Study on coordination and quantification of ecological protection and high quality development in the Yellow River Basin

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Abstract. In this paper, a quantitative index system for the coordinated promotion of ecological protection and high-quality development in the Yellow River Basin is constructed, and the method of "single index quantification multi index synthesis multi criteria integration" is adopted to quantitatively evaluate the coordination degree of ecological protection and high-quality development in the Yellow River Basin. Using the data of the Yellow River Basin from 2009 to 2018 for example, the results show that the coordination degree of the Yellow River Basin shows an upward trend from "close coordination" to "relatively collaborative" from 2009 to 2018.

1. Introduction
With the proposal of the national major strategy of ecological protection and high-quality development in the Yellow River Basin, more and more scholars focus on this aspect of research. The ecological protection of the Yellow River mainly focuses on climate control, water resources utilization, wetland protection, delta ecological evolution, water strategic layout, comprehensive management and sustainable development[1]; The research on high-quality economic and social development focuses on the promotion and support system of the Yellow River development strategy, innovation driven, development of central cities and urban agglomerations, industrial layout, measurement of high-quality development level, overall planning and coordination, and construction of the Yellow River economic axis belt. The research on ecological protection and high-quality development in the Yellow River Basin has a certain foundation, but there is a lack of in-depth research on collaborative quantification. Moreover, most of the research on the collaborative promotion of ecological protection and high-quality development are still in the stage of theoretical discussion and case analysis[2]. They only emphasize the mutual promotion and coordinated development of multi-system, and ecological protection and development of high quality. We study is mostly in the theoretical discussion and case analysis stage, more than a single emphasis on system mutual promotion and coordinated development, not form a unified measurement method of the quantitative standard and lack of coordination is determined based on the comprehensive theoretical analysis, promote criteria, build the index system, a quantitative method system synergy theory of quantitative research are put forward.
2. The research content

2.1. Principle of collaborative promotion
From the point of view of science and practice, quantitative criterion is a kind of paradigm, which integrates the guidelines and norms related to scientific benchmark and research content, and is the code of conduct that should be followed from theory to practice on the basis of consensus[3]. Based on the understanding of the national major strategy of ecological protection and high-quality development in the Yellow River Basin, the paper puts forward "four criteria" for coordinated promotion, namely, healthy ecological environment, high-quality economic development, harmonious coexistence of human and water, and happiness of people's life.

2.2. Collaborative promotion of quantitative index system
Based on the framework of collaborative quantitative criteria, and considering the spatial differences and key issues of different regions in the basin, the representative indicators were selected to measure the synergy status of ecological protection and high-quality economic development[4]. At the same time, according to the principles of scientificity, systemativeness, applicability and accessibility, a quantitative index system is constructed, which is composed of "target layer, criterion layer (subsystem layer), classification layer and index layer".

According to the analysis of the quantitative criteria, whether the ecological protection and high-quality development of the Yellow River basin can be coordinated is reflected in four aspects: ecological environment health, high-quality economic development, harmonious coexistence of human and water, and people's life happiness. Therefore, ecological environment health, high-quality economic development, harmonious coexistence of human and water, and people's life happiness are taken as four subsystems to measure their development level.

① The subsystem of ecological and environmental health is embodied in ecological restoration and environmental protection. In view of the high sediment concentration and serious soil and water loss in the Yellow River Basin, four indicators were selected to reflect ecological restoration, including forest coverage rate, newly increased soil erosion control area this year, proportion of wetland area in the area under jurisdiction, and proportion of natural reserve area in the area under the jurisdiction to reflect ecological restoration; annual mean value of PM2.5, the amount of fertilizer application, the proportion of investment in pollution control and the proportion of class I-III water quality functional areas were selected four indicators reflect environmental protection.

② The subsystem of high-quality economic development should consider three aspects: economic base, innovation driven and open cooperation. In terms of economic basis, the economic development degree, economic regulation ability, economic stability and economic structure are reflected by four indicators of per capita GDP, per capita financial income, economic fluctuation rate and the contribution rate of the tertiary industry; in the aspect of innovation drive, R & D investment is reflected by R & D investment intensity and the number of employees in 10000 employees, and R & D output is reflected by invention patent authorization of 10000 people; in terms of opening up and cooperation, the degree of dependence on foreign trade is used to reflect the degree of local dependence on the international market; the degree of dependence on foreign direct investment is used to reflect the degree of dependence of local economy on foreign direct investment; and the degree of dependence on foreign direct investment is used to reflect the degree of local utilization of international resources and development of international market.

③ The subsystem of harmonious coexistence of human and water mainly embodies the harmony between human and resource environment, especially the harmony between human and water resource. It is measured from three aspects of water resource condition, water environment impact and water resource utilization. The condition of water resource is reflected by per capita water resource, total amount of reservoir water storage at the end of the year and comprehensive production capacity of water supply; the proportion of regional area and daily sewage treatment capacity reflect the impact of water environment, and the water consumption per 10000 yuan GDP, the utilization rate of water resources and the effective utilization coefficient of irrigation water are used to reflect the utilization of water.
The sub-system of people's happiness of life is reflected from three aspects: quality of life, population characteristics and public services. The quality of life is reflected by urban-rural income ratio, Engel coefficient, rural poor population and urban registered unemployment rate. Population characteristics are reflected by urbanization rate, aging ratio and per capita education years. Internet penetration rate, per capita urban road area and per capita basic maintenance are used. The accumulated balance of old insurance and health technicians per thousand people reflect the level of public services.

2.3. Collaborative quantification method

The single index is quantified by piecewise fuzzy membership analysis method, and each index is mapped to the interval of [0,1] by piecewise function. According to the relationship between indicators and synergy degree, it is divided into positive indicators and reverse indicators. The corresponding change curve of single index synergy degree is shown in Figure 1. The index function is divided into five sections, corresponding to the five characteristic values of each index, the worst value (a), the poor value (b), the pass value (c), the better value (d), the optimal value (E), and the corresponding synergy degree are 0, 0.3, 0.6, 0.8 and 1, respectively.

![Figure 1. Change curve of single index synergetic degree](image)

The calculation formula of sub synergy degree of single index is as follows, where formula (1) represents positive index and formula (2) represents reverse index:

$$\text{SHD}_i = \begin{cases} 0 & (x_i \leq a_i) \\ 0.3 \frac{x_i - a_i}{b_i - a_i} & (a_i < x_i \leq b_i) \\ 0.3 + 0.3 \frac{x_i - b_i}{e_i - b_i} & (b_i < x_i \leq e_i) \\ 0.6 + 0.2 \frac{x_i - e_i}{d_i - e_i} & (e_i < x_i \leq d_i) \\ 0.8 + 0.2 \frac{x_i - d_i}{a_i - d_i} & (d_i < x_i \leq a_i) \\ 1 & (x_i > a_i) \end{cases} \quad (1)$$

$$\text{SHD}_i = \begin{cases} 1 & (x_i \leq e_i) \\ 0.8 + 0.2 \frac{d_i - x_i}{d_i - e_i} & (e_i < x_i \leq d_i) \\ 0.6 + 0.2 \frac{c_i - x_i}{c_i - d_i} & (d_i < x_i \leq c_i) \\ 0.3 + 0.3 \frac{b_i - x_i}{b_i - c_i} & (c_i < x_i \leq b_i) \\ 0.3 \frac{a_i - x_i}{a_i - b_i} & (b_i < x_i \leq a_i) \\ 0 & (a_i < x_i) \end{cases} \quad (2)$$

Aiming at the four sub-system layers of ecological environment health, high-quality economic development, harmonious coexistence of human and water, and people's life happiness, this paper adopts the method of multi index integration to comprehensively evaluate the collaborative development index of the four subsystems, and the calculation formula is as follows:
\[ \text{SIEHD}(T) = \sum_{i=1}^{n} w_i \text{SHD}_i[Y^i(T)] \]  

(3)

In the formula, \( Y^i(T) \) is the value of a certain quantitative index at \( t \) time, and its single index quantitative result is \( \text{SHD}_i[Y^i(T)] \); \( \text{SIEHD}(T) \) is the overall coordinated development index at \( t \) time; \( n \) is the number of quantitative indicators of four subsystems: ecological environment health, high-quality economic development, harmonious coexistence of human and water, and people’s life happiness; \( w_i \) is the weight of each quantitative index.

After calculating the overall synergy degree, it is divided into seven grades according to the numerical value, which are shown in Table 1.

| Coordination level                      | SIEHD range   |
|----------------------------------------|---------------|
| Fully coordinated                      | 1             |
| The basic collaborative                | [1.8,1)       |
| A collaborative                        | [0.6,0.8)     |
| Close together                         | [0.4,0.6)     |
| Less collaborative                     | [0.2,0.4)     |
| Basically no coordination              | (0,0.2)       |
| No coordination at all                 | 0             |

3. Case study

The coordination degree of ecological protection and high quality development in the Yellow River Basin from 2009 to 2018 was quantitatively evaluated. After the index data collection, it is necessary to determine the characteristic value of each index. Combined with the data of each province in the Yellow River Basin and the attribute of the index, five characteristic values of each index are determined according to the selected quantitative method. According to SMI-P method, the development indexes of ecological environment health, high-quality economic development, harmonious coexistence of human and water, and happiness of people’s life in the Yellow River Basin from 2009 to 2018 are calculated by using MATLAB, and then the total synergy degree is calculated according to the weight weighting. The calculation results of the overall coordination degree of the Yellow River Basin are shown in Table 2.

| Project                                | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|----------------------------------------|------|------|------|------|------|------|------|------|------|------|
| Ecological environmental health        | 0.112| 0.112| 0.114| 0.117| 0.121| 0.123| 0.122| 0.124| 0.126| 0.129|
| High-quality economic development      | 0.079| 0.090| 0.104| 0.118| 0.127| 0.133| 0.139| 0.146| 0.148| 0.151|
| People and water coexist harmoniously | 0.153| 0.149| 0.159| 0.156| 0.156| 0.168| 0.168| 0.166| 0.172| 0.172|
| The people live a happy life           | 0.081| 0.091| 0.103| 0.113| 0.123| 0.132| 0.135| 0.140| 0.147| 0.152|
| Composite indicator                    | 0.425| 0.442| 0.480| 0.504| 0.528| 0.555| 0.564| 0.577| 0.593| 0.605|
| Coordination level                     | Close | Close | Close | Close | Close | Close | Close | Close | Close | Close |
4. Conclusion
Based on the analysis of relevant literature, the relationship between ecological protection and high-quality development in the Yellow River Basin is discussed. From the quantitative point of view, four quantitative criteria are put forward, namely "healthy ecological environment, high-quality economic development, harmonious coexistence of human and water, and happiness of people's life"; Smi-p method was used to calculate the synergy degree. Taking 2009-2018 as an example for analysis and calculation, and compared with the calculation results of other scholars, the results show that the overall coordination degree of the Yellow River Basin has changed from "close coordination" to "relatively collaborative", but the overall coordination degree is not high; the two subsystems of high-quality economic development and people's life happiness have increased greatly, while the two subsystems of ecological environment health and harmonious coexistence of human and water develop slowly; There are some differences in the level of coordinated development among the provinces in the Yellow River Basin, but they have been steadily improved year by year. From the comparison results, we can see that the calculation ranking of the nine provinces in the Yellow River Basin has certain similarity with other scholars, which proves that the quantitative criteria, index system and quantitative methods constructed in this paper have certain applicability.

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References
[1] Andrew J M, Jeffrey A N, Ma H B, et al. (2019) Modeling Deltaic Lobe-Building Cycles and Channel Avulsions for the Yellow River Delta. J. Geophysical Research: Earth Surface, 124(11): 2438–2462.
[2] HIDEYASU S.(2011) A Computing Theory for Collaborative and Transparent Decision Making Under Time Constraint. Information Systems Frontiers, 13(2): 207-220.
[3] MAH MUT P, MOOSA S, MARK G.(2019) Optimal Control and Cooperative Game Theory Based Analysis of a Byproduct Synergy System. J. of Cleaner Production, 243(5): 731-742.
[4] Cloern J E, Jassby A D,(2012) Drivers of change in estuarine coastal ecosystems: Discoveries from four decades of study in San Francisco Bay. Reviews of Geophysics, 50(4): 1-33.