Spatial and Temporal Differentiation Characteristics of Regional Water Governance Performance

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ABSTRACT

By designing the regional water governance performance evaluation index system, this paper uses the ideal solution model and the coupling coordination degree model to construct a regional water governance performance evaluation model and takes the Beijing-Tianjin-Hebei region as an example to analyze the spatial and temporal differentiation characteristics of regional water governance performance. Studies have shown that the water resources pressure has been alleviated through optimization of water supply structure, industrial upgrading, agricultural water saving, water-use efficiency improvement and water pollution control, and the water governance performance index in the Beijing-Tianjin-Hebei region has been effectively improved: Beijing, Tianjin, and Hebei has increased from 0.60, 0.52, and 0.49 to 0.98, 0.96, and 0.98, respectively, among which the level of economic governance in the Beijing-Tianjin-Hebei region has been effectively improved, the industrial structure has been continuously optimized, the quality of industrial development has been continuously enhanced, and the water-use efficiency and pollution discharge performance have continued to improve. Beijing's economic governance performance index has the fastest growth rate, with an average annual growth rate of 5.93%; the economic governance performance index growth rate of the Tianjin-Hebei region has reached 2.64%. The economic governance level of the Beijing-Tianjin-Hebei region has been effectively improved, the social water-use structure has been continuously optimized, and the social water demand has been greatly guaranteed. Beijing's social governance performance index has the fastest growth rate, with an average annual growth rate of 5.26%, followed by Tianjin (4.64%) and Hebei (4.34%). The water supply capacity of the Beijing-Tianjin-Hebei region has been greatly guaranteed and the ecological protection has been continuously increased. Beijing's ecological governance performance index has the fastest growth rate, with an average annual growth rate of 4.82%, followed by Tianjin (4.68%) and Hebei (2.78%).

Keywords: *Water governance, Performance, Index, Model, Spatial and temporal differentiation characteristics.*

1. INTRODUCTION

In order to actively respond to the challenges of China's regional water resources, the national ministries and commissions have intensively issued water governance policies, accelerated the reform of regional water resources supply side and the establishment of water resources management policies and systems, and established and improved the rational allocation and efficient utilization of regional water resources. For example, the "Water Pollution Prevention and Control Plan for Key River Basins (2016-2020)" emphasizes breaking the restrictions of administrative regions, building an integrated and overall protection mechanism for regional water resources, and strengthening the linkage mechanism of water resources protection law enforcement; the "Guiding Opinions on Incorporating Unconventional Water Sources into the Unified Allocation of Water Resources" proposes to improve the regional water resources supply guarantee system and realize the optimization of the regional multiple water sources allocation pattern. These policies have provided important support for improving regional water governance performance. How to carry out regional water governance performance evaluation and its temporal and spatial differentiation characteristics

analysis and improve regional water governance performance capability has become a research hotspot concerned by government management departments and academic circles.

2. LITERATURE REVIEW

Beginning in the 1970s, the international community and Chinese and foreign scholars began to conduct in-depth research on national regional water governance policies and systems to establish and improve water governance systems, for example, scholars such as Blake et al.[1][2][3][4], Ven[5], Hassan[6] and others have formulated water management policies in developed countries such as the United States, the Netherlands, and the United Kingdom; Serageldin[7], Perret[8] and others have explored the practical experience of water governance around the world, especially in developing countries;Gleick[9], Cech[10], Douglas[11], Michael[12][13] and others have done research on the global water governance model and historical experience facing the 21st century. Through the exploration of water governance practice in the international community, it can be found that the implementation of comprehensive water body management based on the principle of the rule of law and the orientation of environmental goals has become an effective way of water governance [14-18]. Water governance focuses on balancing and coordinating competing multiple water-related interests. At the same time, the practice of water governance shows that it is necessary to establish and improve the water governance system, give full play to the status and role of administrative institutions in water-related affairs consultation and stakeholder participation[19][20], improve the legal system, establish a coordination mechanism, explore a pluralistic co-governance model, and implement the party-government joint responsibility system[21][22][23].

In order to further improve the system and mechanism of China's regional water governance and learn from the international research results of water governance, many scholars have conducted in-depth explorations on the theory and practice of China's regional water governance. From the perspective of water governance practice, establishing and improving the flood control, drought relief and disaster mitigation system, improving water supply guarantee capabilities, accelerating agricultural water conservancy construction, and strengthening water ecological restoration and water environmental protection have long been the focus of China's regional water governance[24][25]. The core task of regional water governance is to accelerate the comprehensive transformation from the contradiction between human and water to the harmony between human and water[26][27][28]. China has basically formed a water governance system based on laws and regulations, guaranteed by the formulation of water management policies and systems, with water administrative departments as the mainstay and multi-departmental collaboration[31]. The key to the reform of the regional water governance system is the transformation of the functions of public institutions for water resources management. The decisive role of the market in the allocation of water resources and water management must be continuously expanded and the regional water governance system must be continuously improved by improving efficiency and attracting social participation[32][33][34][35].

The existing literature provides an important reference for actively carrying out the analysis of the spatial and temporal differentiation characteristics of regional water governance performance. A review of the literature shows that regional water governance conforms to the system framework idea of economic, social and ecological coordinated development. To this end, this paper constructs a regional water governance performance evaluation system from three dimensions of economy, society and ecology, and analyzes the temporal and spatial differentiation characteristics of regional water governance performance.

3. RESEARCH METHODS

3.1 Design of Regional Water Governance Performance Evaluation Index System

Based on the system framework idea of the coordinated development of regional economy, society and ecology, the authors identify the evaluation factors of regional water governance performance, follow the principles of science, dynamics, data availability and hierarchy, and construct a regional water governance performance evaluation index system, as shown in "Table 1".

Table 1. Regional water governance performance evaluation index system

Evaluation dimension	Evaluation factor	Evaluation index	Index unit
Economic governance performance	Economic development level	GDP per capita	yuan / person
		The added value of the secondary industry	100 million yuan
		The added value of the tertiary industry	100 million yuan
	Industrial development quality	The added value of the tertiary industry as a proportion of GDP	%
		The matching degree between industrial water-use structure and industrial structure	-
	Water-use efficiency	Water consumption per 10,000 yuan of GDP	m^3/10,000 yuan
		Water consumption per 10,000 yuan of industrial added value	m^3/10,000 yuan
		Water consumption per 10,000 yuan of added value of the tertiary industry	m^3/10,000 yuan
		Per capita water consumption	m^3/person
		Per capita household water consumption	m^3/person
		Water consumption per unit irrigated area	m^3/mu
		Water consumption per unit of grain production	m^3/ton
	Pollution discharge performance	Wastewater discharge per 10,000 yuan of GDP	t/10,000 yuan
		Chemical oxygen demand emissions per 10,000 yuan of GDP	t/10,000 yuan
Social governance performance	Social development level	Population growth rate	%
		Urbanization rate	%
	Water-use structure	Economic water-use ratio	%
		Agricultural water-use ratio	%
		Residential water-use ratio	%
		Ecological water-use ratio	%
Ecological governance performance	Water supply structure	Surface water supply ratio	%
		Groundwater supply ratio	%
		Unconventional water supply ratio	%
	Ecological protection	Water conservancy investment as a percentage of fixed asset investment	%
		Local fiscal expenditure on environmental protection as a percentage of GDP	%
		Soil erosion control area as a percentage	%
		Wastewater treatment rate	%
		Forest cover rate	%

3.2 Regional Water Governance Performance Evaluation Model

Combined with "Table 1", this paper applies the ideal solution model and the coupling coordination degree model to analyze the spatial and temporal differentiation characteristics of regional water governance performance. The specific steps can be expressed as:

Step 1 — Using the ideal solution model to evaluate the economic governance performance index, social governance performance index and ecological governance performance index of regional water governance performance. It can be expressed as:

$$F_{ij}(t)=\frac{1}{1+\left(\frac{d_{ijt}\left(x_{ijtk},x_{ik}^{\alpha}\right)}{d_{ijt}\left(x_{ijtk},x_{ijk}^{\beta}\right)}\right)^{2}}$$

$$\begin{cases} d_{ijt}\left(x_{itk},x_{ik}^{\alpha}\right)=\sqrt{\sum_{k=1}^{n}w_k\left(x_{ijtk}-x_{ijk}^{\alpha}\right)^2} \\ d_{ijt}\left(x_{itk},x_{ik}^{\beta}\right)=\sqrt{\sum_{k=1}^{n}w_k\left(x_{ijtk}-x_{ijk}^{\beta}\right)^2} \\ x_{ijk}^{\alpha}=\max_{t=1}^{T}\left(x_{ijtk}\right) \\ x_{ijk}^{\beta}=\min_{t=1}^{T}\left(x_{ijtk}\right) \end{cases} \quad (1)$$

In formula (1), $F_{ij}(t)$ is the index of the j dimension of the i region in the t period ($j=1,2,3$ represents economic governance, social governance and ecological governance respectively). $d_{ijt}\left(x_{ijtk},x_{ijk}^{\alpha}\right)$ and $d_{ijt}\left(x_{ijtk},x_{ijk}^{\beta}\right)$ are the distances between the k evaluation index and the ideal value and negative ideal value of the index in the j dimension of the i region in the t period, respectively. Among them, it sets $x_{ijk}^{\alpha}=(1,1,\mathrm{L}\ ,1)$ and $x_{ijk}^{\beta}=(0,0,\mathrm{L}\ ,0)$ as the "ideal value" and "negative ideal value" of the k evaluation index of the j dimension of the i region, respectively. x_{ijtk} is the standardized index value, c_{ijtk} is the original data value of the index, ① the forward index standardization: $x_{ijtk}=\frac{c_{ijtk}}{\max_{t=1}^{T}\left(c_{ijtk}\right)}$; ② the reverse index standardization: $x_{ijtk}=\frac{\min_{t=1}^{T}\left(c_{ijtk}\right)}{c_{ijtk}}$. w_k is the weight of the k evaluation index. In order to reduce the interference of human factors, the hierarchical equal weight method is used to determine the weight of the index.

Step 2 — Using the coupling coordination degree model to evaluate the regional water governance performance, which can be expressed as:

$$F_i(t)=\sqrt{C_i(t)\cdot P_i(t)}$$

$$\begin{cases} C_i(t)=\left[\frac{\prod_{j=1}^{3}F_{ij}(t)}{P_i(t)^3}\right]^{\frac{1}{2}} \\ P_i(t)=\frac{\sum_{j=1}^{3}F_{ij}(t)}{3} \end{cases} \quad (2)$$

In formula (2), $F_i(t)$ is the water governance performance index of the i region in the t period; $C_i(t)$ is the coupling degree of the economic governance performance index, the social governance performance index and the ecological governance performance index of the i region in the t period; $P_i(t)$ is the coordination degree of the economic governance performance index, social governance performance index and ecological governance performance index of the i region in the t period.

4. EMPIRICAL RESEARCH

According to "Table 1", the water governance performance evaluation index data in the Beijing-Tianjin-Hebei region is obtained and the evaluation index data is calculated from the original data. Among them, the original water resources data is mainly from China Water Statistical Yearbook, China Water Resources Bulletin, Beijing Water Resources Bulletin, Tianjin Water Resources Bulletin and Hebei Water Resources Bulletin; the original economic and social development data is mainly from China Statistical Yearbook, Beijing Statistical Yearbook, Tianjin Statistical Yearbook, and Hebei Statistical Yearbook; the original ecological data mainly comes from Beijing Environmental Status Bulletin, Tianjin Environmental Status Bulletin, and Hebei Province Environmental Status Bulletin.

According to formulas (1) and (2), the water governance performance of the Beijing-Tianjin-Hebei region from 2000 to 2019 is calculated (see "Figure 1").

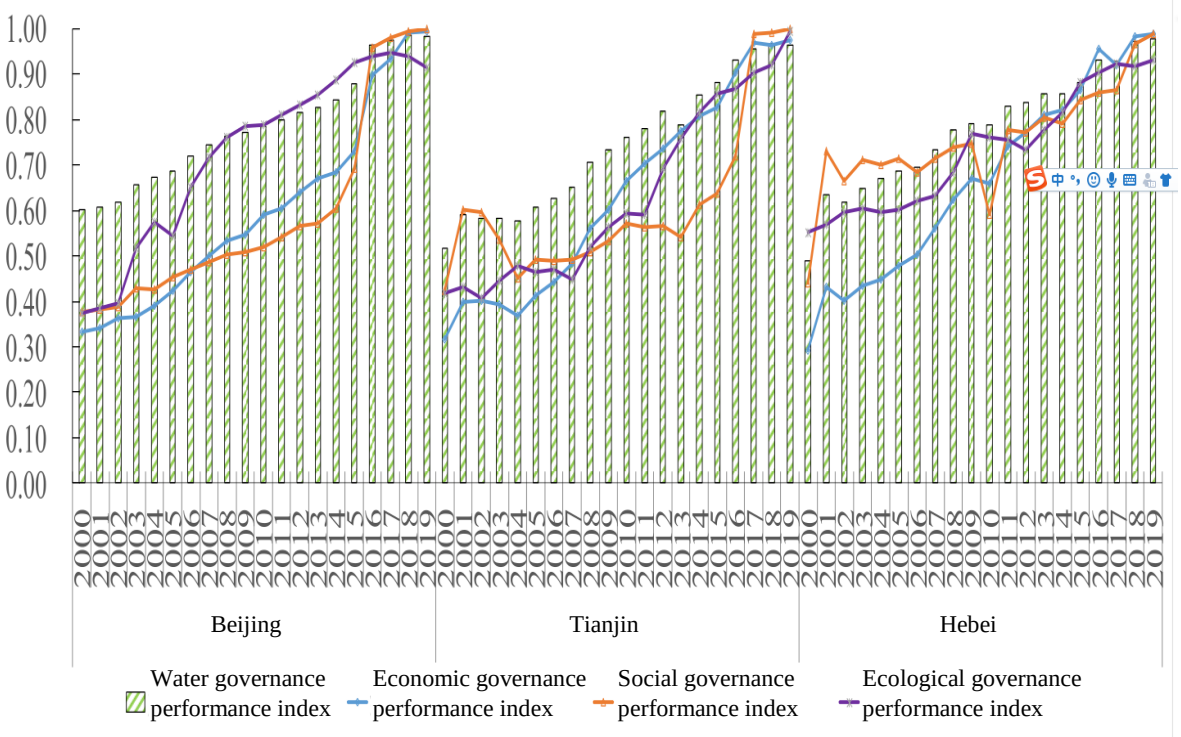

Figure 1 Water governance performance in the Beijing-Tianjin-Hebei region from 2000 to 2019.

According to "Figure 1", from 2000 to 2019, water resources pressure has been alleviated through optimization of water supply structure, industrial upgrading, agricultural water saving, water-use efficiency improvement and water pollution control, and the water governance performance index in the Beijing-Tianjin-Hebei region has been effectively improved: Beijing, Tianjin, and Hebei increased from 0.60, 0.52, and 0.49 to 0.98, 0.96, and 0.98, respectively. Among them, the water governance performance index in Beijing was higher than that in the Tianjin-Hebei region, but the growth rate of the water governance performance index in the Beijing-Tianjin-Hebei region reached 2.64%. By 2019, Tianjin's water governance performance index was slightly lower than that of Beijing and Hebei.

First, the economic governance performance index of the Beijing-Tianjin-Hebei region continued to improve, indicating that the economic governance level of the Beijing-Tianjin-Hebei region was effectively improved, the industrial structure was continuously optimized, the quality of industrial development was continuously improved, and the water-use efficiency and pollution discharge performance continued to improve. Among them, Beijing's economic governance performance index had the fastest growth rate, with an average annual growth rate of 5.93%; the economic governance performance index growth rate of the Tianjin-Hebei region reached 2.64%. However, by 2019, the Beijing economic governance performance index was relatively the largest, reaching the optimal value of 1. The economic governance performance indices of Tianjin and Hebei were also close to the optimal value, at 0.97 and 0.99, respectively.

Second, the overall social governance performance index in the Beijing-Tianjin-Hebei region showed a fluctuating upward trend, indicating that the economic governance level of the Beijing-Tianjin-Hebei region was effectively improved, the social water-use structure was continuously optimized, and the social water demand was greatly guaranteed. Among them, Beijing's social governance performance index had the fastest growth rate, with an average annual growth rate of 5.26%, followed by Tianjin (4.64%) and Hebei (4.34%). By 2019, the social governance performance index in the Beijing-Tianjin region reached the optimal value of 1, in other words, the social water-use structure in the Beijing-Tianjin region was continuously optimized since 2000, and reached the optimal value in 2019. Hebei's social governance performance index was close to the optimal value of 1.

Then, the ecological governance performance index of the Beijing-Tianjin-Hebei region continued to rise, indicating that the water supply capacity of the Beijing-Tianjin-Hebei region was greatly guaranteed and the ecological protection was continuously increased. Among them, Beijing's ecological governance performance index had the fastest growth rate, with an average annual growth rate of 4.82%, followed by Tianjin (4.68%) and Hebei (2.78%). By 2019, the ecological governance performance index in the Beijing-Tianjin-Hebei region didn't reach the optimal value of 1, at 0.92, 0.99 and 0.93, respectively.

5. CONCLUSION

Based on the system framework of the coordinated development of regional economy, society and ecology, this paper constructs a regional water governance performance evaluation index system from three dimensions of economy, society and ecology. It uses the ideal solution model and the coupling coordination degree model to construct a regional water governance performance evaluation model. This method can comprehensively reflect the spatial and temporal differentiation characteristics of regional water governance performance and scientifically evaluate the comprehensive problems existing in regional water governance. Therefore, it is beneficial to optimize the regional water resources allocation pattern and improve the performance of regional water management.

AUTHORS' CONTRIBUTIONS

Dan Wu was responsible for experimental design and writing the manuscript, Mengyao Liu was responsible for research collection and writing the manuscript.

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