ISSN: 2710-0588

The Identification and Resilience Evaluation of urban Water Ecological Resilience in the Huaihe River Basin

-- Take Bengbu City as an Example

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Abstract

Water is the foundation of life, survival, production and ecology. As the carrier of water resources, river basins support human economic and social activities and give birth to diverse civilizations. However, at present, facing problems such as water shortage, uneven distribution, pollution and landscape destruction, water environmental protection is related to the well-being of people. In the new stage of development, the 14th Five-Year Plan emphasizes pollution prevention and ecological protection, and the 20th National Congress of the Communist Party of China also advocates green development and transformation. As a part of the green development strategy, the concept of resilient cities brings new perspectives to the study of aquatic ecosystems. The construction of a water ecological resilience evaluation system can identify the key influencing factors, help researchers propose effective optimization strategies, and provide a basis for decision-making. Taking Bengbu City as an example, this study analyzes the water ecological resilience from 2012 to 2022, and puts forward guidelines and optimization strategies based on the analysis of overall and representative indicators. It aims to improve the planning system of water ecosystems in China and promote the sustainable development of water ecosystems.

Keywords

Aquatic ecosystems; Resilience evaluation; DPSIR model.

1. Introduction

Recently, with the consent of the State Council, the Ministry of Ecology and Environment and other five departments jointly issued the "Key River Basins

Water Ecological Environment Protection Planning", the top-level planning and layout of the water ecological environmental protection work in the Huaihe River Basin, and clarified the goals and tasks of the "14th Five-Year Plan" water ecological environmental protection work, for which we have made the following goals:

(1) Solve the problem of identification and analysis of resilience factors. Starting from the concept of water ecological resilience, we searched for the relevant water ecological environment indicators of Bengbu City from 2013 to 2022 from the database, combined with relevant research results at home and abroad, determined the specific water ecological resilience elements to construct an evaluation system of water ecological resilience, and used DPSIR model and entropy weight method to measure the water ecological resilience level of the Huaihe River Basin.

(2) Put forward effective policies for urban water ecology in the Huaihe River Basin. Under the premise of the 14th Five-Year Plan and the 20th National Congress of the Communist Party of

ISSN: 2710-0588

China, this paper provides theoretical support for improving the planning system of the water ecosystem in the Huaihe River Basin and provides technical support for the sustainable development of the water ecosystem in the Huaihe River Basin.

2. Literature Review

2.1. Current status of foreign research

At present, the planning and construction of urban water systems in foreign countries pay more attention to the construction of urban water ecology, which is mainly guided and supported by the theory of urban hydrology, landscape ecology, ecological restoration, waterfront development, and greenway [1-3]. There are also a lot of water system planning and design practices in foreign countries, such as the water system transformation movement in Germany, the planning and design of the Mill River Greenway in the United States, the plan to create multi-natural rivers in Japan, and the urban water system planning in Utreux, the Netherlands, etc., all of which have successfully restored the water ecosystem and confirmed the credibility of the research.

2.2. Current status of domestic research

The research on water system planning theory in China has borrowed many foreign experiences, but on this basis, many localized theories have been developed based on the domestic situation [1]. For example, Cai Qinghua's watershed ecology theory, Wang Peifang and Wang Chao's urban water ecosystem theory, and Yu Kongjian and Mo Lin's sponge city theory. In recent years, many cities in China have also chosen the corresponding water system special planning according to their own needs and characteristics, such as the implementation of the water system planning concept plan of Nanyang New Urban District, the water landscape system planning of Yancheng, and the overall urban design solicitation plan of Beijing sub-center.

Based on the above literature, it can be seen that since 2000, the research of water ecosystem has gradually attracted the attention of scholars, and the number of papers on water ecosystem research at home and abroad has gradually increased.

3. Study Design

3.1. Indicator selection and data processing

Bengbu City is located in the northeast of Anhui Province, in the middle reaches of the Huai River, located in the Qinling-Huai River line, the geographical dividing line between the north and south of China, and belongs to the junction zone of the Huang-Huai-Hai Plain and the Jianghuai hills. The geographical coordinates are 116°45′ to 118°04′ east longitude and 32°43′ to 33°30′ north latitude [4]. Taking Bengbu City as the research object, firstly, the water ecological resilience indicators were searched by consulting the relevant literature and databases, and then the data processing was carried out, and the entropy weight method was used to determine the weight Wi of each index, which paved the way for the index analysis of the DPSIR model in the future. The data used in this study are mainly from the China Statistical Yearbook 2014-2023.

(1) Take the data of Bengbu City index n years, the number of indicators m, and construct the original matrix.

$$X - \left(x_{ij}\right)_{m\times n}, i = 1,2,\cdots,m; j = 1,2,\cdots,n \quad (1)$$

ISSN: 2710-0588

Among them, X_{ij} is the initial value of the performance evaluation index, which represents the value of the ith indicator in the jth year.

(2) Data standardization.

$$f_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \tag{2}$$

Where, f_{ij} is the normalized value of x_{ij} and n is the number of regions.

(3) Calculate the entropy value.

$$U_j = \frac{1}{\ln n} \sum_{i=1}^{n} f_{ij} \ln f_{ij} \tag{3}$$

Among them, U_j is the entropy value of the jth evaluation index.

(4) Calculate entropy weight.

$$W_j = \frac{1-U_j}{\sum_{j=1}^{m} U_j} j = 1,2,3,\cdots,m \tag{4}$$

Where, w_j is the entropy weight of the j-th evaluation index.

3.2. Construction of evaluation indicators

The selection of ecological resilience evaluation indicators follows nine principles: systematic, universal, typical, suitable, independent, quantifiable, data availability, technical operability, and forward-looking [5]. Through literature review, the evaluation indicators covering artificial ecosystems and natural ecosystems were screened and determined by using the Delphi method, and the water ecological resilience evaluation index was finally divided into five levels by combining the weights of each index, which constituted the water ecological resilience evaluation system.

4. Evaluation and Analysis of Water Ecological Resilience

4.1. Analysis of water ecological resilience evaluation indicators

By substituting the data into the water ecological resilience evaluation system, the comprehensive evaluation of water ecological resilience in Bengbu City from 2013 to 2022 was obtained, and the annual growth rate of each was obtained by observing the five criterion layers of driving force, pressure, state, impact, and response [6], which indicators of the water ecosystem were insufficient.

Table 1. 2013-2022 Comprehensive evaluation of water ecological resilience in Bengbu

Target layer	Criterion layer	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Water ecological assessment	D	0.34	0.39	0.36	0.46	0.41	0.44	0.41	0.54	0.60	0.58
	P	0.25	0.31	0.33	0.46	0.49	0.52	0.48	0.58	0.72	0.65
	S	0.31	0.41	0.41	0.51	0.52	0.56	0.51	0.62	0.62	0.62
	I	0.31	0.37	0.42	0.45	0.39	0.46	0.54	0.66	0.61	0.55
	R	0.31	0.38	0.44	0.54	0.43	0.44	0.46	0.58	0.61	0.54

ISSN: 2710-0588

4.2. Analysis of representative evaluation indicators of water ecological resilience

Through the overall analysis of the representative indicators, if you want to "prescribe the right medicine" and get better improvement methods and effects, it is necessary to conduct in-depth analysis of the representative indicators, because the index weight will have an impact on the representative indicators, so the analysis method of "high weight representative indicators" is formed here, supplemented by "low weight representative indicators", and corresponding countermeasures are put forward for the optimization of water ecological resilience in Bengbu City according to the results obtained from the analysis.

5. Strategic Thinking on the Optimization of Water Ecological Resilience in Bengbu

After the analysis of the above water ecological resilience evaluation indicators, under the premise of saving water resources and ensuring water security, combined with the strategic goals of "determining the city by water, the land by water, the people by water, and the production by water", the overall guidelines should be formulated firstly, and the corresponding countermeasures should be put forward through the shortcomings of the five criterion layers, and secondly, targeted policies should be made for the representative indicators, so as to improve the planning system of the water ecosystem in the Huaihe River Basin and enhance the water ecological resilience of the Huaihe River Basin. Actively learn from the international advanced water ecological protection concepts and experience, strengthen exchanges and cooperation with relevant foreign institutions, universities and research institutes, and introduce advanced governance technology and management models.

Participate in international water ecological protection and climate change response and other issues, and enhance the influence and voice of Bengbu in global water ecological governance. Explore the establishment of more effective public participation mechanisms, such as through social media, mobile apps and other platforms, so that the public can more easily participate in water ecological protection activities, such as water quality monitoring, garbage cleanup, ecological education, etc.

Establish a reward mechanism to encourage the public to actively report pollution behavior, and form a good atmosphere of social supervision. Combined with urban renewal and the construction of new districts, promote the concept of green infrastructure, such as the construction of rain gardens, ecological parking lots, permeable pavement, etc., to improve the city's natural accumulation, infiltration, purification and utilization of rainwater, and reduce the pressure of urban drainage

Increase the area of urban green space and improve the function of urban ecosystem services. Strengthen the popularization and education of knowledge related to water ecological protection, especially for adolescents and children, and cultivate their awareness and sense of responsibility for environmental protection.

Carry out professional training and capacity building activities for government workers, business leaders, environmental protection volunteers and other groups to improve their ability and level of water ecological protection.

6. Conclusion and Discussion

During the "14th Five-Year Plan" period, China's development is still in a period of important strategic opportunities, with the in-depth promotion of new industrialization, the urbanization rate in the rapid growth range, the continuous increase in pollutant discharge pressure in the fields of industry, life, and agriculture, the improvement of water environment quality in key

ISSN: 2710-0588

river basins is not stable [7], and the continuous improvement of the water ecological environment is arduous. Based on the concept of water ecological resilience, this study proposes the development direction of water ecological resilience research based on relevant research results at home and abroad, combines the DPSIR model with ecological resilience to construct an evaluation system for water ecological resilience, and selects the evaluation indicators according to nine principles. The entropy weight method was used to determine the subjective and objective weights of the evaluation indexes, and the water ecological resilience of Bengbu City from 2012 to 2022 was analyzed, and the dynamic rigid control principles and strategies were proposed, which provided reference and suggestions for the planning and construction of water ecology construction in the Huaihe River Basin[8], and provided technical support for the sustainable development of China's water ecosystem.

Acknowledgments

This work was supported by the national research project of Anhui University of Finance and Economics, "Research on the Identification and Resilience Evaluation of Urban Water Ecological Resilience Factors in the Huaihe River Basin: A Case Study of Bengbu City" (Project No.: 202310378023).

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