Evaluation of Water Resources Carrying Capacity of Four Provinces and Regions in Liaohe River Basin

Langduo Wang

School of Geographical Sciences, Liaoning Normal University, Dalian 116029, China.

Abstract: Based on the perspective of human-water relations coordination, the TOPSIS model, coupled with the coordinated development model quantitatively analyses the water resources carrying capacity and spatial-temporal evolution of the four provinces and regions of the Liaohe River Basin and the degree of the subsystems' carrying capacity and coordinated development from 2005 to 2020. The results show that: a. The fluctuation trend of the region as a whole from 2005 to 2020 indicates that the state of water resources carrying capacity is unstable. b. The fluctuation range of the carrying capacity of the four subsystems is large, and the fluctuation of the water resources and water ecology subsystems is more significant, and the carrying capacity of the water resources and water ecology subsystems is lower than that of the water society and water economy subsystems, and the amount of water resources development and utilisation has exceeded the water resources subsystems' carrying capacity Water resources development and utilisation has exceeded the carrying capacity of the water resources subsystem.

Keywords: Water resources carrying capacity; TOPSIS model; Coupled coordination degree

1. Introduction

Water is a valuable resource indispensable to human survival and development, along with social development, the relationship between people and water is becoming more and more complex[1]. Water resources carrying capacity refers to the maximum scale of economic and social development that regional water resources can sustain to support the region when it is close to destroying the sustainable use of water resources, which is based on the human-water relationship and the theory of human-water harmony of the subdivision research. The study of water resources carrying capacity[2,3] has become the core and link of water science, i.e. the focus and hotspot in the study of human-water relationship, which is of great significance to the sustainable socio-economic development, ecological environmental protection and optimal allocation of water resources.

2. Research Methodology and Data Sources

2.1 Research Methodology

Water resources carrying capacity is a more comprehensive capacity, water resources in the entire economic society and ecosystem as the main bearer, in the assessment of regional water resources carrying capacity should be considered in a comprehensive manner of various subsystems. The construction of the index system in this paper refers to the research of Zuo Qiting[4], Tang Jiakai[5], Wu Mingyan[6] and other scholars, and takes into full consideration of the actual situation of the four provinces and regions in the Liaohe River Basin, and designates water resources carrying capacity as the target layer, and designates the four subsystems affecting the water resources carrying capacity as the four criterion layers, i.e., water resources, water society, water economy and water ecology. water resources, proportion of surface water resources, per capita daily domestic water consumption, population density, rural per capita arable land area, 10,000 yuan of GDP water

consumption, per mu of irrigated farmland water consumption and water use elasticity coefficient, fertiliser application intensity, 10,000 yuan of GDP wastewater discharge, and afforestation area.

The weights were determined by standardising the raw data first, and then using entropy weight and coefficient of variation method[7] combined with the principle of minimum information entropy to calculate the combined weights of each indicator. In the subsequent analysis, the TOPSIS model[8] was used to calculate the water resources carrying capacity level, and the "coupling coordination" model[9] was used to study the interactions between the subsystems within the system, so as to comprehensively analyse the coordination within the system in each province and region of the Liaohe River Basin.

2.2 Data Sources

The data in this paper come from the Provincial Statistical Yearbook, China Statistical Yearbook, Water Resources Bulletin, Rural Statistical Yearbook of each province and district, and government work reports for 2005-2020.

3. Analysis of Results

3.1 Analysis of Water Resources Carrying Capacity Levels

From 2005 to 2020, the water resources carrying capacity of the four provinces and regions in the Liaohe River Basin is in a fluctuating trend, and the average value of the water resources carrying capacity index of the four provinces and regions decreases from 0.589 in 2005 to 0.549 in 2020, and the fluctuating trend of the overall water resources carrying capacity of the region indicates that the state of water resources carrying capacity is unstable, and water resources pressure is still relatively embarrassing. From the time change point of view, by the Liaohe River Basin is more obvious influence of the Inner Mongolia Autonomous Region and Liaoning Province, the water resources carrying capacity index respectively by 2005, 0.775, 0.748 fell to 0.469 in 2020, 0.489 overall fluctuations in the downward trend; and Hebei Province and Jilin Province, the water resources carrying capacity index but by 2005, 0.437, 0.397 in 2005 to 0.516 and 0.723 in 2020, and the coordinated development of regional nature, society and ecology has become an inevitable trend of future regional sustainable development. From the point of view of spatial change, in 2005, the order of water resources carrying capacity index is: Inner Mongolia (0.775), Liaoning (0.748), Hebei (0.437), Jilin (0.397), and in 2020, the order of Jilin (0.723), Hebei (0.516), Liaoning (0.489), Inner Mongolia (0.469), which can be seen in the carrying capacity of water resources. This shows that there are obvious differences in various regions, and the degree of change in the spatial differences in water resources carrying capacity is large, and the water resources carrying capacity of Jilin Province and Hebei Province has increased significantly.

3.2 Analyses of the Results of the Water Resources Carrying Capacity Subsystems

From 2005 to 2020, the carrying capacity of the four subsystems of water resources, water society, water economy and water ecology in the four provinces of the Liaohe River Basin, with the exception of Liaoning Province, shows a decreasing, then increasing, then decreasing, and finally increasing trend, while the carrying capacity of each subsystem in Liaoning Province is maintained at a medium level, and in the calculation of the whole study, it is found that the weights of each subsystem in Liaoning Province are relatively close to each other, which shows that the development of each subsystem of the Liaoning water resources carrying capacity is relatively balanced. The weights of the subsystems in Liaoning Province are also close to each other, indicating that the development of each subsystem of water resources carrying capacity in Liaoning Province is relatively balanced. In the remaining three provinces and regions, it can be found that the fluctuation range of the water resources subsystem is larger, indicating that the natural conditions of water resources do have a large uncertainty, Hebei, Inner Mongolia and Jilin had abundant precipitation in 2011-2013, especially in 2012 and 2013, which produced a large modulus, so the water resources subsystem has a high carrying capacity; the water society and water economy subsystems show a steady upward trend from 2010 to 2020. The water society and water economy subsystems have shown a steady upward trend since 2010-2020. Overall, the carrying capacity of the water resources and water ecology subsystems is lower than that of the water society and water economy subsystems.

3.3 Analysis of the Degree of Coordination of Subsystem Coupling

The degree of coupling between the four subsystems of water resources, water society, water economy and water ecology in the four provinces and regions of the Liaohe River Basin is high and the degree of coordination is good. The mean value

of the coupling degree of the four subsystems shows an increasing trend year by year, and the trend of the coupling coordination degree is basically consistent with the trend of the coupling degree, but it also shows that the coupling coordination degree is affected by the development degree. From the perspective of temporal change, the overall trend of subsystem coupling coordination degree in Inner Mongolia and Jilin Province shows an increasing trend, with a large increase but also fluctuations, and the coupling coordination degree in Hebei Province and Liaoning Province is basically good. From the perspective of spatial change, the coupling coordination degree of the four provinces and regions is ranked from high to low as Liaoning (0.715), Hebei (0.649), Jilin (0.619), Inner Mongolia (0.583) the four provinces and regions belong to the intermediate level of coupling coordination development. In conclusion, the degree of coordinated development of the overall subsystem carrying capacity of the Liaohe River Basin is good, and the subsystems are gradually converging to a balanced development.

4. Conclusion and Discussion

Based on the perspective of human-water relations coordination, we constructed a comprehensive evaluation index system of water resources carrying capacity from four aspects: water resources, water society, water economy and water ecology, and quantitatively analysed the spatial and temporal evolution of water resources carrying capacity and the degree of coordinated development of various subsystems from 2005 to 2020 by using the coefficient of variation-entropy weighting method, the TOPSIS model, and the coupled coordinated development model, and came up with the following conclusions For:

(1) The fluctuation trend of the region as a whole from 2005 to 2020 indicates that the state of water resources carrying capacity is unstable.

(2) The fluctuation range of the carrying capacity of the four subsystems is large, and the fluctuation of the water resources and water ecology subsystems is more significant, and the carrying capacity of the water resources and water ecology subsystems is lower than that of the water society and water economy subsystems, and the amount of water resources development and utilisation has exceeded the water resources subsystems' carrying capacity Water resources development and utilisation has exceeded the carrying capacity of the water resources subsystem.

References

[1] Zuo Qiting. Disciplinary system and development layout of human-water relations[J]. Journal of Water Resources and Water Engineering,2021,32(3):1-5.

[2] JULiang JIN, Pengfei CHEN, Menglu CHEN et al. Bibliometric analysis of water resources carrying capacity research based on knowledge mapping[A]. Water Resources Conservation, 2019, 35(6):14-24.

[3] LI Ruyi, SHU Longcang, LU Chengpeng et al. Application and Comparison of Water Resources Carrying Capacity Evaluation Methods in Jining City[J], Water Resources Conservation, 2018, 34(6):65-70.

[4] Zuo Qiting, Zhang Zhizhuo, Wu Binbin. Evaluation of water resources carrying capacity of nine provinces and districts in the Yellow River Basin based on the combined weights TOPSIS model[J]. Water Resources Protection, 2020,36(2):1-7.

[5] Tang Jiakai. Study on the Evaluation of Water Resources Carrying Capacity and Obstacle Factors in Nine Provinces and Regions along the Yellow River [D]. Lanzhou: Lanzhou University, 2021.

[6] WU Mingyan, ZENG Xiaochun, LIU Xingde, JIN Wangqiang. Water resources carrying capacity of five provinces and regions in Northwest China based on entropy weight TOPSIS model[J/OL]. China Rural Water Conservancy and Hydropower, 20220613.

[7] Chen Hongguang, Li Xiaoning, Li Chenyang. Evaluation of water resources system resilience based on the entropy weight method of coefficient of variation - A case study of water resources in Heilongjiang Province in 2007-2016[A]. Ecological Economy, 2021,37(1):179-184.

[8] Lei Xunping, Qiu Guanghua. Empirical study on regional resource and environmental carrying capacity evaluation based on entropy weight TOPSIS model[J]. Journal of Environmental Science, 2016,36(1):314-323.

[9] ZHENG Defeng, XU Wenjin, JIANG Junchao, LU Leiting. Analysis of the evolution trend and coordinated development of water resources carrying capacity and urbanisation quality in China[A]. Economic Geography, 2021, 41(1).