



Quantitative Evaluation Research on Happy River and Lake in Bengbu City

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Abstract. The quantitative evaluation of happy rivers and lakes in Bengbu City is carried out in the context of the "Beautiful Huaihe River" project, which provides a theoretical basis for government departments to study the policy measures to stabilize the happy rivers and lakes. Taking Bengbu City as an example, based on the fuzzy comprehensive evaluation model, the evaluation index system of happy rivers and lakes was constructed, and the index of happy rivers and lakes in Bengbu City in recent years was calculated. The index of happy rivers and lakes in the study area showed a fluctuating upward trend in the index of happy rivers and lakes in Bengbu City from 2014 to 2021, and the grades of the three years of 2018, 2020, and 2021 reached the level of happiness. The drought in 2019 led to the scarcity of precipitation and lake storage, and the index of happiness was generally happy. The ARIMA time series model was used to predict the future development trend of happy rivers and lakes, and the index of happy rivers and lakes from 2021 to 2030 will be always at the happy level.

Keywords: Happy river and lake; Fuzzy comprehensive evaluation model; Time series model

1 Introduction

Recently, many scholars have studied and evaluated the health of embracing river urban rivers and lakes through different measurement standards. Overseas, Zhao [1] and others took Yangmei River as an example, and determined the results of watershed ecosystem health evaluation by weighting the indicators. At the same time, the ecological health level and spatial pattern in different periods were compared to analyze the reasons for the dynamic changes in the ecological health of the watershed. Osei Akoto [2] et al. analyzed from microbiological aspects to investigate the suitability of the Cisa River in Kumasi Metropolis, as well as the key factors affecting its water quality and the risk of children's and adult's health. Wu [3] et al. took the example of the Hunzhe Lake, and constructed, through the remote sensing-based technology and the landscape index, the wetland health index system consisting of 12 indicators and calculated its weights using hierarchical analysis method (AHP). In

China, Jin Xin [4] and others took Wulie River in Chengde City as an example, and constructed a comprehensive evaluation index system of river health from the three aspects of basic environment of the river, ecological support function of the river and socio-economic service function, and the results effectively identified the health status of the river. Yu Zhihui [5] and others quantitatively evaluated and dynamically analyzed the river health under different urbanization levels in Huzhou City by constructing a river health evaluation index system and applying the entropy weight object element model. Li Gang [6-8] et al. took the North Moat of Nanjing as an example, established a PSR model, determined the river health grades through the object element topable model, and judged the trend of river health development based on the distance between the integrated correlation of each grade. Zhang Yufan [9-10] and others took the Jinshui River in Zhengzhou City as an example, constructed an urban river health evaluation index system, and evaluated and predicted the health level and development trend of the river by using the combination assignment method and the material element topable model. Zhu Jie [11] et al. established a comprehensive evaluation model of happy rivers and lakes by TOPSIS method, and verified the model by evaluating the construction level of happy rivers and lakes in a city in Zhejiang Province from 2015-2019, which provides reference for the evaluation of happy rivers and lakes in other river-hugging cities.

Bengbu City, Anhui Province, has superior natural conditions, accompanied by water, the Huai River through the city, flowing through the Bengbu City area is about 145.5 kilometers long. This paper is based on the happy river judgment guidelines, combined with domestic and foreign scholars on the health of rivers and lakes, combining the natural attributes of rivers and lakes and social attributes, and constructing a happy river and lake evaluation index system that meets the actual situation of Bengbu City from five aspects: water supply security, water safety, regional water quality, regional economy, and regional ecology, to analyze the state of the development of the construction of happy rivers and lakes in Bengbu City. Bengbu City located in the middle and lower reaches of the Huaihe River, for the transition zone of subtropical and warm temperate zone, belongs to the warm temperate zone semi-moist monsoon climate zone, hot and rainy in summer, winter cold and sunny and dry, drought in the fall and little rain, prone to drought and flooding disasters. There are many rivers and lakes in the territory, all of which are in the Huaihe River basin. The water system is divided into the Huaihe River system and Huaihongxin River system, of which the watershed area of Huaihe River system is about 2,120km², and the main rivers and lakes are the lower part of the Beihang River, the Tianhe Lake, the Naihe River, the Longzi River, etc.; Huaihongxin River system covers an area of about 3,832km², and the main rivers and lakes are the trunk of the Huaihongxin River, the upper part of the Beihang River, the Shiliang River, the Sifang Lake and so on [12].

2 Methodology for evaluating happy rivers and lakes

2.1 Construction of the evaluation indicator system

The evaluation index system of happy rivers and lakes adopts a 3-level system framework of goals, guidelines and indicators. Based on the reading of relevant literature on the connotation of happy rivers and lakes and the indicator system, and combining with the specific situation in the study area, the evaluation system framework is finally determined: A target layer, the quality of rivers and lakes in Bengbu City is evaluated as "happy rivers and lakes"; B criterion layer, the evaluation framework is constructed based on the data of five aspects of water supply security, water safety, regional water quality, regional economy and regional ecological environment as the judgment criteria. C. Indicator layer, the selection and application of specific indicators for the five aspects of the guideline layer, and the data as the basis for the indicators to measure whether to meet the requirements of happy rivers and lakes [13].

There are many factors affecting the evaluation of happy rivers and lakes, such as the status of water resources, socio-economic situation, the surrounding ecological environment, etc.; and the definition of happiness is different in each place, which is regional and specific. Therefore, the selection of evaluation indexes about happy rivers and lakes is very crucial. In this paper, we select the precipitation, lake storage and water production system of Bengbu to reflect the water supply security; we select the per capita water resources, total water consumption compliance rate and water utilization rate to reflect the water security; we select the water quality compliance rate of drinking water sources, surface water quality compliance rate and groundwater quality compliance rate to reflect the water quality of the region; we select the water consumption of 10,000 yuan GDP, 10,000 yuan of industrial added value, and the coefficient of effective utilization of irrigation water to reflect the regional economic situation; we select the ecological situation; we select the ecological situation to reflect the social and economic situation; and the definition of happiness in each place has regional and special characteristics. Reflecting the regional economic situation; selecting the ecological environment water demand ratio, land ecological security index, ecological environment status index to reflect the regional ecological situation.

2.2 Evaluation indicators and grading criteria

According to the guideline layer screened out precipitation, lake storage, the number of water-producing systems, per capita water resources, total water use compliance rate, water utilization rate, drinking water quality compliance rate, surface water quality compliance rate, groundwater quality compliance rate, 10,000 yuan of GDP water consumption, 10,000 yuan of industrial value-added water consumption, effective utilization coefficient of irrigation water, the ecological environment of water demand as a percentage of the ecological environment, the ecological security index, the ecological environment index 15 major evaluation indicators, and each indicator of the specific water resources situation of rivers and lakes in the Bengbu City area and the existing evaluation criteria for the evaluation of this chapter is divided into three lev-

els. Condition index 15 main evaluation indicators, and each indicator Bengbu City District within the specific water resources of rivers and lakes and the existing evaluation standards for the chapter evaluation is divided into three levels, specific evaluation index weights and grading standards as shown in Table 1. Among them, level I belongs to the happiness level, level II belongs to the general happiness level, and level III belongs to the unhappiness level.

Table 1. Evaluation indicator weights and grading criteria

target layer	standardized layer	weights	indicator layer	unit	marking scheme		
					I	II	III
Happy River and Lake Rating A	Water supply security B1	0.30	Precipitation C1	mm	900	800	700
			Lake storage C2	10 ⁸ m ³	9	6	4
			Produced water coefficient C3	-	0.4	0.3	0.2
	Water Security B2	0.20	Water resources per capita C4	m ³	800	600	300
			Total water use compliance rate C5	%	100	75	50
			Water utilization C6	%	100	90	80
			Drinking water source water quality compliance rate C7	%	100	95	90
			Surface water quality compliance rate C8	%	100	95	90
	Regional water quality B3	0.30	Groundwater quality compliance rate C9	%	100	95	90
			Water consumption of 10,000 yuan GDP C10	m ³	70	100	120
			Water consumption of 10,000 yuan of industrial added value C11	m ³	30	60	90
	Regional economy B4	0.10	Coefficient of effective utilization of irrigation water for agricultural land C12	-	0.6	0.55	0.50
			Ecological water demand as a percentage of C13	%	4	2.5	1.5
	Regional Ecology B5	0.10	Land Ecological Security Index C14	-	70	50	40
			Ecological condition index C15	-	70	60	55
rating value					0.90	0.50	0.30

2.3 Evaluation methodology

The evaluation of the Happy River is a comprehensive evaluation with multiple indicators, multiple criteria and multiple levels, and there are many methods that can be drawn on, such as the object-element analysis method, the fuzzy comprehensive evaluation method and the gray correlation analysis method [14]. Due to the fuzzy and characteristic nature of the evaluation of happy rivers and lakes, this chapter adopts the fuzzy comprehensive evaluation model on the basis of reference to the research of other scholars to carry out a shallow evaluation study of the happy rivers and lakes in the study area, reflecting whether the people of the region are satisfied with the water environment and whether they have met the people's requirements for happiness in the period of 2014-2021. The construction of the fuzzy comprehensive evaluation model about Happy River Lake is as follows.

Assuming, U represents an ensemble composed of the factors in the evaluation indexes, X represents a collection of rubrics composed according to the evaluation grading criteria table. Each factor in the U set is evaluated, and the evaluation result U_K and each comment in the X set form a fuzzy comprehensive evaluation matrix W:

$$W = \begin{bmatrix} W_{11} & \cdots & W_{1T} \\ \vdots & \ddots & \vdots \\ W_{K1} & \cdots & W_{KT} \end{bmatrix} \tag{1}$$

Where W_{KT} denotes the affiliation of the kth factor in the tth evaluation level. The W applied here in this paper is for the 15 factors in the indicator level; however, since different factors have different degrees of influence on the evaluation, a set of weighting factors is introduced. The weights $R = \{R_1, R_2, \dots, R_n\}$, the sum of R_n is 1. In this paper, the weights are assigned to the data of the five aspects of the criterion layer to get

$$R_1 + R_2 + R_3 + R_4 + R_5 = 1 \tag{2}$$

Then the set of fuzzy comprehensive judgment results is

$$A = \sum_1^5 (R_1 W_{1T} + R_2 W_{2T} + R_3 W_{3T} + R_4 W_{4T} + R_5 W_{5T}) \tag{3}$$

Happiness scales calculated according to this model: 3 indicates complete happiness level, 0 indicates complete unhappiness level. The range between the two is defined as: (3 to 2.3) happy, (2.3 to 1.0) generally happy, (1.0 to 0) unhappy.

2.4 Analysis of results

The historical data were analyzed to get the corresponding output data, and the corresponding index data of relevant water resources in Bengbu City are shown in Table 2 below. Using the fuzzy comprehensive evaluation system to calculate the happy river and lake index of Bengbu City during the period of 2014-2021, and get the corresponding results. Taking the data of Bengbu City in 2021 as an example, the specific calculation is shown in Table 3.

Table 2. Bengbu City 2014-2021 Evaluation Indicators Raw Data

	2014	2015	2016	2017	2018	2019	2020	2021
C1	945.8	902.3	949.6	1011.4	1276.3	614.9	948.9	897.3
C2	8.908	9.822	9.545	10.318	9.641	7.674	9.461	8.96
C3	0.4	0.38	0.38	0.39	0.42	0.29	0.37	0.41
C4	689.93	625.04	649.24	686.30	931.20	311.90	626.10	657.35
C5	100	100	100	100	100	100	100	100
C6	100	98.8	98.1	98.3	100	100	100	100
C7	100	100	100	100	100	100	100	100
C8	100	100	100	100	100	100	100	100
C9	100	100	100	100	100	100	100	100
C10	115.9	118.0	109.4	94.5	80.5	69.2	66.7	65.90
C11	52.3	47.1	43.8	40	33.9	28.9	28.1	23.20
C12	0.54	0.55	0.56	0.56	0.567	0.571	0.580	0.588
C13	2.3	2.2	1.5	1.8	1.5	3.2	3.8	4.4
C14	54.6	55.1	60.5	59.9	65.5	66.7	67.3	68.8
C15	60.5	62.3	62.7	64.8	64.9	65.0	66.0	66.0

Table 3. Bengbu 2021 Evaluation Indicator Values and Weights

target layer	standardized layer	weights	indicator layer	unit	2021	corresponding value		
Happy River and Lake Rating A	Water supply security B1	0.30	C1	mm	897.3	0.50		
			C2	10 ⁸ m ³	8.96	0.50		
			C3	-	0.41	0.90		
			C4	m ³	657.35	0.50		
	Water Security B2	0.20	C5	%	100	0.90		
			C6	%	100	0.90		
	Regional water quality B3	0.30	C7	%	100	0.90		
			C8	%	100	0.90		
			C9	%	100	0.90		
			Regional economy B4	0.10	C10	m ³	65.90	0.90
					C11	m ³	23.20	0.90
					C12	-	0.588	0.50
			Regional Ecology B5	0.10	C13	%	4.4	0.90
	C14	-			70	0.90		
	C15	-			66.0	0.50		

Calculate the Happy River and Lake Index in 2021 according to the fuzzy comprehensive evaluation model:

$$A = \sum_{i=1}^5 (R_i W_{1T} + R_2 W_{2T} + R_3 W_{3T} + R_4 W_{4T} + R_5 W_{5T}) = 2.243$$

Then the grade of happy rivers and lakes in Bengbu City in 2021 is happy, and according to the calculation of the above (3) equation, the index of happy rivers and lakes in Bengbu City from 2014 to 2021 is obtained as shown in Table 4 below.

Table 4. Bengbu City 2014-2021 Happy River and Lake Statistical Table

particular year	Happy River and Lake	Happy River & Lake
	Index	Rating
2014	2.20	General happiness
2015	2.14	General happiness
2016	2.14	General happiness
2017	2.18	General happiness
2018	2.44	happiness
2019	2.10	General happiness
2020	2.34	happiness
2021	2.30	happiness

Based on the above calculations, the change of Bengbu Happy River and Lake Index from 2014 to 2021 is plotted, as shown in Fig. 1, the Happy River and Lake Index of Bengbu City shows a fluctuating upward trend from 2014 to 2021, and the Happy River and Lake Index are all above 2.0. the decline of the happiness index in 2019 is due to the drought-induced problems such as the lack of precipitation and water storage in lakes and reservoirs, which is not an anthropogenic factor.

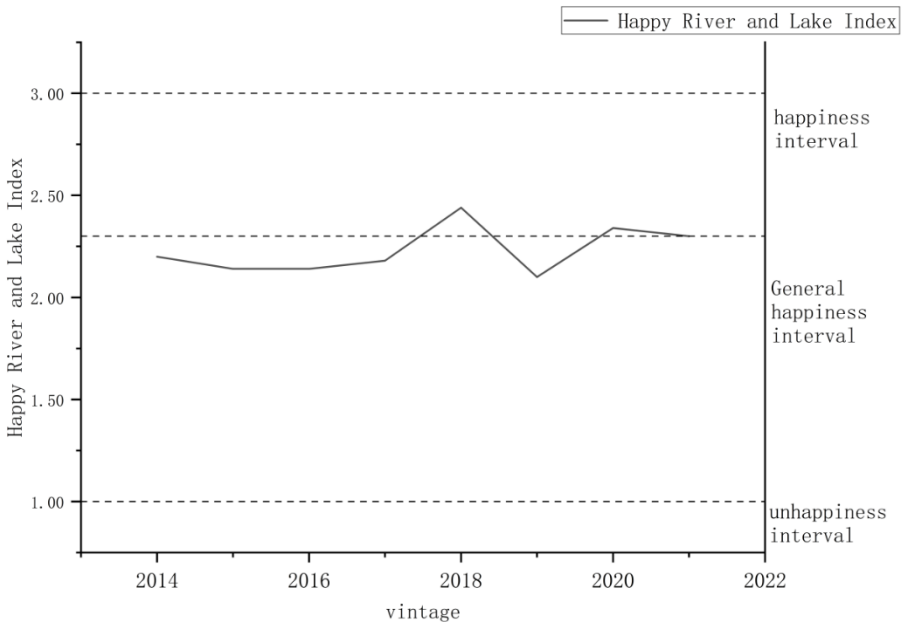


Figure 1. Changes in Bengbu's Happy River and Lake Index, 2014-2021

Therefore, if we want to improve the level of happy rivers and lakes in Bengbu City, we can start from the regional economy and regional ecology, effectively utilize the irrigation water of farmland, control the industrial water consumption while economic development, increase the percentage of ecological environment water demand, and improve the index of ecological environment condition.

3 Happy River and Lake Index Forecast

The ARIMA(1,1,2) model was built for the study area for the next ten years according to the construction of the ARIMA time prediction model described above. Figure 2 below shows the results of the algorithm for the study area. From the figure, it can be seen that the predicted value of the river and lake happiness index in Bengbu City in ten years is within its confidence interval, and the prediction accuracy of the ARIMA time series model is high through the Z-test. Observing Table 5 it can be seen that the results of the statistical study on the prediction of the happy river and lake index of Bengbu City in 2022-2030 show that in 2012-2021, the happy river and lake index of Bengbu City is steadily increasing; in the prediction of 2022-2030, it is found that Bengbu City reaches and stays at the happiness level in the next ten years. Since the lower confidence limit is below 2.3, the phenomenon of general happiness may exist, so the level of happy rivers and lakes in Bengbu City has more room to rise in the future. The quantitative evaluation study and prediction of happy rivers and lakes in Bengbu City in this paper provides a scientific basis for the government to consolidate the level of happy rivers and lakes in the city, to build a happy river, and to continuously enhance the people's sense of obtaining, happiness and security

Table 5. Bengbu Happy River and Lake Index Forecast Statistics, 2022-2030

particular year	Happy River and Lake	Happy River & Lake
	Index	Rating
2022	2.36	happiness
2023	2.36	happiness
2024	2.40	happiness
2025	2.42	happiness
2026	2.45	happiness
2027	2.47	happiness
2028	2.50	happiness
2029	2.52	happiness
2030	2.55	happiness

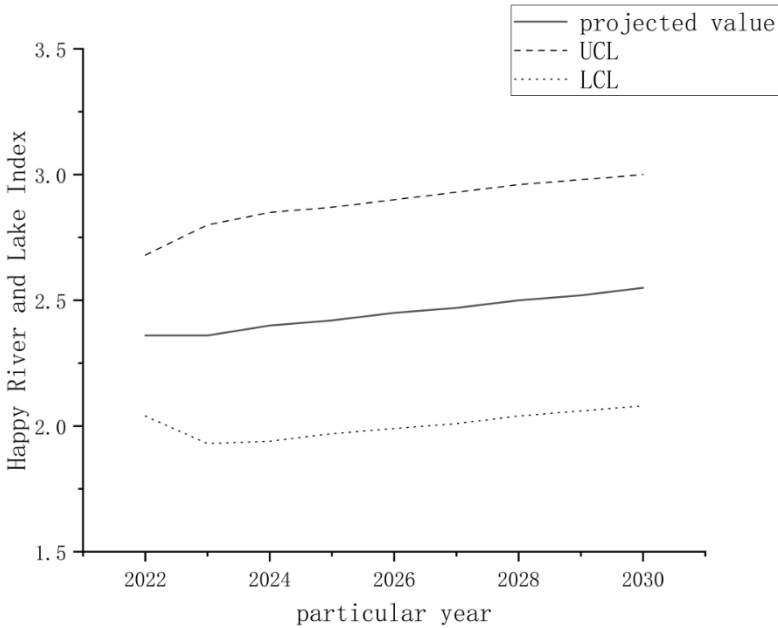


Figure 2. Forecast of Happy River and Lake Index in Bengbu City during 2022-2030

4 Discussion and prospects

In this paper, the comprehensive fuzzy evaluation model is applied to construct the evaluation system of urban happiness rivers and lakes, taking Bengbu City as an example, and has achieved better application results. However, there are still some deficiencies in the content of the study and places that need to be improved.

(1) The concept of building "happy rivers and lakes" has been put forward for a short period of time, and the word "happiness" has a wide meaning. Our country has a vast area and uneven population distribution, so there are different requirements for the connotation of happiness in different areas. The selection of indicators in the evaluation system of happy rivers and lakes needs to be screened according to different situations.

(2) This paper adopts the fuzzy comprehensive evaluation model to construct the evaluation system of happy rivers and lakes in Bengbu City, and some other models can be used to construct the evaluation system of happy rivers and lakes in Bengbu City.

(3) The application of the prediction model for the happy river and lake index is still imperfect, and the reasonableness of the setting of each index layer needs to be professionally researched and established.

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