63	25.34	24.70	22.19	20.52	24.23	17.99	22.28
PECB	58.27	53.84	46.90	39.60	46.47	46.83	49.35	41.08	51.88	49.04	46.16	54.72	52.43
PECS	11.72	12.49	14.02	9.06	7.83	8.93	12.61	12.75	10.61	11.87	10.12	9.50	11.45
PECF	9.18	14.42	15.53	12.58	13.72	14.62	12.69	21.47	15.32	18.57	19.50	17.80	13.84

Based on the perceived effectiveness evaluation results, the spatial distribution of PEC sub-indices in the BTH region is presented in Figure 6. PECE showed a gradual decreasing trend from north to south. Except for Beijing, which has a wide margin, all the other regions have relatively low values with significant disparities. The PECS was higher in the large

central and western cities and lower in other areas. The PECF was generally high, with the central regions being more prominent.

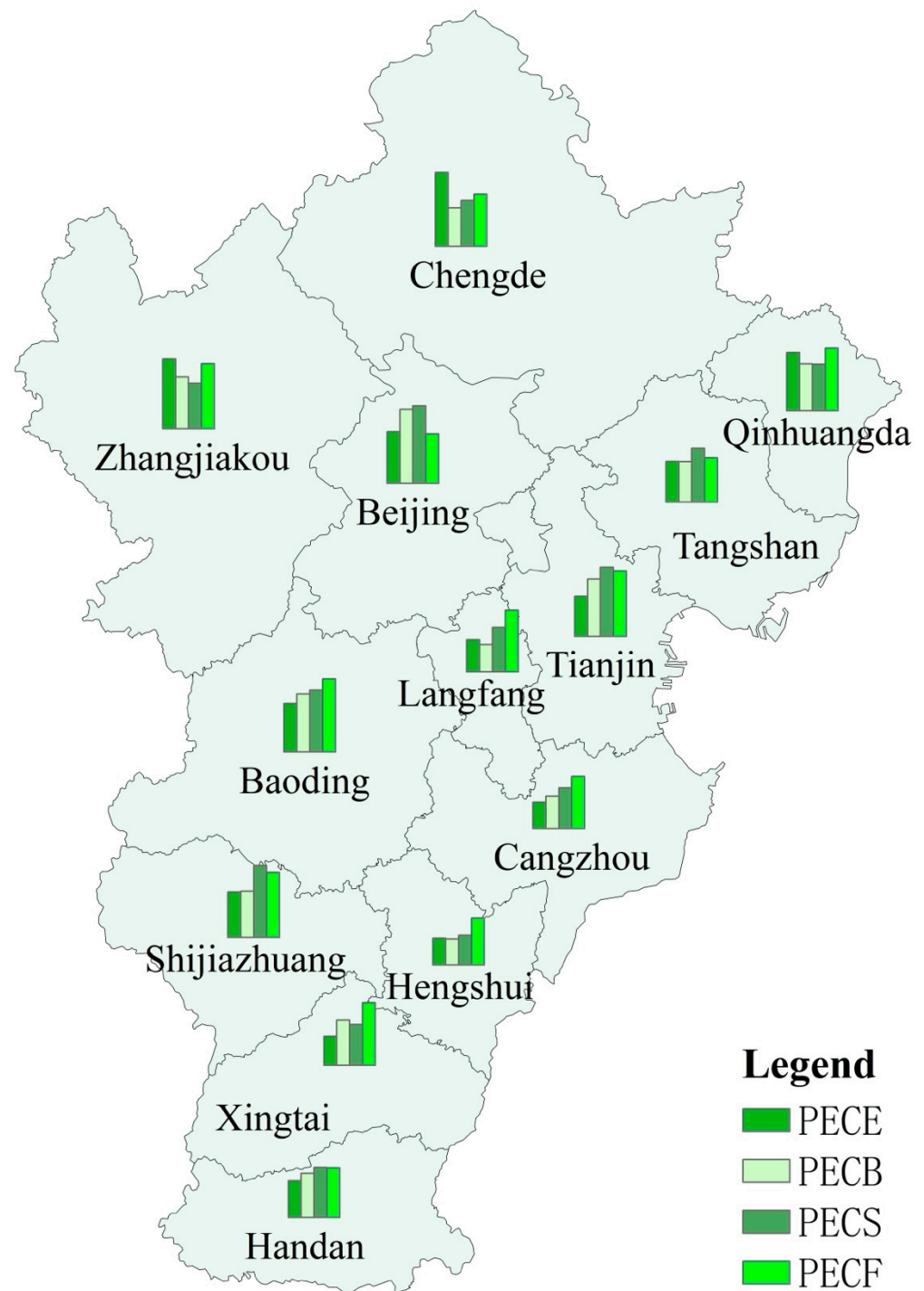


Figure 6. Spatial distribution of PEC sub-indices in the BTH Region.

Beijing has notable advantages in PECB and PECS, demonstrating that, by leveraging its strong economic strength and broad market, it has achieved outstanding results in realising the economic value of CSEPs and driving people's well-being. However, its PECE and PECF were at a medium level; therefore, it is necessary to further explore the landscape value of high-quality ecological environments and to strengthen the feedback on benefits. Tianjin, Shijiazhuang, and Baoding are relatively common in PECS and PECF, whereas their PECE are at a medium level. This indicates that these cities have performed well

in enhancing their ecological and cultural well-being and providing feedback benefits for ecological protection. Nevertheless, there is room for improvement in cultivating the ecological context of CSEPs, and it is essential to further consolidate their resource base. Chengde, Zhangjiakou, and other cities in the northwestern mountainous areas lead in PECE, indicating that these cities have a high-quality ecological and cultural background. Zhangjiakou and Qinhuangdao led in PECF and have achieved good results in feeding back the benefits from the value of CSEPs. However, their PECB was at a medium level; therefore, the economic value of CSEPs warrants further exploration. All sub-indices of Tangshan were at a medium level, with PECS being slightly higher. It has achieved relatively balanced development across all dimensions but lacks clear advantages, resulting in insufficient driving force and benchmarking effect in the overall value realisation of CSEPs. Langfang and Xingtai had slightly higher PECF, whereas the other subindices were at low levels. This indicates that these two cities have taken certain actions to reap the benefits of CSEPs, but they remain relatively weak in areas such as enhancing ecosystem functions related to CSEPs, realising economic value, and promoting people's well-being. The full-chain development of CSEPs' value realisation is still inadequate. Cangzhou, Hengshui, and Handan in the southeast had poor levels in all sub-indices, indicating that these regions have various shortcomings in the exploration of CSEPs. Improvements are required across multiple aspects, including the basic reserves of ecological and cultural resources, conversion pathways for economic value, the effects of improving people's well-being, and the intensity of benefit feedback. The overall effectiveness of value realisation was relatively weak.

5. Discussion

The perceived effectiveness evaluation results show that the BTH region achieved relatively good effectiveness in MSEPs value realisation, whereas the effectiveness of RSEPs and CSEPs value realisation was moderate. Owing to the significant regional differences in ecological resource endowments among cities, there were large disparities in the evaluation results. Undoubtedly, Beijing occupies a core position—it not only has the highest level of comprehensive value realisation, but also drives the value realisation of areas surrounding it. Within Hebei Province, the northern mountainous areas have a rich variety of ecological products and achieve relatively high value realisation effectiveness, followed by the central areas, while the southern coastal areas show poor value realisation effectiveness. It is evident that a solid ecological foundation and market mechanisms are key supports for the value realisation of ecological products. After economic benefits are realised, they must be fed back to the ecological and social spheres to form a closed loop in the value chain. Only in this way can the endogenous motivation for ecological protection be stimulated, and the sustainability of value realisation be ensured.

Looking ahead, given the path dependency in ecological products value realisation, the southern plain regions demonstrating weaker performance should establish leading rather than comprehensive development strategies—for instance, by prioritising the exploitation of the multidimensional value of farmland ecosystems. Furthermore, the development disparities arising from regional differentiation require more sophisticated coordination mechanisms, such as improving cross-regional ecological compensation and benefit-sharing systems, and establishing a unified ecological products trading platform for the BTH region to enhance the overall efficiency of regional value realisation. In this process, the core radiating and innovative leadership role of megacities like Beijing and Tianjin is evident; they should further promote the replication and dissemination of their experiences to surrounding areas through standardised model practices, innovative policy tools, and joint project development.

This framework provides new evidence and insights for evaluating the value realisation effectiveness of ecological products. First, it is a classified and multi-dimensional evaluation framework, which not only takes into account the characteristics of different types of ecological products but also covers the entire chain of “ecological background–economic conversion–social well-being–benefit feedback”. As a result, it can provide a more comprehensive reflection of the effectiveness of regional ecological products value realisation. Second, to address the ambiguity of ecological products value realisation effectiveness (which makes precise quantification difficult), a scale design approach that combines subjective and objective elements was introduced. It incorporates both objective data and authoritative experts’ opinions, establishing a dual verification mechanism of “objective data support + expert experience calibration”. Third, evaluation items for ecological subindices were developed separately based on the characteristics of specific ecological products. This enhances the applicability and targeting of the scales in specific scenarios.

Admittedly, due to the complexity of ecological products, the availability of data, and constraints on evaluation scenarios, no evaluation framework for the effectiveness of ecological products value realisation can be flawless. This study is no exception, presenting preliminary results that indicate considerable potential for methodological enhancement. The design of the scale items may be further refined by incorporating more dynamic and socioeconomic factors. This aims to reflect the long-term trends and comprehensive impacts more accurately. However, in the expert scoring process, subjective perceptions from different groups, such as managers, ecological protection practitioners, and the general public, can also be included. A “stratified weighting method” can be adopted to assign weights to different groups, thereby enhancing the representativeness of the evaluation results and their value for practical guidance.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land14112269/s1>, S1: OSM analysis of perceived effectiveness in ecological products value realization; S2: Policy documents referenced in the scale design; S3: Optimization of evaluation scales; S4: Item descriptions, evaluation criteria, and data sources of PEM evaluation scale; S5: Item descriptions, evaluation criteria, and data sources of PER evaluation scale; S6: Item descriptions, evaluation criteria, and data sources of PEC evaluation scale.

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Abbreviations

The following abbreviations are used in this manuscript:

MSEPs	Material-supply-oriented ecological products
RSEPs	Regulatory-service-oriented ecological products
CSEPs	Cultural-service-oriented ecological products
PEM	Perceived effectiveness index of MSEPs value realisation
PEME	Ecological sub-index of PEM
PEMB	Economic benefit sub-index of PEM
PEMS	Social effectiveness sub-index of PEM
PEFM	Benefit feedback sub-index of PEM
PER	Perceived effectiveness index of RSEPs value realisation
PERE	Ecological sub-index of PER
PERB	Economic benefit sub-index of PER
PERS	Social effectiveness sub-index of PER
PERF	Benefit feedback sub-index of PER
PEC	Perceived effectiveness index of CSEPs value realisation
PECE	Ecological sub-index of PEC
PECB	Economic benefit sub-index of PEC
PECS	Social effectiveness sub-index of PEC
PECF	Benefit feedback sub-index of PEC

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