Measurement and Comprehensive Evaluation of Eco-Economic Development Level in the Yangtze River Basin

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Abstract. The construction of ecological civilization and the protection of ecological environment are crucial to the green transformation of economic society and the high-quality development of ecological economy. Based on the panel data of the 11 provinces (municipalities) in the Yangtze River Basin from 2009 to 2023, this paper constructs an indicator system for measuring the ecological economic development levels, and uses entropy method and equidistance division method to measure it comprehensively. The research shows that the growth rate of ecological economy in the Yangtze River basin is significant and the trend is good during this period, and the downstream region is the first, followed by the middle, and the upper reaches are relatively lagging behind. Therefore, it is suggested that more efforts should be made to build a coordinated development mechanism of ecological economy in the Yangtze River basin, strengthen the construction of regional ecological compensation mechanism and improve the policy support system, so as to provide assistance and guidance for the sustainable development of ecological economy in the Yangtze River Basin.

Keywords: the Yangtze River Basin, ecological economy, entropy, proximity degree, equidistant division method

1 Introduction

The report of the 20th National Congress of the Communist Party of China explicitly states that achieving harmonious co-existence between humanity and nature constitutes one of the core essential requirements of Chinese-style modernization. Promoting the economic and social development towards a green and low-carbon trajectory represents a pivotal avenue for the realization of high-quality development[1]. At the current juncture, our attention to ecological civilization construction has reached an unprecedented height[2]. Against this backdrop, China's ecological environment protection work has witnessed a historic transformation, yielding globally-recognized accomplishments[3].

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Consequently, it is particularly crucial and of far-reaching significance to construct a scientific and reasonable eco-economic evaluation index system, accurately identify key ecological problems, and explore practical solutions.

Tracing back to its origin, the concept of "ecological economics" was first put forward in 1966 by the renowned American economist Boulding in his academic paper *The Economics of the Coming Spaceship Earth*[4]. Boulding incisively pointed out that the traditional economic development model, owing to its disregard for the natural ecological environment, had ensnared human economic activities in a detrimental cycle. This cycle was characterized by a mere semblance of growth, lacking the substance of genuine development.

In crucial areas such as the dynamic appraisal of the ecological-economic composite index and the precise measurement of development levels, numerous scholars have proffered research outcomes of profound value. Specifically, Sun Buzhong et al. (2017) constructed an evaluation index system for the eco-economic composite index from five significant dimensions: social development, economic growth, ecological construction, resource utilization, and environmental protection[5]. Employing the method of hierarchical cluster analysis, they scientifically categorized the eco-economic development levels of various regions under different dimensions into three types6[]. Sun Jianguo et al. (2021) innovatively designated input variables, desirable outputs, and undesirable outputs as the key indicators for evaluating eco-economic efficiency. Through empirical research methods, they conducted a comprehensive measurement of the scientific and technological innovation efficiency and eco-economic efficiency within the Yellow River Basin area. With meticulous attention to detail, they explored their spatio-temporal evolution trends and accurately simulated the interaction relationship between the two[7]. In addition, some scholars have dedicated themselves to conducting a comprehensive statistical measurement of the national eco-economic development level, which has further enriched the research achievements in this field[8].

Upon a systematic review and synthesis of relevant research literature, there remain numerous aspects that urgently require refinement and enhancement. In the existing literature regarding the measurement of eco-economic development levels, the research perspectives mainly concentrate on the national scale or specific river basins, exemplified by the Yellow River Basin. Conversely, research evaluating the eco-economic development of the Yangtze River Basin is extremely rare. This dearth of research has engendered a significant lacuna in furnishing theoretical underpinnings for the ecological economic development of urban areas within the Yangtze River Economic Belt region. In view of these considerations, this research is expected to make marginal contributions in the following aspects. First, by closely aligning with the actual development status of the ecological economy in the Yangtze River Basin, a measurement index system for the development level of the ecological economy in this basin will be constructed. As a result, it will be possible to intuitively and effectively present the comprehensive development level of the ecological economy the Basin. Second, the equal-distance division method will be employed to rate the development level of the ecological economy in the Basin. This will clearly reveal the actual situation of the comprehensive ecological economic development level, thereby providing solid theoretical references and practical guidelines with operability for promoting the high-quality development of the ecological economy in the Yangtze River Basin.

2 Research Design

2.1 Construction of the Indicator System

Upon a thorough and in-depth perusal of the extant research outcomes, it becomes apparent that, within the theoretical edifice of ecological economics, the incorporation of ecological and environmental costs engendered by human activities into the economic analysis procedure engenders a holistic "society-economy-nature" systemic vantage point9]. When combined with the internal theoretical logic of measuring the ecological economic development level in the Yangtze River Basin, it is discernible that the evaluation of the ecological economy in each city should encompass four key dimensions: social development, economic growth, ecological construction, and resource utilization[10]. Adhering to the principles of scientificity, systematicness, hierarchy, regionality, and representativeness necessary for constructing an evaluation indicator system, and concurrently taking into account the accessibility of data, this study draws on the cutting-edge research achievements of Yuan Chunjian (2024) [11], Hu Shihua et al. (2022)12], and Shen Shiming et al. (2023) [13]. Subsequently, it proceeds to establish an indicator system for the ecological economic development level of the Yangtze River Basin from four echelons: ecological investment, production output, ecological environment, and ecological development benefits. This system exhibits an architectural configuration of "system layer-criterion layer-indicator layer" (1-4-19), as meticulously delineated in Table 1.

2.2 Research Subjects and Data Sources

This research centers on the regions traversed by the Yangtze River. Relying on provincial-level administrative jurisdictions as the demarcation basis, with full reference to the "14th Five-Year Plan for the Development of the Yangtze River Economic Belt"14], and comprehensively considering the degree of proximity of each province to the Yangtze River, the scope of the study area was ultimately delimited. The research sample is constructed by selecting panel data spanning from 2009 to 2023, covering two municipalities directly under the Central Government, namely, Shanghai and Chongqing, and eight provinces, including Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Guizhou, and Yunnan. These data are used to construct the research sample[15]. The data predominantly derives from the China Statistical Yearbook, China Fixed-Asset Investment Statistical Yearbook, China Environmental Statistics Yearbook, and other relevant yearbooks corresponding to the sample period. Furthermore, a portion of the data is acquired through the EPS (Economy Prediction System) Global Statistical Data Analysis Platform. Regarding the individual missing data points, initially, the SPSS 27.0 statistical software is employed to conduct a fitting linear regression analysis, aiming to restore the original state of the data. In cases where data gaps persisted, the interpolation method is utilized for supplementation[16]. This is done to ensure the integrity and continuity of the research sample data, thereby laying a solid data foundation for subsequent in-depth research.

Table 1. The Indicator System for Measuring the Eco-economic Development Level of the Yangtze River Basin11

System Layer	Criterion Layer	Indicator Layer	Type	Indicator Unit	Weight (w_j)
Ecological-economy Development Level in Yangtze River Basin	Ecological Investment	Per Capita Input in Fixed Assets	+	ten thousand yuan per person	0.1922
		Investment in Drainage and Sewage Disposal	+	hundred million yuan	0.2641
		Per Capita Investment in Environmental Infrastructure	+	ten thousand yuan per person	0.1652
		Investment in Landscaping	+	ten thousand yuan per person	0.1948
		Local Fiscal Expenditure on Environmental Protection	+	hundred million yuan	0.1837
	Ecological Output	Per Capita GDP	+	yuan per person	0.1958
		Forest Area	+	ten thousand hectares	0.2865
		Per Capita General Budget Revenue	+	ten thousand yuan per person	0.2703
		Green Coverage Rate in Built-up Areas	+	%	0.0404
		Per Capita Disposable Income	+	yuan	0.2071
	Ecological Environment	Intensity of Chemical Fertilizer Use	-	tons per hectare	0.1762
		Sulfur Dioxide Emissions	-	ten thousand tons	0.1476
		Urban Sewage Treatment Rate	+	%	0.0812
		Per Capita Water Resources Quantity	+	tons per person	0.2548
		Per Capita Volume of Living Garbage Clearance	+	tons per person	0.3402
		Proportion of Days With Good Air Quality	+	%	0.0882
	Ecological Development Benefits	Area of National Nature Reserves	+	ten thousand hectares	0.6445
		Comprehensive Utilization Rate of Industrial Solid Waste	+	%	0.2108
		Harmless Treatment Rate of Domestic Garbage	+	%	0.0565

Note: The weights of each indicator were calculated using the weight - calculation steps in the entropy method with the help of STATAMP 18.0 software.

3 Measurement and Analysis of the Ecological Economic Development Level

3.1 Measurement Methods

In the existing academic literature, the methods of assigning weights to indicators can generally be classified into two categories: subjective weighting methods and objective weighting methods. In this research, the Entropy Weight Method, a type of objective weighting approach, is adopted to compute the ecological development level index for the Yangtze River Basin. The Entropy Weight Method determines the weights corresponding to indicators accurately based entirely on the amount of information carried by the observed values of each indicator. Characterized by a high degree of objectivity, it remains impervious to the influence of subjective elements. As such, it is capable of furnishing more scientifically rigorous and unbiased data support for subsequent research endeavors[17].

Step 1: Dimensionless Treatment of Indicators

When measuring the eco-economic development level of the Yangtze River Basin, numerous indicators need to be considered comprehensively. The initial values of these indicators exhibit significant disparities in both measurement units and quantitative scales. The inconsistency in measurement units can easily lead to dimensional differences in the data. If direct analysis is carried out, it will interfere with the accuracy of the final evaluation results. Therefore, it is imperative to execute a dimensionality-reduction treatment on the data. Furthermore, the original dataset may contain zero values, which can pose obstacles to subsequent calculations and analyses. For these reasons, this research utilizes the efficacy coefficient method. Through the unique transformation mechanism of this method, the dimensional differences among the data of different indicators can be effectively eliminated.

The formula for standardization processing is as follows:

1) Positively-oriented maximum-type indicators:

$$X_{ij}^{'} = 0.9 \times \frac{X_{ij} - \{X_{ij}\}_{\min}}{\{X_{ij}\}_{\max} - \{X_{ij}\}_{\min}} + 0.1 \tag{1}$$

2) Reversely-oriented minimum-type indicators:

$$X_{ij}^{'} = 0.9 \times \frac{\{X_{ij}\}_{\max} - X_{ij}}{\{X_{ij}\}_{\max} - \{X_{ij}\}_{\min}} + 0.1 \tag{2}$$

where $X_{ij}^{'}$ is the standardized value of the j-th indicator in the i-th year, $\{X_{ij}\}_{\max}$ and $\{X_{ij}\}_{\min}$ are the maximum and minimum values of the j-th indicator respectively.

Step 2: Calculate the proportion of the value of the j-th indicator in the i-th year. The calculation formula is as follows:

$$Y_{ij} = \frac{X_{ij}^{'}}{\sum_{i=1}^{m} X_{ij}^{'}} \qquad (j = 1, 2, 3, \cdots, n) \tag{3}$$

Step 3: Calculate the entropy value of the indicator:

$$e_j = -\frac{1}{\ln(n)} \sum_{i=1}^{m} \left(Y_{ij} \times \ln Y_{ij} \right) \qquad (j = 1, 2, 3, \cdots, n) \tag{4}$$

Step 4: Calculate the coefficient of variation:

$$d_j = 1 - e_j \qquad (j = 1, 2, 3, \cdots, n) \tag{5}$$

Step 5: Calculate the entropy weight of the indicator:

$$\omega_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \qquad (j = 1, 2, 3, \cdots, n) \tag{6}$$

3.2 Measurement Results and Analysis

Based on the indicator system and measurement methods established previously, the comprehensive scores of the eco-economic development levels of the 11 provinces (municipalities) in the Yangtze River Basin from 2009 to 2023 are computed. Subsequently, through the application of weighted-average techniques, the aggregated score representing the overarching eco-economic development level of the Yangtze River Basin is derived, as presented in Table 2.

Upon analysis, it has been discerned that the eco-economic development levels of the provinces (municipalities) within the Yangtze River Basin have, in general, manifested a consistent and upward - trending trajectory. This phenomenon clearly evinces that the upper, middle, and lower reaches of the Yangtze River are steadily advancing in a positive direction along the course of eco-economic development. Specifically, in the upper reaches of the Yangtze River, by calculating the average values from 2009 to 2023, Sichuan emerges as the highest-ranked entity in the region, registering a value of 0.4093, whereas Guizhou occupies the lowest position with a value of 0.3207. The ratio of their eco-economic development level indices is 1.28. In the middle reaches, based on the average values from 2009 to 2023, Jiangxi tops the ranking with a value of 0.3814, and Hunan ranks last with 0.3633, with a corresponding index ratio of 1.05. In the lower reaches, according to the ranking of average values from 2009 to 2023, Shanghai ranks first with 0.4431, and Anhui ranks last with 0.3521, with the ratio of their eco-economic development level indices reaching 1.26.

Table 2. Measurement Scores of Eco-economic Development Level in the Yangtze River Basin

region	Province	2009	2010	2011	2012	2013	2014	2015	2016	2017
Lower Reaches	Shanghai	0.3434	0.3655	0.3572	0.3722	0.3799	0.3838	0.4108	0.4167	0.4631
	Jiangsu	0.2968	0.3190	0.3424	0.3553	0.3825	0.4054	0.4105	0.4224	0.4275
	Zhejiang	0.3189	0.3369	0.3412	0.3681	0.3616	0.3970	0.4187	0.4507	0.4514
	Anhui	0.2434	0.2617	0.2839	0.3026	0.3141	0.3170	0.3429	0.3584	0.3807
	Average	0.3006	0.3208	0.3312	0.3495	0.3595	0.3758	0.3957	0.4120	0.4307
Middle Reaches	Jiangxi	0.2575	0.3131	0.3031	0.3571	0.3242	0.3420	0.3556	0.3695	0.3945
	Hubei	0.2520	0.2706	0.2873	0.3066	0.2988	0.3335	0.3325	0.3940	0.4118
	Hunan	0.2991	0.2938	0.2894	0.3134	0.3176	0.3334	0.3551	0.3716	0.3836
	Average	0.2695	0.2925	0.2933	0.3257	0.3135	0.3363	0.3477	0.3783	0.3966
Upper Reaches	Chong-qing	0.2685	0.3089	0.3647	0.3436	0.3307	0.3413	0.3525	0.3677	0.3935
	Sichuan	0.3031	0.3098	0.3216	0.3388	0.3372	0.3660	0.3645	0.3932	0.4152
	Yunnan	0.2877	0.3101	0.2943	0.3040	0.3069	0.3253	0.3410	0.3584	0.3760
	Guizhou	0.2236	0.2391	0.2479	0.2707	0.2679	0.3073	0.3185	0.3346	0.3395
	Average	0.2707	0.2920	0.3071	0.3143	0.3107	0.3350	0.3441	0.3635	0.3811
Whole Basin Average		0.2813	0.3026	0.3121	0.3302	0.3292	0.3502	0.3639	0.3852	0.4034

Table 2(Continued). Measurement Scores of Eco-economic Development Level in the Yangtze River Basin

Region	Province	2018	2019	2020	2021	2022	2023	Average	Ranking
Lower Reaches	Shanghai	0.5108	0.5010	0.4977	0.5304	0.5400	0.5747	0.4431	1
	Jiangsu	0.4538	0.4580	0.4877	0.4992	0.5071	0.5220	0.4193	3
	Zhejiang	0.4656	0.4858	0.4947	0.5145	0.5040	0.5081	0.4278	2
	Anhui	0.3899	0.3956	0.4077	0.4159	0.4253	0.4426	0.3521	10
	Average	0.4550	0.4601	0.4720	0.4900	0.4941	0.5118	0.4106	
Middle Reaches	Jiangxi	0.4156	0.4562	0.4440	0.4694	0.4483	0.4708	0.3814	5
	Hubei	0.4191	0.4455	0.4381	0.4505	0.4426	0.4709	0.3702	7
	Hunan	0.3778	0.3964	0.4257	0.4431	0.4218	0.4279	0.3633	8
	Average	0.4042	0.4327	0.4359	0.4544	0.4376	0.4565	0.3717	

	Chongqing	0.4013	0.4126	0.4459	0.4530	0.4504	0.4748	0.3806	6
	Sichuan	0.4535	0.4711	0.4872	0.5155	0.5236	0.5394	0.4093	4
Upper Reaches	Yunnan	0.3894	0.3930	0.3973	0.4088	0.4213	0.4262	0.3560	9
	Guizhou	0.3509	0.3677	0.3778	0.3951	0.3820	0.3871	0.3207	11
	Average	0.3988	0.4111	0.4270	0.4431	0.4444	0.4569	0.3666	
Whole Basin Average		0.4207	0.4348	0.4458	0.4632	0.4606	0.4768	0.3840	

These empirical data compellingly suggest that within each of the upper, middle, and lower reaches, there exist varying degrees of disequilibrium in eco-economic development. Notably, this disequilibrium is particularly pronounced in the upper reaches of the Yangtze River. In contrast, the disparity in eco-economic development levels within the middle reaches is relatively marginal. From an overarching perspective encompassing the 11 provinces (municipalities) in the Yangtze River Basin, when comparing Shanghai, which holds the highest mean value, with Guizhou, which has the lowest mean value, the ratio of their eco-economic development level indices attains a substantial 1.38. This significant difference indicates that in the process of promoting the coordinated eco-economic development of the Yangtze River Basin, narrowing the regional disparities is an important and arduous task. Concerted efforts from all stakeholders are urgently required, and targeted countermeasures should be expeditiously implemented to address this pressing issue.

For the convenience of analysis, the overall average data of the Yangtze River Basin within the research time frame, as well as the annual average data of the three regions, namely the upper, middle, and lower reaches, are presented in an intuitive and visual form. The specific situation is shown in Fig. 1.

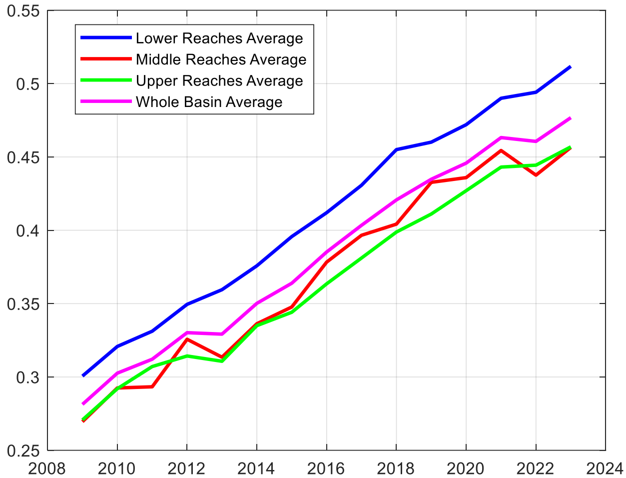

Fig. 1. Annual Average Values of Eco-economic Development Level Indicators in the Upper, Middle and Lower Reaches of the Yangtze River Basin

As clearly discernible from Fig. 1, throughout the entire research period, the eco-economic development levels of the upper, middle, and lower reaches of the Yangtze River Basin, as well as that of the entire basin, have demonstrated a steady upward trend. This trend amply indicates that the eco-economic development level has achieved tangible improvement across the 11 provinces (municipalities) within the scope of the Yangtze River Basin. Specifically, in the comparison of the average values of the eco-economic development levels across various years, the lower reaches of the Yangtze River have consistently taken the lead, firmly ranking first. The middle reaches follow closely behind, ranking second, while the upper reaches are relatively lower, with the average value at the lowest level. Evidently, the overall development pattern of the ecological economy in the Yangtze River Basin exhibits a distinct characteristic of "higher in the lower reaches, second-highest in the middle reaches, and lower in the upper reaches".

A more in-depth analysis reveals that the eco-economic development level of the lower-reaches area of the Yangtze River Basin exhibits a notably significant leading advantage when compared with that of the middle-and upper-reaches. While there exists a discernible disparity in the eco-economic development levels between the upper and middle-reaches, the margin by which the lower-reaches outpaces the middle-reaches is substantially larger than the differential between the middle and upper-reaches. This finding is in exact congruence with the conclusion derived from the previous analysis of the ratio of the maximum and minimum mean values, which highlighted a considerable gap between them.

4 Comprehensive Evaluation of the Ecological - economic Development Level

4.1 Integrated Evaluation Index System

In this paper, the equidistant division method is introduced to construct a rating system for the eco-economic development level of the Yangtze River Basin. This system aims to systematically quantify the eco-economic development status of the Yangtze River Basin. Through rigorous classification, the eco-economic development level is orderly divided into five levels from high to low, marked as Level I, Level II, Level III, Level IV, and Level V in sequence. The specific classification is shown in Table 3.

Table 3. Criteria for Determining the Eco-economic Development Levels

Quality of Natural Ecological Environment Governance	Levels (from highest to lowest)	Value range of closeness degree
Excellent	I	$0.8<D\leq1$
Good	II	$0.6<D\leq0.8$
Medium	III	$0.4<D\leq6$
Relatively Low	IV	$0.2\leq D\leq0.4$
Minimal	V	$D<0.2$

4.2 Calculation of Comprehensive Evaluation Values and Their Analysis

Based on the index entropy weights obtained by the entropy method mentioned above, we proceed to construct a weighted normalized matrix. Specifically, we first calculate the distance between each indicator and the ideal solution. Then, based on this, we further calculate the degree of closeness, and thus obtain the comprehensive evaluation value. The calculation of the degree of closeness is carried out based on the distances between the evaluation object and the positive and negative ideal solutions. The calculation formula is as follows:

$$\delta\left(t_k\right)=\frac{S_i^-\left(t_k\right)}{S^+\left(t_k\right)+S^-\left(t_k\right)} \tag{7}$$

where $\delta\left(t_k\right)\in\left[0,1\right]$, the larger the value, the higher the level of eco-economic development. The rating results of the eco-economic development levels of the 11 provinces (municipalities) in the Yangtze River Basin in each year during the research period are shown in Table 4.

As can be seen from Table 4, during the period from 2009 to 2021, the eco-economic development trend in the Yangtze River Basin showed an upward trajectory. Its development level gradually improved from the initial "relatively low" level to a "good" state. In 2012, the eco-economic development of the basin achieved a key breakthrough, successfully moving from the "relatively low" stage to the "medium" level. Subsequently, by 2019, it further reached a good development state and has remained relatively stable since then. Nevertheless, it is imperative to recognize that numerous challenges persist in the pursuit of high-caliber eco-economic development, and the journey ahead remains arduous.

With the rapid advancement of the economy and society, the living standards and consumption levels of residents have significantly improved. However, this has also led to a relatively severe impact on the ecological environment, exerting a negative influence on the sustainable and stable development of ecological economy. For a long time, the extensive development path adopted in China and the irrational pattern of international division of labor have further exacerbated the scale of waste gas and wastewater emissions. As a result, the ecological environment is under immense pressure, which greatly hinders the progress of ecological economy towards high - quality development. In addition, there are still numerous imperfections in China's laws and regulations in the field of ecological economy, and the relevant technologies are not yet mature. These crucial issues have become the core factors restricting the high - quality development of ecological economy and urgently need to be addressed and improved.

Table 4. Rating Results of the Ecological - economic Development Level

Year	Measured Closeness Degree	Rating	Quality of Natural Ecological Environment Governance
2009	0.3660	IV	Relatively Low
2010	0.3816	IV	Relatively Low

2011	0.3865	IV	Relatively Low
2012	0.5626	III	Medium
2013	0.5262	III	Medium
2014	0.4555	III	Medium
2015	0.4670	III	Medium
2016	0.4509	III	Medium
2017	0.5126	III	Medium
2018	0.4515	III	Medium
2019	0.6024	II	Good
2020	0.6466	II	Good
2021	0.6024	II	Good
2022	0.6181	II	Good
2023	0.6335	II	Good

5 Conclusions and Suggestions

In view of the ecological - economic development in the Yangtze River Basin, this study used panel data from 11 provinces (municipalities) in the basin from 2009-2023 as research samples. An index system for measuring the ecological - economic development level was established, and the entropy method and equal-distance division method were used for comprehensive evaluation. The results show: Firstly, during the eco-economic development, the eco-economic development levels of provinces (municipalities) in the Yangtze River Basin generally show an upward trend. Comparing annual average values, the lower reaches of the Yangtze River perform best, ranking first; the middle reaches rank second; the upper reaches develop relatively slowly, with the lowest average value. Secondly, in terms of the evolution of eco-economic levels, in 2012, the eco-economic development level in the Yangtze River Basin advanced from the “relatively low” to the “medium” stage. By 2019, it further improved from “medium” to “good” and has remained stable since, showing good prospects.

Based on the measurement and analysis of the ecological - economic level in the Yangtze River Basin, the following suggestions are put forward to optimize the ecological environment and promote high - quality development:

Firstly, establish a collaborative mechanism to promote resource sharing and complementary advantages among the upper, middle, and lower reaches. The lower reaches, leveraging their technological and financial resources, should cooperate with the industries in the middle reaches and the ecological resources in the upper reaches. Through joint construction of industrial parks and project cooperation, facilitate the gradient transfer and collaborative upgrading of industries to achieve balanced development.

Secondly, improve relevant regulations, clarify the subjects, objects, standards, and methods of compensation. The lower reaches should compensate the upper reaches, and the funds should be used for ecological restoration, etc. Broaden the financing channels.

Besides fiscal transfer payments, raise funds through ecological taxes, bonds, etc., and encourage private capital to participate in the form of PPP. Determine the compensation standards by comprehensively considering factors such as ecological value and costs, and use scientific methods for evaluation.

Thirdly, improve relevant laws and regulations, formulate protection and development regulations, and clarify the responsibilities, supervision, and penalty standards for environmental protection. Optimize fiscal, tax, and financial policies, increase subsidies and tax incentives, set up special funds, and guide financial institutions to provide support. Establish a monitoring and evaluation system, use information technology for real-time monitoring and evaluation, and adjust policies in a timely manner.

References

1. Zhu Yitian, Huang Zhijun. Review of "Return to the Original Ecology: Contemporary Interpretation of Marxist Economic Philosophy" [J]. Statistics & Decision, 2024, 40(24): 2 + 189.
2. Gong Gu. Creating the "Ecological Protection Compilation" of the Code for the Comprehensive Realization of Ecosystem Governance [J]. Journal of China University of Geosciences (Social Sciences Edition), 1 - 9.
3. Luo Peng, Tan Cunfeng, Chen Qiangqiang, Pan Xiang, Qi Juanfei. Evaluation of the Coupling Coordination between Ecosystem Health and Economic Development in the Gansu Section of the Yellow River Basin [J]. Yellow River, 1 - 8.
4. Boulding K E. The economics of knowledge and the knowledge of economics [J]. American Economic Review, 1966, 56(2): 1 - 13.
5. Sun Buzhong, Fan Heng, Huang Shijuan, He Yixiong. Dynamic Evaluation of the Comprehensive Index of Ecological Economy Based on the Gray Entropy Weight Method of Optimal Convergence: A Case Study of Jiangxi Province [J]. Ecological Economy, 2017, 33(12): 77 - 82.
6. Li Ruikai, Wang Guan, Zhao Zongze, Zhang Jiayun. Spatiotemporal Analysis of the Coupling Coordination Degree of Ecological Economy in Henan Province [J]. Acta Ecologica Sinica, 2025, (03): 1 - 12.
7. Sun Jianguo, Wang Yajie, Zhang Haiyan. Research on Scientific and Technological Innovation and Ecological Economy in the Yellow River Basin: Based on the Super - SBM Model and PVAR Model [J]. Ecological Economy, 2021, 37(09): 61 - 69.
8. Li Xiaojuan, Wan Dajuan. Research on the Coupling and Coordination between Economic Development Level and Ecological Environment Protection in Western Hunan: Taking Huaihua City, Hunan Province as an Example [J]. Economic Geography, 1 - 12.
9. Liu Sifang. The Connotative Meaning, Implicit Methods and Innovative Contributions of General Secretary Xi Jinping's Important Expositions on Promoting the Development of the Yangtze River Economic Belt [J]. Reform, 2024, (02): 1 - 14.
10. Wang Yiqi, Yu Haiyun. Research on the Evaluation of Ecological Collaborative Development and Welfare Effects in the Yellow River Basin [J]. Operations Research and Management Science, 2024, 33(10): 166 - 171.
11. Yuan Chunjian. Statistical Measurement of the Development Level of China's Ecological Economy [J]. Statistics & Decision, 2024, 40(03): 106 - 111.
12. Hu Shihua, Huang Tianjian, Wang Kai. The Co - development of Digital Economy and Green Economy: Spatiotemporal Differentiation, Dynamic Evolution and Convergence

Characteristics [J]. Modern Finance and Economics (Journal of Tianjin University of Finance and Economics), 2022, 42(09): 3 - 19.
13. Shen Shiming, Xu Rui, Chen Feier. Spatial Disequilibrium and Convergence of High - Quality Development of China's Green - Low - Carbon - Circular Economy [J]. China Business and Market, 2023, 37(02): 18 - 30.
14. Zhang Li, Tang Honglei. Research on the Measurement of the Collaborative Development Level of Urban Ecological Economy in the Yangtze River Delta [J]. Ecological Economy, 2023, 39(04): 103 - 110.
15. Jiang Weizong, Xu Jianhui, Zhao Tian. Research on the Spatiotemporal Pattern and Heterogeneity of Carbon Emissions in the Yangtze River Basin Based on Night - Time Light Data [J]. Resources and Environment in the Yangtze Basin, 2024, 33(09): 2004 - 2017.
16. Ma Hailiang, Zhao Yuhua, Zhao Xin. Statistical Measurement and Spatiotemporal Difference Research on the Economic Resilience of Cities in the Yangtze River Basin [J]. Journal of Economics of Water Resources, 2024, 42(06): 25 - 32.
17. Li Jianjun. Measurement, Spatiotemporal Characteristics and Influencing Factor Analysis of the Development Level of China's Digital Trade [J]. Economic Review, 2024, (11): 83 - 95.