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The Coupling Relationship and Driving Factors between Water Resources Utilization and High-quality Economic Development in the Yellow River Basin

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Abstract: Taking the Yellow River Basin from 2008 to 2019 as the research object, this paper constructs the index system of water resources utilization efficiency and high-quality economic development, makes a comprehensive evaluation and coupling analysis of them by using entropy method and coupling coordination degree model, and uses geographic detectors to detect the influencing factors driving coupling coordination scheduling. The results show that: (1) The comprehensive evaluation index of water resources utilization rate in the Yellow River Basin shows a fluctuating upward trend as a whole. The water resources utilization rate of the nine provinces of the Yellow River has obvious differences in different years. The water resources utilization efficiency of Gansu is the highest in 2008 and Sichuan is the highest in 2019. (2) The comprehensive evaluation index of high-quality economic development in the Yellow River Basin is increasing year by year, with significant regional differences. The high-quality economic development of Shanxi and Shaanxi was the highest in 2008, and the high-quality economic development level of Henan and Ningxia was the highest in 2019. (3) The coupling degree and coupling coordination degree of the Yellow River Basin and all provinces show an increasing trend. The coupling coordination degree of the whole basin has increased from being on the verge of imbalance to good coordination, especially after 2015. (4) Socio economic factors are the leading factors affecting the coupling and coordination between water resources utilization efficiency and high-quality economic development. Water resources conditions and government financial support also play an important role.

Keywords: Water resources utilization rate, High quality of economic development, Coupled co scheduling, Geographic detectors, Yellow River Flow.

1. Introduction

There has been a serious shortage of water resources in the Yellow River Basin since ancient times. Most areas along the river basin belong to arid and semi-arid climate areas, resulting in a severe ecological crisis in the areas with fragile ecological environment along the river basin. It has become a national strategy to protect the ecological security of the Yellow River Basin and promote the healthy economic development of the basin. The Yellow River has raised generations of Chinese children, but the average annual total water resources of the Yellow River is only about 3% of the total water resources of the country, far lower than that of other waters. In history, the Yellow River has experienced problems such as cut-off and drying up, but the scarce water resources have to supply more than 100 million people in the basin, and the development and utilization rate of water resources is as high as 80%. Therefore, protecting the water resources of the Yellow River, improving the utilization efficiency of water resources and increasing water use control can effectively improve the utilization efficiency of water resources and reduce the stagnation of economic development caused by insufficient water resources. Economic development will destroy the ecological environment to a certain extent, put pressure on water resources, and the implementation of economic transformation can also solve the existing water resources problems in the Yellow River Basin in turn. The coordinated development of the two can not only protect the water resources of the Yellow River Basin, but also drive the social and economic development of the basin.

Water resource is an indispensable resource for human production and life. Water resource utilization efficiency is an important basis for evaluating the control and protection of water resources in the region [2], and also represents the strength of people's awareness of water conservation in the region. Scholars use different methods to evaluate the utilization efficiency of water resources, such as data envelopment analysis [3], DEA model [4], DEA Malmquist model [5], EBM model [6], projection pursuit model [7], etc. Since the 19th National Congress of the Communist Party of China, China has been carrying out economic transformation from high-speed economic development to high-quality economic development. Different scholars have systematically studied the evaluation of high-quality economic development from different perspectives such as provincial level [8], urban level [9], urban agglomeration [10]. The relationship between water resources utilization and economic development has become a research hotspot in recent years, such as the matching degree between water resources utilization and economic development, the situation analysis of decoupling between water resources utilization and economy [11], and the spatial correlation between water resources utilization and economic development [12]. Due to the shortage of water resources in the Yellow River Basin, the utilization efficiency has always been the focus of academic research, and its economic development has also attracted much attention. From the perspective of their coordinated development, some scholars believe that the utilization efficiency of water resources and economic development can

interact to promote the common development of both sides, and take Henan Province as an example to analyze the coupling between the utilization efficiency of water resources and high-quality economic development [13-14]. It is concluded that the high degree of coupling and coordination between water resources utilization rate and high-quality economic development in Henan Province is the synchronous development.

At present, most studies focus on a province or upstream and downstream of the Yellow River basin to study the coordination of water resources utilization and economic development. There is no analysis on the change characteristics and change trajectory of the whole basin in terms of time and space, nor on the influencing factors behind it. Based on this, this paper mainly studies the utilization rate of water resources and the high-quality economic development level of the Yellow River Basin, analyzes the coupling and coordination relationship between them, analyzes the coupling and coordination degree, and explores the deep reasons for promoting the coordinated development of the two, so as to better promote the ecological protection and high-quality development of the Yellow River Basin.

2. Research Design and Data Sources

2.1. Research Design

2.1.1. Construction of Index System

Referring to the current research results [13-15], considering the availability of data in the study area, we build the index system of water resource utilization efficiency and economic development. For the utilization rate of water resources, the ecological benefits of water resources should be taken into account. Therefore, six indicators are selected to represent the utilization efficiency of water resources in this paper, as shown in Table 1. High quality economic development is a necessary stage of China's economic transformation. High quality development means abandoning the traditional concept of economic development and taking sustainable development as the goal. Now it has attracted more and more attention. Based on the five concepts of "innovation, coordination, green, openness and sharing", this paper constructs a high-quality economic development index system. Each concept belongs to one dimension, and 16 indicators are constructed, as shown in Table 2.

Table 1. Evaluation index system of water resources utilization

Index	Unit	Attribute
Water penetration rate	%	+
Daily treatment capacity of urban sewage	10000 cubic meters	+
Per capita water consumption	M3 / person	+
Per capita water resources	M3 / person	+
Development and utilization rate of water resources	%	-
Proportion of ecological water use	%	+

Table 2. Evaluation index system of high-quality economic development

Dimension	Index	Unit	Attribute
Innovation-driven development	Expenditure on R&D	Ten thousand yuan	+
	R&D personnel	people	+
	Number of Patents Granted	piece	-
Coordinated development	Urban and Rural Consumption Expenditure Ratio	%	-
	Ratio of Urban and Rural per Capita Disposable Income	%	+
	The Proportion of the Tertiary Industry	%	-
Green development	Forest Coverage Rate	%	+
	Coverage Rate of Urban Green Areas	%	+
	Consumption Waters Harmless Treatment Rate	%	+
Open development	Total Value of import and export	Ten thousand dollars	+
	Total Amount of Foreign Investment	Ten thousand dollars	+
	Total investment by foreign enterprises	Million dollars	+
Shareable development	Students Enrollment in regular Institutionsof Higher Education	ten thousand people	+
	Business Volume of Postal Services	RMB100mn	+
	Number of Beds in Health Care Institutions per 10,000 people	/	+

2.1.2. Entropy Method

Entropy method is widely used in academic circles because of its objectivity, scientificity, simplicity and clarity. Therefore, this paper uses entropy method to determine the index weight.

Firstly, standardize all indicators, and the calculation formula is as follows:

$$r_{ij} = \frac{X_{ij} - X_{imin}}{X_{imax} - X_{imin}} \quad (1)$$

$$r_{ij} = \frac{X_{imax} - X_{ij}}{X_{imax} - X_{imin}} \quad (2)$$

Where X_{ij} is the original value of the index; r_{ij} is the value of an indicator after standardization, i is the number of indicators, j is the year, x_{imax} is the maximum value of the ith indicator and X_{imin} is the minimum value of the ith indicator.

The proportion of index j in year iis $p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}$.

The information entropy of the j-th index is $e_j = -k \sum_{i=1}^{m} p_{ij} lnp_{ij}$, where $k = ln$, n is the number of years.

The j-th index information redundancy is$d_j = 1 - e_j$.

The weight of index j is $w_j = \frac{d_j}{\sum_{i=1}^{m} d_j}$.

The comprehensive evaluation index in the i-th year, that is, the level of water resources utilization efficiency is$\sum_{j=1}^{n} w_j \times r_{ij}$.

2.1.3. Coupling Degree Model and Coupling Coordination Model

Referring to the concept of coupling in physics, the following coupling degree model is constructed:

$$C = 2 \times \sqrt{\frac{U_1 \times U_2}{(U_1 + U_2)^2}} \quad (3)$$

Where, U is the comprehensive evaluation index of each system, and its value is between 0 and 1; C is the coupling degree, and the value range is 0 ~ 1. The closer C is to 1, the better the coupling condition.

The calculation formula of the coupling coordination degree model is:

$$D = \sqrt{(C \bullet T)} \quad (4)$$

$$T = aU_1 + bU_2 \quad (5)$$

Where, D is the coupling co scheduling; C is the coupling degree; T is the comprehensive evaluation index, and t is between 0 and 1; a and bare the undetermined coefficients.

According to the previous research results and the actual situation of the region, the coupling coordination degree is divided. Table 3 shows the standards for the classification of coupling coordination degree. According to the interval of the calculated D value, the degree of coupling coordination is divided into 10 levels from extreme imbalance to reluctantly coordination and then to high-quality coordination.

Table 3. Classification criteria of coupling coordination degree

D-value interval	Coordination level	Coupling coordination degree	D-value interval	Coordination level	Coupling coordination degree
(0~0.1)	1	Extreme disorder	[0.5~0.6)	6	Reluctantly coordinate
[0.1~0.2)	2	Severe imbalance	[0.6~0.7)	7	Primary coordination
[0.2~0.3)	3	Moderate disorder	[0.7~0.8)	8	Intermediate coordination
[0.3~0.4)	4	Mild disorder	[0.8~0.9)	9	Good coordination
[0.4~0.5)	5	Verge of disorder	[0.9~1.0)	10	High quality coordination

2.1.4. Geographic Detector

Quantitatively detect the explanatory power of each driving factor on the ecological footprint (i.e. q value) through spatial heterogeneity, and its expression is as follows:

$$q = 1 - \frac{1}{n\sigma^2} \sum_{h=1}^{L} n_k \sigma_k^2 \quad (6)$$

Where, h is the number of units in the hierarchical study area of independent variable X or dependent variable Y; $\sigma_k^2$and σ^2 is the variance of layer h and Y value of the whole region.

2.2. Data Sources

The water resources and socio-economic data studied in this paper mainly come from the 2008-2020 China Statistical Yearbook, China water resources bulletin, the Yellow River water resources bulletin, as well as the statistical yearbook and water source Bulletin of 9 provinces in the Yellow River Basin.

3. Empirical Results and Analysis

3.1. Temporal and Spatial Evolution of Water Resources Utilization in the Yellow River Basin

3.1.1. Time Evolution Analysis of Water Resources Utilization Rate in the Yellow River Basin

Figure 1 shows the change trend of comprehensive evaluation index of water resources utilization rate and high-quality economic development in the Yellow River Basin from 2008 to 2019. As can be seen from Figure 1, the overall water resources utilization efficiency of the Yellow River Basin showed a fluctuating upward trend during the study period. From 2008 to 2013, the water resources utilization efficiency increased from 0.2764 to 0.4970, from 2013 to 2015, decreased to 0.4486, from 2015 to 2019, increased to 0.7284, and from 2008 to 2019, with an increase of 62.09%. The water resources utilization efficiency has been significantly improved.

From 2008 to 2019, the total water resources per capita and water consumption per capita in the Yellow River Basin increased by 562 million cubic meters and 2.91 cubic meters respectively. The increase of total water resources was greater than that of water consumption. From 2013 to 2015, the total water resources per capita in the Yellow River Basin decreased by 1.099 billion cubic meters and the water consumption increased by 937 million cubic meters, resulting in the reduction of water resource utilization efficiency during this period. In terms of water use, the ecological water consumption and domestic water consumption in the Yellow River Basin increased the most from 2008 to 2019, with 268% and 23% respectively. Agricultural water consumption remained basically unchanged, and industrial water consumption decreased by 15%. There are obvious differences in the distribution of water resources in different regions of the Yellow River Basin. Among them, Sichuan and Qinghai are rich in water resources, and the annual average proportion of water resources is about 52% and 15.2%. Shanxi and Ningxia are scarce, and the annual average proportion of water resources is only about 2% and 0.23%. The annual average proportion of water resources in other

provinces (regions) is between 5% and 8%. From the perspective of water use, the industrial water consumption in the Yellow River Basin has changed from the original extensive mode to the saving mode. During the study period, due to the large population scale and rapid growth, the domestic and ecological water consumption in some areas of the Yellow River Basin has increased greatly. On the whole, the utilization efficiency of water resources in the Yellow River Basin has been significantly improved from 2008 to 2019, and there is a certain room for improvement due to the influence of economic structure, industrial structure and resource endowment.

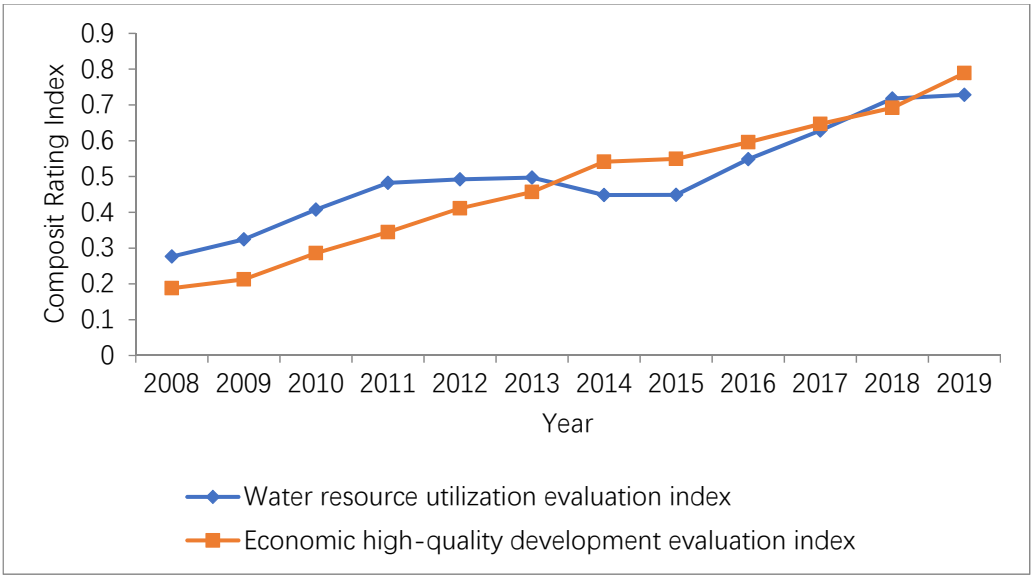


Figure 1. Comprehensive evaluation indexes of water resources utilization rate and high-quality economic development in the Yellow River Basin

3.1.2. Spatial Evolution Analysis of Water Resources Utilization Rate in the Yellow River Basin

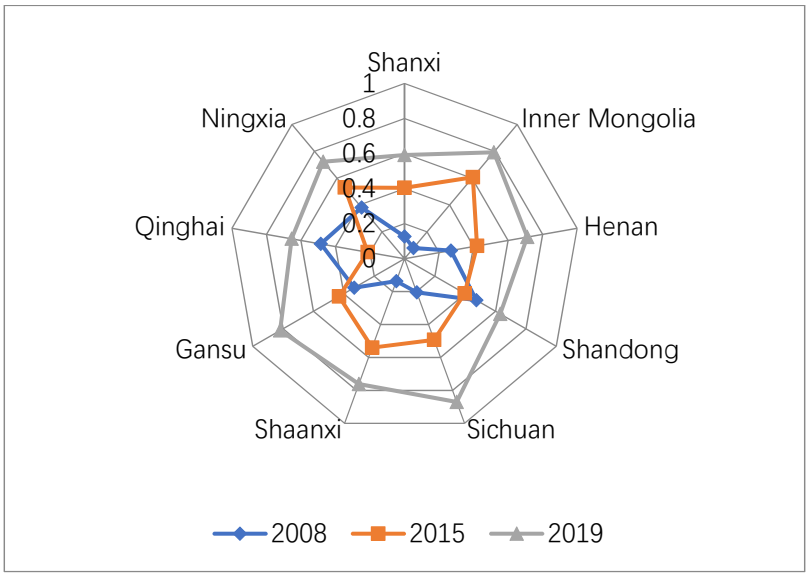
Figure 2 shows the results of water resource utilization and high-quality economic development of the nine provinces of the Yellow River from 2008 to 2019. Due to the large number of years involved in the study period, it is impossible to compare them one by one. According to the change trend of the overall water resources utilization efficiency and high-quality economic development evaluation index in the Yellow River Basin and the implementation year of high-quality economy, 2008, 2015 and 2018 are selected as the research nodes. It can be seen from figure 2A that the water resources utilization rate of the nine provinces in the Yellow River Basin showed an increasing trend from 2008 to 2019. The water resources utilization rate of Inner Mongolia was the lowest in the basin in 2008, only 0.0797, increased to 0.7932 in 2019, and the water resources utilization efficiency of Gansu was the highest, 0.4851 in 2008 and 0.6537 in 2019. In 2008, the total amount of water resources in Inner Mongolia was 41.21 billion cubic meters, and the per capita amount of water resources was 1710.30 cubic meters / person. In 2019, the total amount of water resources and per capita amount of water resources increased to 44.790 billion cubic meters and 1765.50 cubic meters / person respectively, and the domestic water and industrial water decreased by 29.05% and 31.78% respectively. The development and utilization of regional water resources improved significantly. The total amount of water resources in Gansu has increased steadily. Since 2015, the agricultural water consumption has decreased and the domestic water consumption has remained stable. Therefore, the total amount of water consumption has decreased, which has improved the utilization rate of water resources in the region. The increase and decrease of water resources utilization rate in different provinces in different time periods are slightly different, but they all show an upward trend. The province with the largest increase is Inner Mongolia, and the province with the smallest increase is Shandong, with an increase of 0.7135 and 0.1573 respectively. Compared with 2008, Shandong's total water resources and per capita water resources in 2019 decreased by 13.35 billion m3 and 107.60 m3 / person respectively, agricultural water consumption decreased by 14.56%, and the utilization rate of water resources increased little. In 2008, the regional difference of water resources utilization efficiency of the nine provinces of the Yellow River was obvious. The water resources utilization efficiency of the upstream region was significantly higher than that of the middle and lower reaches. Qinghai Province with the largest water resources utilization efficiency was five times that of Inner Mongolia Autonomous Region with the smallest water resources utilization efficiency. By 2019, the overall watershed gap will be reduced, and the regional difference is almost insignificant compared with 2008.

3.2. Temporal and Spatial Evolution of High-quality Economic Development in the Yellow River Basin

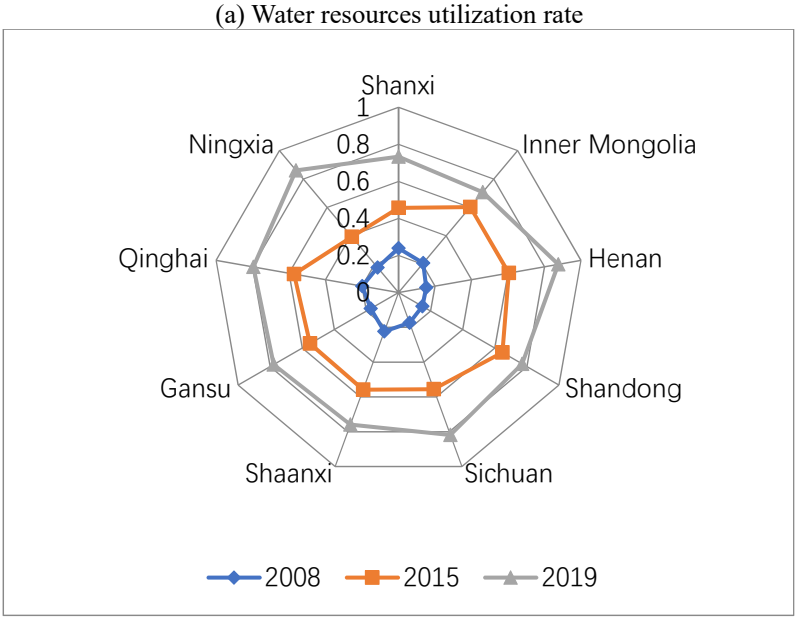
3.2.1. Time Evolution Analysis of High-quality Economic Development in the Yellow River Basin

As can be seen from Figure 1, the comprehensive evaluation index of high-quality economic development in the Yellow River Basin from 2008 to 2019 showed an increasing trend year by year, with a total increase of 76.14%. Different index values increased to varying degrees during the study period. The coordinated development of various indicators improved the high-quality economic development level of the Yellow River Basin. During the study period, the Yellow River Basin has a large growth in innovative development and shared development, and the growth of patent grant in innovative development is the largest. Especially after 2017, the amount of patent grant can reflect

the output of innovation to a certain extent; In terms of shared development, the total business volume of the postal industry has increased rapidly since 2013. By 2019, the total business volume of the postal industry has increased by about 12 times that of 2008, and the number of beds in medical and health institutions has increased by 1.4 times. Among the other development dimensions, the growth rate of green development is the smallest, and the forest coverage and green coverage of urban construction areas are basically stable.



(a) Water resources utilization rate



(b) High-quality economic development

Figure 2. Changes in water resource utilization and high-quality economic development in the nine provinces of the Yellow River

3.2.2. Spatial Evolution Analysis of High-quality Economic Development in the Yellow River Basin

It can be seen from figure 2b that there were significant regional differences in high-quality economic development in the nine provinces of the Yellow River from 2008 to 2019. Contrary to the utilization efficiency of water resources, the high-quality economic development in the middle and lower reaches was higher than that in the upper reaches. The high-quality economic development of Shanxi and Shaanxi was the highest in 2008, the high-quality economic development level of Henan and Ningxia was the highest in 2019, and the highest level of high-quality economic development shifted from Shanxi and Shaanxi to Henan and Ningxia. Compared with the trend of water resources, the change trend of high-quality economic development in the nine provinces of the Yellow River is increasing year by year. The fastest growth rate is Henan and the slowest is Shanxi, with an increase of 72.11% and 49.35% respectively. Henan Province has a large population, and its economic aggregate, fiscal revenue and other indicators rank first in the central and western regions. Henan has continuously improved in the optimization of industrial structure, expansion of opening-up and innovation of science and technology. While paying attention to ecology, it has driven the steady improvement of the quality and efficiency of economic development. Although Shanxi has achieved stable economic development and accelerated urbanization after the implementation of high-quality economic transformation, its fossil energy production and consumption account for 80% of energy production and consumption, which poses a great threat to the local ecological security and leads to unsustainable economic development.

3.3. Coupling Analysis of Water Resources Utilization Rate and High-quality Economic Development in the Yellow River Basin

3.3.1. Analysis on Coupling Time Evolution of Water Resources Utilization Rate and High-Quality Economic Development in the Yellow River Basin

Figure 3 shows the change trend of coupling degree and coupling coordination degree of water resources utilization and high-quality economic development in the Yellow River Basin from 2008 to 2019. It can be seen from the figure that although both coupling degree and coupling coordination degree showed an upward trend during the study period, the growth trend of coupling degree was gentle, while the increase of coupling coordination degree was large, which was related to the initial state of the two. In 2008, the coupling degree between water resources utilization rate and high-quality economic development was 0.9198, and the highest coupling degree was 0.9952 in 2018, an increase of only 8.02%. The average value of the coupling degree is 0.9754. From 2012 to 2019, the coupling degree is above the average value. From 2015 to 2018, the coupling degree is around 1 and tends to be stable, which indicates that the overall coupling degree of the basin has shown a high level in the early stage of the study. Although it has been improved during the study period, there is little room for improvement. The synergy between water resources utilization efficiency and high-quality economic development promotes each other. Only analyzing the coupling degree can not reflect the good and bad of coordinated development. Therefore, this paper measures the coupling cooperative scheduling based on the coupling degree.

It can be seen from Figure 3 that the coupling coordination degree of water resources utilization rate and high-quality economic development in the Yellow River Basin showed an upward trend from 2008 to 2019, with an increase rate of 87.97%, indicating that the overall water resources utilization rate and high-quality economic development direction of the Yellow River Basin were consistent and mutually promoted during the study period. From 2008 to 2019, the degree of coupling and coordination has gone through five stages: approaching imbalance, barely coordination, primary coordination, intermediate coordination and good coordination. Except for 2008 and 2009, the degree of coupling and coordination in other years is in a coordinated state, indicating that the utilization rate of water resources and the level of economic development in the Yellow River Basin have been greatly improved during the study period. The improvement in economic development is mainly due to the economic development and transformation strategy formulated by the central government. In terms of water resources utilization efficiency, it not only benefits from the unified management mode, but also depends on the targeted and personalized management of various regions, so as to improve the water resources utilization rate in an all-round way, strictly control the water consumption, strengthen the treatment of water pollution, eliminate the direct discharge of industrial sewage, and promote the improvement of the coupling and coordination level between water resources utilization rate and high-quality economic development.

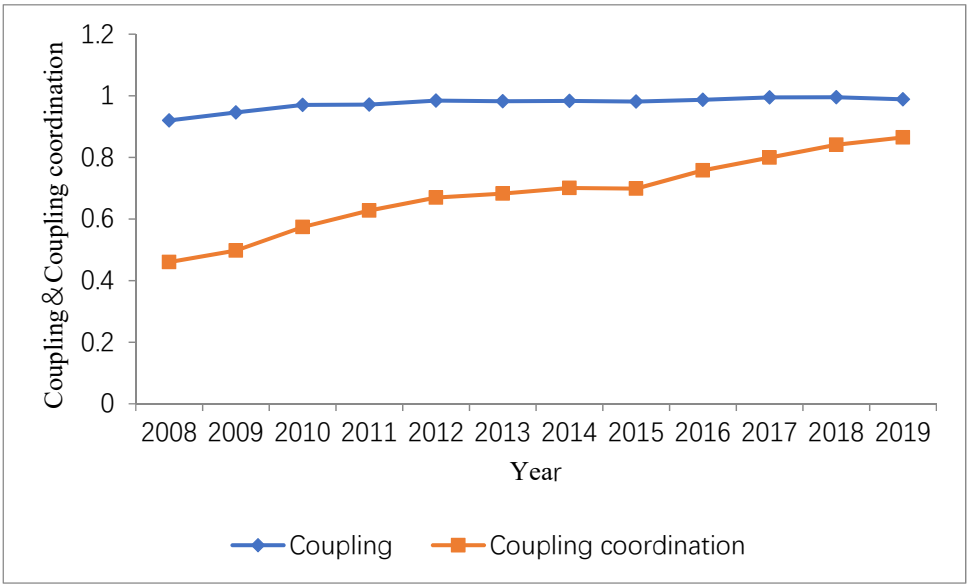


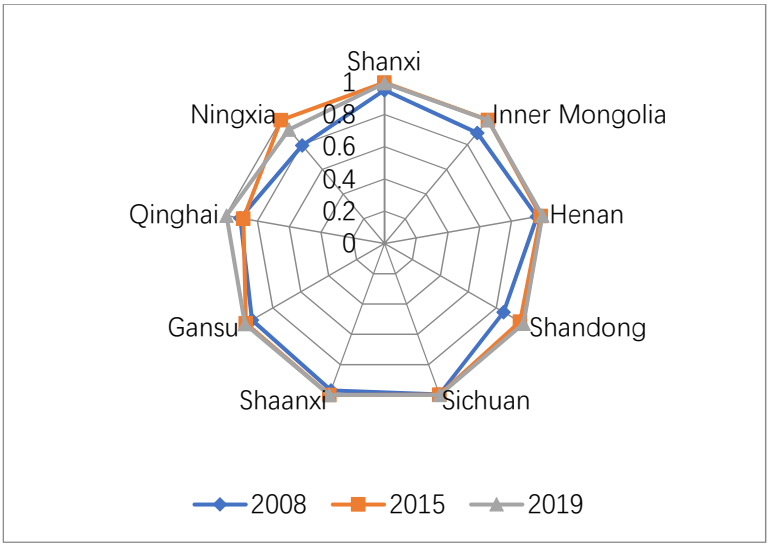
Figure 3. Coupling degree and coupling co dispatching between water resources utilization rate and high-quality economic development in the Yellow River Basin

3.3.2. Coupling Spatial Evolution Analysis of Water Resources Utilization Rate and High-quality Economic Development in the Yellow River Basin

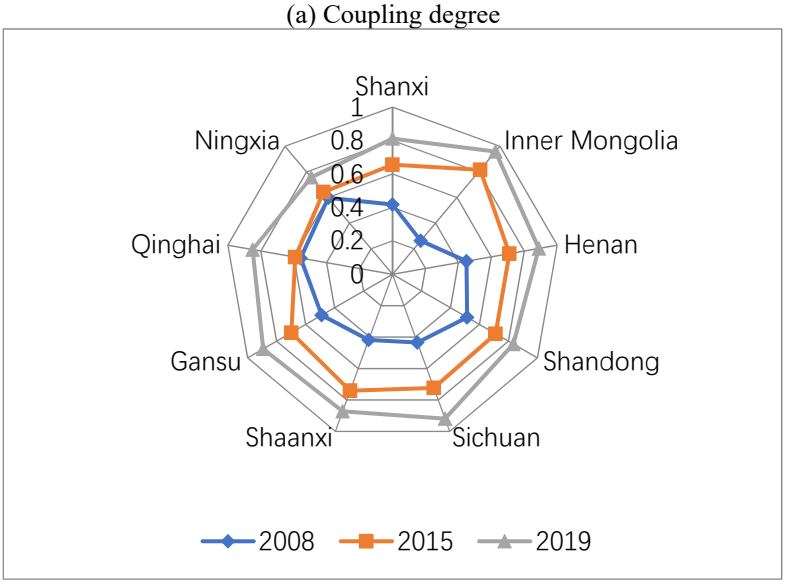
Figure 4 shows the coupling degree of water resources utilization rate and high-quality economic development and the change trend of coupling co dispatching in the nine provinces of the Yellow River from 2008 to 2019. As can be seen from figure 4a, the coupling degree of Inner Mongolia, Shandong and Ningxia among the nine provinces of the Yellow River in 2008 was less than 0.9, and the coupling degree of water resource utilization and high-quality economic development in the nine provinces of the Yellow River since 2015 exceeded 0.9, indicating that the coupling degree of the two was very high during the study period.

It can be seen from figure 4B that from 2008 to 2019, the coupling coordination degree between water resources utilization rate and high-quality economic development in the nine provinces of the Yellow River basically showed an increasing trend, with Inner Mongolia increasing the most. The coupling coordination degree in 2019 was 2.65 times that

in 2008, and Ningxia increased the least, only 26.71%. In 2008, most of the nine provinces of the Yellow River were on the verge of imbalance. Only Shandong, Qinghai and Ningxia achieved barely coordination. In 2019, all provinces except Ningxia reached a good degree of coordination or above. From 2013 to 2019, the coupling coordination degree of all provinces entered a rapid growth, which is the same as the overall trend of the Yellow River Basin, Since China began to implement high-quality economic transformation, the coupling coordination level of all provinces has reached above the intermediate coordination level. During the study period, the coupling coordination degree of the nine provinces of the Yellow River shifted from the upper reaches to the middle and lower reaches, and the gap of the coupling coordination degree of the whole basin gradually decreased, indicating that the coupling coordination degree of all regions has a good development trend and strong regional coordination. The nine provinces of the Yellow River have obvious regionalization characteristics of social and economic development. Most of the provinces in the upper reaches of the Yellow River are in ecologically fragile areas, and the economic development is relatively backward compared with the lower reaches. The huge gap between the utilization efficiency of water resources and the speed of economic development between regions led to the low level of coupling and coordination between the overall utilization rate of water resources and high-quality economic development in the Yellow River Basin in 2008. In recent years, the economic development model of the Yellow River Basin began to change, The economic development model should not only focus on speed and ignore the quality of development. Only by turning to high-quality development can the basin economy develop in a green, healthy and sustainable direction. The provinces in the basin begin to implement the dual control scheme of total and intensity of water resources consumption. In addition to the policies and regulations related to water resources management issued by the provinces, joint law enforcement and mutual cooperation between provinces can greatly improve the efficiency of water resources utilization, In order to realize the coordinated development of various elements of economic and social development and water resources utilization.



(a) Coupling degree



(b) Coupling co scheduling

Figure 4. Changes of coupling degree and coupling coordination degree between water resources utilization rate and high-quality economic development in the nine provinces of the Yellow River

3.3.3. Temporal and Spatial Transfer Characteristics of Coupling Coordination Degree Between Water Resources Utilization and High-quality Economic Development in the Yellow River Basin

Figure 5 shows the spatial distribution of the standard deviation ellipse of the coupling coordination degree between water resources utilization and high-quality economic development in the Yellow River Basin from 2008 to 2019. It can be seen from Figure 5 that the standard deviation ellipse as a whole shows a spatial distribution pattern of West (South) - East (North). It shows a moving path to the Northeast in 2015 and 2019, with a center of gravity transfer distance of 100.89km. From 2008 to 2015, the ratio of the major and minor axes of the standard deviation ellipse decreased from 2.48 to 2.07, and the center of gravity shifted 110.38km to the northeast. From 2015 to 2019, the ratio of the major and minor axes of the standard deviation ellipse increased from 2.06 to 2.10, and the center of gravity shifted to the northwest, moving 14.15km (Table 1). This shows that the coupling coordination degree of the study area tends to expand to the north in both periods, and the expansion trend gradually decreases, the gap between regions is narrowing, and the azimuth turns clockwise. The change of rotation angle is reduced, the coupling development of water resources utilization rate and high-quality economic development in the northeast of the Yellow River Basin is gradually improved, and the overall regional difference shows a decreasing trend.

Table 4. Changes of ellipse parameters of standard deviation of coupling coordination degree between water resources utilization rate and high-quality economic development

Year	Center of gravity position		Migration direction	Ratio of long and short axes	Azimuth / (°)
2008	107.54°N	36.14°E		2.48	83.71
2013	108.59°N	36.65°E	northeast	2.06	76.72
2019	108.18°N	36.54°E	northwest	2.10	78.29

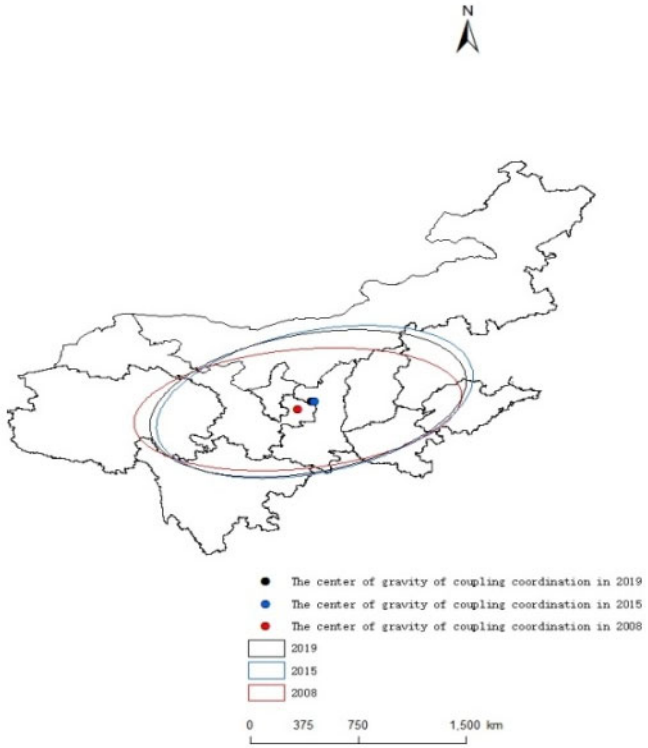


Figure 5. Standard deviation elliptic distribution of coupling coordination degree between water resource utilization and high-quality economic development

3.4. The Utilization Rate of Water Resources and the Driving Factors of High-quality Economic Development in the Yellow River Basin

Combined with the research of scholars at home and abroad and the specific characteristics of the research area, this paper analyzes the factors affecting the coupling between water resources utilization efficiency and high-quality economic development. The selection of independent variables considers the following three aspects: first, the water resources conditions of the region, including the total amount of water resources, precipitation, surface water resources and natural factors. The second is the socio-economic factors. The population change rate and per capita GDP are selected to represent the socio-economic factors. Finally, government financial support is also an important factor. The proportion of science and education expenditure in total expenditure is selected as the representative. According to the detection results of the geographic detector (table), the driving forces of each factor from high to low are: population change rate (0.978), precipitation (0.975), surface water resources (0.973), proportion of science and education expenditure in total expenditure (0.957), total water resources (0.933) and per capita GDP added value index (0.929).

Table 5. Influencing factors of coupling between water resources utilization efficiency and high-quality economic development

Factor	Total water resources	Precipitation	Surface water resources	Population change rate	Proportion of science and education expenditure in total expenditure	Per capita GDP added value index
q value	0.933	0.975	0.973	0.978	0.957	0.929
p value	0.029	0.014	0.012	0.016	0.049	0.022

Socio economic factors are the leading factors affecting the coupling between water resource utilization efficiency and high-quality economic development. The increase or decrease of population size and the speed of economic development will affect the regional demand for water resources, and the change of population size will also bring changes in regional economic development. The provinces with the largest population increase and decrease in the nine provinces of the Yellow River in 2019 are Ningxia and Inner Mongolia, with 9.86% and - 2.89% respectively. Population is an important factor in promoting economic growth. High quality labor productivity will not only contribute to local GDP, but also reduce the excessive consumption of regional natural resources. The water resource conditions of the region itself are also an important factor affecting the coupling of water resource utilization efficiency and high-quality economic development. Some provinces in the basin have rich water resources and abundant precipitation, which is conducive to improving the water resource utilization efficiency of the region. If we can carry out social production with a high-quality economic model, we can make the most of this natural advantage and reduce the pollution of water resources at the same time, Improve the efficiency of water resources utilization and high-quality economic development. Government financial support plays a key role in improving the coupling between the two. The nine provinces of the Yellow River have increased their support for science, technology and education from 2008 to 2018. Scientific and technological innovation is the driving force of high-quality economic development. Improving population quality can effectively improve the damage to the environment and excessive consumption of resources, and effectively improve the utilization efficiency of regional water resources.

4. Conclusions and Suggestions

4.1. Conclusion

This paper constructs a comprehensive evaluation index system of water resources utilization rate and high-quality economic development in the Yellow River Basin, measures the coupling and coordination relationship between them by using entropy method and coupling and coordination model, and analyzes the factors affecting the coupling and coordination between water resources utilization rate and high-quality economic development with the help of Geographic detectors. The research results show that:

(1) From 2008 to 2019, the comprehensive evaluation index of water resources utilization rate in the Yellow River Basin showed a fluctuating upward trend, with an increase of 62.09%. The nine provinces of the Yellow River have obvious differences in water resources utilization rate in different years from 2008 to 2019. Gansu has the highest water resources utilization efficiency in 2008, Sichuan has the highest in 2019, Inner Mongolia has the largest increment, and Shandong has the smallest increase, with an increase of 0.713 and 0.1573 respectively.

(2) From 2008 to 2019, the comprehensive evaluation index of high-quality economic development in the Yellow River Basin showed an upward trend year by year, with an increase of 76.14%. There were significant regional differences in high-quality economic development in the nine provinces of the Yellow River Basin from 2008 to 2019. The high-quality economic development of Shanxi and Shaanxi was the highest in 2008, the high-quality economic development level of Henan and Ningxia was the highest in 2019, and the highest level of high-quality economic development shifted from Shanxi and Shaanxi to Henan and Ningxia.

(3) From 2008 to 2019, the coupling degree and coupling coordination degree of water resources utilization rate and high-quality economic development in the Yellow River Basin showed an upward trend, the growth of coupling degree was gentle, and the growth of coupling coordination quota was large. The degree of coupling coordination has increased from being on the verge of imbalance to good coordination. From 2008 to 2019, the coupling degree and coupling coordination degree of water resources utilization rate and high-quality economic development in the nine provinces of the Yellow River showed an increasing trend year by year. Since 2013, the coupling degree of the nine provinces of the Yellow River has exceeded 0.9, indicating that the coupling degree of the two is very high during the study period. In terms of coupling coordination degree, most of the nine provinces of the Yellow River were on the verge of imbalance in 2008. Only Shandong, Qinghai and Ningxia achieved barely coordination, and all provinces except Ningxia achieved good or above coordination in 2019. The standard deviation of the coupling coordination degree between water resources utilization rate and high-quality economic development in the Yellow River Basin from 2008 to 2019 shows a spatial distribution pattern of West (by South) - East (by North), which shows that the coupling coordination degree of the study area tends to expand to the Northeast in these two periods, the expansion trend gradually decreases, and the gap between regions is narrowing day by day.

(4) The results show that socio-economic factors are the deep-seated reasons driving the coupling between water resources utilization and high-quality economic development in the Yellow River Basin. The difference of resource endowment will have a great impact on water resources utilization. The degree of government financial support is also an important reason to improve the coupling and coordination between water resources utilization efficiency and high-quality economic development.

4.2. Suggestions

(1) Optimize the allocation of water resources in the basin and strictly control the water consumption. Give priority to ecology, refine the distribution scheme of available water supply of the Yellow River, strengthen the protection of upstream water sources on the basis of meeting the basic needs of production and life, control the ecological flow of sections, ensure the basic principle of ecological water use, and make more use of South-to-North Water Transfer in the middle and lower reaches to reduce the pressure on upstream water use. Strictly implement the control of water consumption in various regions, punish enterprises and individuals who use water exceeding the standard according to law, formulate and implement water consumption restrictions in river basins and regions, strengthen source prevention and ecological protection, strictly abide by the ecological red line, resolutely crack down on cross-border behavior, protect the water environment, reduce industrial overfishing and the expansion of production activities such as water transportation and aquaculture, improve the ecological compensation mechanism and reasonably arrange the utilization of water resources. In areas with shortage and overload of water resources, adjust the local industrial structure, eliminate industries with serious water pollution and large water consumption, reasonably determine the irrigation scale and reasonably plan the agricultural water consumption.

(2) Adhere to the path of high-quality economic development. Ecological and environmental protection and high-quality economic development develop together. Under the guidance of the thought of ecological civilization, while developing economy, reduce the bearing pressure of ecological environment and ensure the sustainable development of watershed ecology. Promote high-quality economic development in the Yellow River basin with the five development concepts of "innovation, coordination, green, openness and sharing". Under the environment-friendly policy, we will strengthen the support of enterprises in the field of clean energy and environmental protection, and strictly support the development of enterprises in the key field of clean energy and environmental protection based on their own capital. Reduce the differences in economic development between regions and between urban and rural areas, so that all regions in the basin can enjoy the benefits of high-quality economic development. Further enhance the publicity of ecological civilization, deepen residents' understanding of ecological civilization, improve citizens' quality, strengthen supervision and management, and guide people's green consumption behavior.

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