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Research on the evaluation index system for happy rivers and lakes: a case study of Xinchang County in Zhejiang Province, China

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The "Happy Rivers and Lakes" initiative is an important measure to systematically address the complex water issues in China. It further highlights the effectiveness of constructing happy rivers and lakes based on river health assessments. This approach aims to identify typical practices and the effectiveness of river and lake management and protection at the local level, guiding for river and lake management and conservation work in the new era. This study focuses on county-level administrative units and develops a research framework for the evaluation index system of happy rivers and lakes. A total of 11 primary indicators and 22 secondary indicators are selected from aspects such as river and lake safety, water resources, water environment, biodiversity, and social services. The evaluation and analysis are conducted around the Chengtan River, Huangze River, and Xinchang River, as well as two large reservoirs in Xinchang County. The results show that the comprehensive evaluation score of happy rivers and lakes in Xinchang County is 92.66, categorizing it as a model of happy rivers and lakes. The evaluation results aim to provide references and guidance for similar regions inside and outside Zhejiang Province in their research and practical applications related to happy rivers and lakes.

KEYWORDS

happy rivers and lakes, evaluation index system, water management and conservation, rivers in mountainous area, Xinchang county

1 Introduction

Amid the intensifying global climate change and the accelerated pace of urbanization, the ecological integrity of rivers and lakes confronts increasingly formidable challenges (Vinna et al., 2018). The scarcity of freshwater resources has emerged as a significant impediment to China's economic advancement, with the country's per capita water resources amounting to merely one-quarter of the global average (Yang, 2021). In response, the Ministry of Water Resources of China promulgated the "Notice on the Construction of Happy Rivers and Lakes" in April 2022. Furthermore, in July 2023, a more methodical framework for the administration and protection of China's rivers was articulated with the publication of the "Work Plan for the Evaluation of the Effectiveness of Happy Rivers and Lakes Construction (Trial)." This plan encompasses the integrated stewardship of water resources, the aquatic environment, and water ecology, as well as stringent regulation of river and lake shoreline space management, and river sand mining oversight, with an emphasis on building and sustaining safe, healthy, beautiful, and blissful rivers and lakes. Zhejiang Province is spearheading the national endeavor to craft happy rivers and lakes. In 2023, it unveiled a five-year "Zhejiang Province Comprehensive Plan for Building Happy Rivers and Lakes" (2023-2027), aiming to establish an axis based on eight principal water systems (Statistics Bureau of Zhejiang Province. Water environment, 2023) and to create nearly a hundred distinctive county-level happy mother rivers. This initiative also aspires to establish over a thousand high-quality, aesthetically pleasing water villages and to revitalize waterfront corridors extending beyond ten thousand kilometers, forming a foundational pattern of "eight belts, a hundred corridors, a thousand pearls, ten thousand paths" ("Among the eight major water systems, a hundred ecological corridors of joyful rivers and lakes are formed, with numerous beautiful lakes and rivers scattered throughout the fluvial network, extending the reach of the happiness-inducing waterway network to thousands of miles (Voice of Zhejiang, 2023).")throughout the region.

Upon examining national and international research, the concept of happy rivers and lakes is unique to China. Related scholarly pursuits, such as river health and ecological restoration (HAN and XIA, 2020), are more prevalent elsewhere (Wang, 2020). The notion of river health traced back to the 1970s in the United States and saw further refinement in the 1990s (Faust et al., 2016; Gardner et al., 2019). Initially, research centered on the natural characteristics of rivers, but over time, it evolved to encompass the river itself, human requirements, and the societal functions of rivers. Scofield defines river health as a state wherein a river's biodiversity and ecosystem functions remain largely unimpaired (Schofield and Davies, 1996).

Rooted in the concept of healthy rivers and lakes, happy rivers and lakes prioritize a people-centric approach, fostering harmonious coexistence between humans and water. This paradigm takes into account human needs and perceptions as its starting point, undertaking comprehensive evaluations of aspects such as river safety, ecology, livability, intelligence, culture, development, and public satisfaction to establish a holistic, scientific, and actionable system for assessing the quality of river and lake ecological environments and integrated development. Research in the realm of happy rivers and lakes emphasizes not only the conservation of river ecosystems but also sustainably addressing human needs (Li and Huang, 2024). Wu (2024) encapsulates Xiangtan City's endeavors in constructing happy rivers and lakes from the perspectives of ecological restoration, soil and water conservation, environmental enhancement, and cultural preservation. He advocates that the construction of happy rivers and lakes should honor and adhere to natural principles by conserving water resources and optimizing river hydrological conditions while cultivating a wholesome and livable aquatic milieu. Several scholars have advanced management suggestions, recommending that the construction of happy rivers and lakes encompass aspects such as implementing the river and lake chief system (Wu et al., 2020; Zhang et al., 2022, 2023b), optimizing the allocation and scheduling of water resources, bolstering water ecological protection and restoration, enhancing comprehensive water environment management, promoting water culture, and invigorating green water economy pilots (Jiang, 2024; Song, 2024b; Tong, 2024). Yang Along (2024) evaluated the Songhua River, Nemur River, and Tongken River using the analytic hierarchy process grounded in understanding the essential connotations and system construction of happy rivers and lakes in Longjiang.

Since the concept of happy rivers and lakes was put forward, some scholars have explored research methods. Lv et al. (2024) employed the DPSIR model to construct a happy rivers and lakes evaluation index system for Heilongjiang Province, thereby overcame the pronounced subjectivity inherent in the priorly established indicator system and analyzed the main influencing factors that affect the happy rivers and lakes index. The evaluation framework for happy river and lakes is structured around the concept of "goal—criteria—indicator." The methodology employed for index calculation involves the "single index quantification—multiple indices synthesis—poly-criteria integration" approach (Zuo et al., 2021). The method verified that the proposed evaluation system accurately represented the happy river status of the Yellow River, and the evaluation system is therefore reliable and applicable. The role of the assessment framework for the happy rivers and lakes evaluation index system thus far has been to furnish policymakers with valuable insights integral to comprehensive river management (Zuo et al., 2020). The overall differences among various rivers and lakes in China are quite pronounced, ensuring the precision of self-assessment within river and lake evaluation systems remains a formidable challenge (Liu et al., 2021; Su et al., 2023; Zhang et al., 2023a); thus, the evaluation system for happy rivers and lakes needs further refinement. This paper endeavors to investigate the evaluation index system of happy rivers and lakes in Zhejiang Province, in alignment with Zhejiang's overarching objectives for happy rivers and lakes construction. Xinchang County was chosen as the pilot assessment area to offer decision support for advancing high-quality river and lake development in the new phase for Zhejiang Province, and to furnish scientific evidence for the preservation and management of river and lake ecological environments.

2 Materials and methods

2.1 Study area

Xinchang County falls under the administration of Shaoxing City in Zhejiang Province. Nestled in the eastern realm of Zhejiang and the southeastern part of Shaoxing, it lies between the longitudes of 120°41′34″E and 121°13′34″E, and latitudes of 29°13′55″N to 29°33′52″N. The climate is noted for its mild and humid conditions with pronounced seasons. During spring and early summer, there is a convergence of rain and warmth, followed by sunny and hot conditions in midsummer; autumn and winter offer a harmonious interplay of sunlight and temperature. The region is prone to frequent adverse weather conditions. It is endowed with ample water resources, with a generally balanced supply and demand. The county is laced with tributaries of streams, the landscape punctuated by towering mountains and steep inclines. The river courses are sinuous with substantial elevation changes, leading to swift water flows that are unsuitable for navigation yet fecund in water resources. The yearly average natural runoff is calculated at 947 million m3, with each square kilometer yielding 771,000 m3 of water, and a per capita provision of 2,370 m3, nearly matching the provincial average. Since the inception of the People's Republic of China, the industrious locals have constructed over 600 reservoirs of varying sizes. Xinchang County is situated in the upper reaches of the Cao'e River basin, populated with numerous streams and ravines that merge into three principal rivers: the Xinchang River, the Chengtan River, and the Huangze River. The total area of the basin spans 1,963 km², with Xinchang County encompassing 1,200.7 km². The average water quality at the confluence points of the "Three Rivers"—Xinchang River, Chengtan River, and Huangze River—attains the Class II surface water quality standard according to "Environmental quality standards for surface water" (GB 3838-2002) (Ministry of Ecology and Environment of the People's Republic of China, 2002) (Figure 1).

2.2 Establishment of an evaluation index system for happy rivers and lakes

The geographical landscape of Zhejiang Province can be succinctly described as "seven parts mountains, one part water, and two parts fields," with a predominance of mountainous and hilly terrain. In regions such as Quzhou, Jinhua, Lishui, Wenzhou, and Shaoxing, mountainous rivers are widely distributed. Xinchang County within Shaoxing City is characterized by numerous mountainous rivers, where the river sections are steep and the currents swift, with vast water areas. The ecological attributes of different rivers vary significantly, necessitating the creation of an evaluation index system tailored to the specific conditions of the region. This system will serve as a pivotal guide for the construction and assessment of happy rivers and lakes in Xinchang County and other similar areas (such as Quzhou, Jinhua, Lishui, and Wenzhou). In light of the characteristics of the rivers and lakes in Xinchang County, this index system emphasizes two key aspects: firstly, the

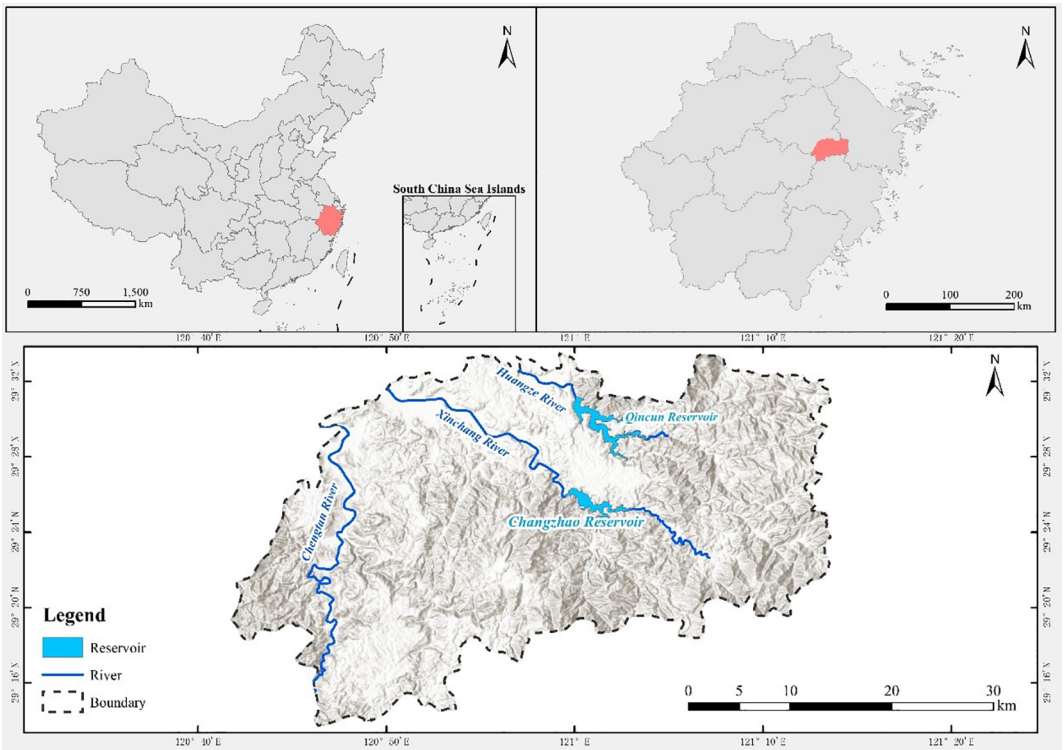

FIGURE 1
Study area, rivers, and reservoirs in Xinchang County.

principle of safeguarding biodiversity; and secondly, the principle of integrating production, ecology, and living (Figure 2).

Integrate the relevant standards from the "Guidelines for the Health Assessment of Rivers and Lakes in Zhejiang Province (Trial)" (August 2023) and the "Guidelines for the Assessment of Aquatic Ecosystem Health in Lakes and Reservoirs in Zhejiang Province (Trial)" (October 2023), while drawing on the technical documents such as the "Guidelines for Assessing the Happiness of Rivers and Lakes in Hangzhou" (2021), the "Guidelines for Assessing the Happiness of Rivers and Lakes in Nanjing (Trial)" (2021), the "Guidelines for Assessing the Happiness of Rivers and Lakes in Suzhou (Trial)" (2021), and the "Guidelines for the Assessment of the Happiness of Rivers and Lakes in the Nanhui District of Huzhou" (2020) to construct an indicator system.

Scope of application: This index system is applicable for assessing both the township-level (and above) and suburban rivers, lakes, and reservoirs within Xinchang County, as well as for the evaluation of "Happy Rivers and Lakes" within other mountainous river and lake networks in Zhejiang Province.

2.2.1 Index selection

The evaluation data is derived from a series of long-term monitoring and multifaceted surveys. The data for this study originates from the "Zhejiang Statistical Yearbook," "Zhejiang Water Resources Bulletin," "Chengtan River Health Assessment Report in Xinchang County," "Huangze River Health Assessment Report in Xinchang County," "Xinchangjiang River Health Assessment Report in Xinchang County," "Qincun Reservoir Aquatic Ecosystem Health Assessment Report in Xinchang County," "Changzhao Reservoir Aquatic Ecosystem Health Assessment Report in Xinchang County," as well as the spring and summer biodiversity investigations conducted in 2023 in Xinchang County.

In this study, the primary indicators encompass the safety of rivers and lakes, riparian vegetation, biodiversity of river and lake ecosystems, the aquatic environment of rivers and lakes, the economic development related to water, drinking water Sources, the management and protection mechanisms for rivers and lakes, the water culture, hydrophilic implementation, and public satisfaction.

Set varying weights for the 22 secondary indicators within the 11 primary indicators, according to the type of evaluation, as specified in Table 1.

According to the standard grading system of this evaluation framework for Happy Rivers and Lakes (with a maximum score of 100 and the highest level being Grade I): a comprehensive evaluation score of 90 (inclusive) ~ 100 qualifies as Grade I (Exemplary Happy River and Lake); a score of 80 (inclusive) ~ 90 qualifies as Grade II (Happy River and Lake); a score of 60 (inclusive) ~ 80 qualifies as Grade III (Ordinary Happy River and Lake); and a score below 60 qualifies as Grade IV, not meeting the standards.

2.2.2 Methodology for calculating metrics

2.2.2.1 The safety rivers and lakes

(1) Flood prevention and disaster mitigation compliance

The compliance rate for flood prevention and disaster mitigation in rivers and lakes has reached 90% or above; the dams of the reservoirs have undergone safety assessments.

The compliance rate for flood prevention and disaster mitigation in rivers and lakes refers to the percentage of shoreline length that meets the designed flood prevention and disaster mitigation standards out of the total shoreline length requiring flood prevention. A compliance rate of 90% or above (including) scores full marks, while a rate below 50% (including) scores no points. The formula for calculating the score is provided in Equation 1.

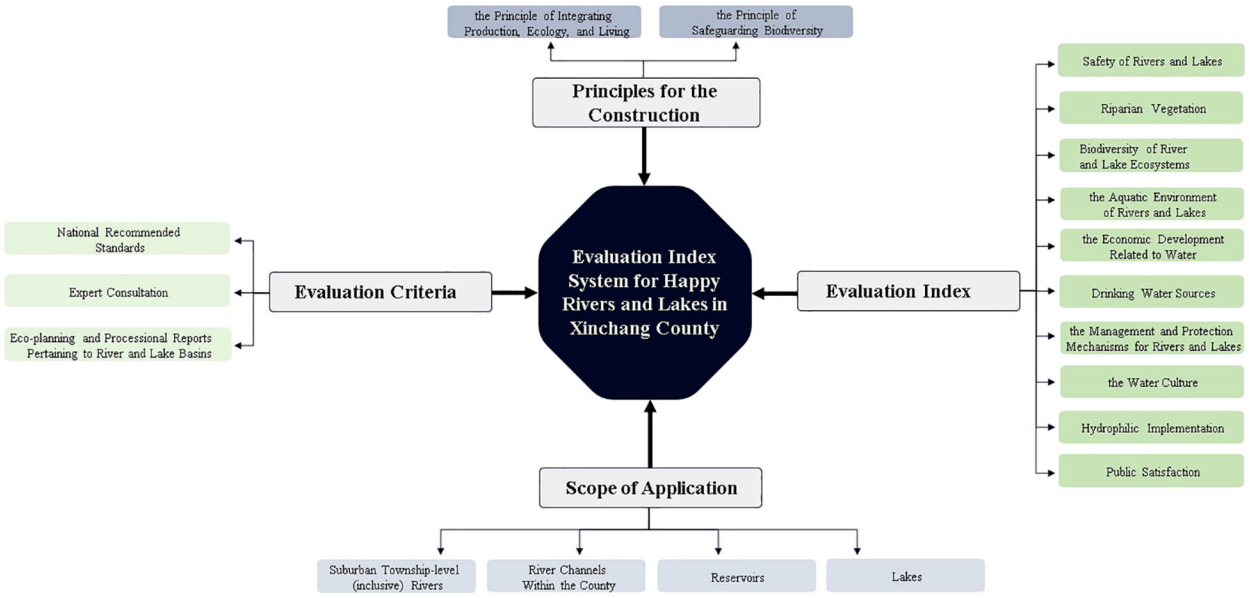

FIGURE 2
Framework for the evaluation of happy river systems in Xinchang County.

TABLE 1 Assessment indicator system for happy rivers and lakes in Xinchang.

Number	Primary Indicator	Primary Indicator Weight	Secondary Indicator	Secondary Indicator Weight
1	the Safety Rivers and Lakes	0.1	Flood Prevention and Disaster Mitigation Compliance	0.5
2			Operation Status of Hydraulic Engineering Projects	0.5
3	Riparian Vegetation	0.15	Shoreline vegetative cover	1
4	Biodiversity of River and Lake Ecosystems	0.25	Diversity of Fish	0.2
5			Diversity of Large Benthic Invertebrates	0.2
6			Diversity of Phytoplankton	0.2
7			Diversity of Zooplankton	0.2
8			Diversity of Periphytic Algae	0.2
9	The Aquatic Environment of Rivers and Lakes	0.15	the Quality of Water	0.5
10			the Assurance of Ecological Flow	0.5
11	the Economic Development Related to Water	0.1	Average annual growth in revenue from water-related tourism	0.3
12			The Annual Growth in the Output Value of Aquaculture	0.3
13			The Per Capita Income Growth Rate from Microhydropower	0.4
14	Drinking Water Sources	0.05	the Compliance Status of Potable Water Sources	1
15	the Management and Protection Mechanisms for Rivers and Lakes	0.1	The "River and Lake Chief System" Collaboration Mechanism Situation	0.5
16			Zoning and Classification Control Situation of River and Lake Water Areas and Shoreline Spaces	0.25
17			Supervision of the River-Related Projects	0.25
18	the Water Culture	0.03	Cultural Display	0.5
19			Development of Cultural, Physical, and Tourism Activities	0.5
20	Hydrophilic Implementation	0.04	The Status of Supporting Facilities for Urban and Rural Hydrophilic Structures	0.5
21			Riverside-waterfront Greenways	0.5
22	Public Satisfaction	0.03	Satisfaction Survey	1

The evaluation result will be "unsatisfactory" in the following situations. a) Public satisfaction survey score is below 60 points; b) The annual average water quality over the past year is below Level V; c) A significant or more serious safety production accident and water-related illegal incident occurred in the past year; d) The significant issues identified through superiors' undercover investigations, spot checks, and media scrutiny have not been resolved within the designated timeframe.

$$P_1 = \begin{cases} 100 & (L_{stdk} \geq 0.9L) \\ 250 \times \frac{L_{stdk}}{L} - 125 & (0.5L < L_{stdk} < 0.9L) \\ 0 & (L_{stdk} \leq 0.5L) \end{cases} \quad (1)$$

P_1 is the score assigned to flood prevention and disaster preparedness compliance in rivers and lakes; L_{stdk} is the length of dikes and revetments that meet the standards (km); and L is the total length of existing dikes or revetments (km).

(2) Operation status of hydraulic engineering projects

The quality of hydraulic engineering is compliant, and hydraulic structures meet design standards. Water conservancy facilities function optimally. Operation of the water project tasks are completed. Where there are no tasks, it is considered a reasonable exception.

This item is scored out of 100 points, with full marks awarded if evaluation criteria are met. For each of the three requirements not fulfilled according to the evaluation standards, 30 points are deducted.

2.2.2.2 Riparian vegetation

The riparian vegetation coverage is defined as the proportion of the vertical projected area of both natural and artificial vegetation along the river (or lake) banks to the total area of the riparian zone. Emphasis is placed on evaluating the coverage status of trees, shrubs, and herbaceous plants across the terrestrial span. Scores for riparian vegetation coverage are determined using both the coverage itself and the natural shoreline rate of the river (or lake), with the criteria for assigning points outlined in Table 2.

TABLE 2 Scoring standards for vegetation coverage of river (lake) riparian zones (natural shoreline method).

The riparian vegetation coverage(%)	(60,100]	(50,60]	(40,50]	(30,40]	(10,30]	[0,10]
score assignment	100	90	85	50	20	0

2.2.2.3 Biodiversity of river and lake ecosystems

(1) Diversity Index

The diversity index for fish, large benthic invertebrates, phytoplankton, zooplankton, and periphytic algae are calculated according to Equation 2. The score assignment criteria can be found in Table 3, with a linear interpolation method applied during the scoring process.

$$H' = -\sum P_i \log_2 P_i \quad (2)$$

In this formula, *H'* represents the Shannon-Wiener diversity index (Ortiz-Burgos, 2016). P_i is the proportion of the entire community made up of species i, excluding non-native species.

2.2.2.4 The aquatic environment of rivers and lakes

(1) The quality of water

The assessment of water quality must incorporate at least five indicators, including pH, dissolved oxygen, permanganate index, ammonia nitrogen, and total phosphorus. The collection of samples, sampling stations, the frequency of monitoring, and the processing of monitoring data should adhere to the relevant regulations outlined in the "Environmental quality standards for surface water" (GB 3838-2002) and the "Regulation for water environmental monitoring" (SL 219-2013) (Ministry of Water Resources of the PRC, 2013). Seasonal rivers during dry periods may be excluded from the monitoring evaluation. Should high baseline values of certain water quality indicators arise due to natural causes such as geological characteristics, soil conditions, or the nature of biological communities, a comparative analysis with corresponding water quality indicators from neighboring rivers and lakes should be conducted. If anthropogenic pollution is ruled out, it may be permissible not to evaluate that particular water quality indicator; however, this decision must be justified with an explanation.

Evaluate the water quality class of river segments (lake areas). According to the "Environmental quality standards for surface water" (GB 3838-2002) and the annual average value of each water quality indicator, use the single-factor evaluation method to assess the water quality class corresponding to each indicator. The overall water quality class of the river or lake is determined by the poorest water quality class among all indicators. Assign a score to the quality of water. The scoring criteria are shown in Table 4.

(2) The assurance of ecological flow

Evaluate the proportion of days on which the ecological flow (or water level) of rivers and lakes meets the control objectives. The formula for calculating the score is as follows:

$$\mathbf{S = D \times A \times 100} \quad (3)$$

S is the score for the satisfaction of ecological flow requirements; *D* is the days meeting the ecological flow (or water level) control objectives for rivers and lakes;*A* is the annual days.

TABLE 3 Diversity index scoring criteria.

Shannon diversity index (*H'*)	*H'*>3	2<*H'*≤3	1≤*H'*≤2	0<*H'*<1
Score assignment	90-100	80-90	70-80	0-70

2.2.2.5 The economic development related to water

The development of a water-based economy seeks to better satisfy the populace's demands for water resources, water environment, and water ecology. It aims to harness the ecological value of water resources while facilitating the conversion of ecological worth into economic value, thereby realizing the concept that lucid waters and lush mountains are indeed invaluable assets. The development of the water economy in Xinchang County is primarily manifested in the following aspects:

(1) Average annual growth in revenue from water-related tourism

The annual growth in the revenue of water-related tourism is expressed through the average annual growth rate of the revenue in this sector. The scoring criteria are detailed in Table 5.

(2) The annual growth in the output value of aquaculture

The growth in the annual output value of aquaculture is represented by the average growth rate of the total annual output value, with the scoring criteria outlined in Table 5.

(3) The per capita income growth rate from microhydropower

The return on investment for microhydropower projects is represented by the annual rate of return for microhydropower, with the scoring criteria outlined in Table 5.

2.2.2.6 Drinking water sources

(1) The compliance status of potable water sources

the construction of centralized drinking water sources has successfully passed inspection, and the compliance rate of water quality standards within the evaluation period is 100%. This item carries a full score of 100 points; meeting the evaluation criteria grants 100 points. If the construction of centralized drinking water sources fails to pass inspection, 50 points are deducted. For each instance of non-compliance within the evaluation period, 50 points are deducted.

2.2.2.7 The management and protection mechanisms for rivers and lakes

(1) The "River and Lake Chief System" collaboration mechanism situation

Evaluation Criteria for River (Lake) Chief System: The River (Lake) Chief must perform their duties effectively, addressing major issues of the river or lake; formulate and implement a "one river, one strategy"; properly install river and lake chief information boards; establish a joint prevention and control mechanism for transboundary waterways.

TABLE 4 Criteria for water quality assessment and scoring.

Water quality class	I	II	III	IV	V	Worse than class V
Score assignment	100	95	85	60	40	0

This item carries a full score of 100 points. Achieving the evaluation criteria awards 100 points; for each instance in which any of the four requirements is not met, 25 points will be deducted until the score is nullified. The formula for assigning points is as follows:

$$P_{hhz}=\begin{cases} 100-25\times N_{hh} & (N_{hh}<10) \\ 0 & (N_{hh}\geq 10) \end{cases} \quad (4)$$

In the formula: P_{hhz} represents the score assigned to the River (Lake) Chief System; N_{hh} denotes the number of problems identified during the implementation of the River (Lake) Chief System.

(2) Zoning and classification control situation of river and lake water areas and shoreline spaces

Standards for evaluation of river and lake shoreline spatial zoning and management: Completion of demarcation of protection or management boundary lines for rivers and lakes; absence of newly unauthorized constructions, indiscriminate stacking, encroachment, or illicit extraction activities within the protection control line and river management area; establishment of a "list database" for historical usage; the water area of rivers and lakes does not decrease within the year, and compensation for occupied projects is enforced.

This item carries a full score of 100 points. Achieving the evaluation criteria awards 100 points; for each instance in which any of the three requirements is not met, 30 points will be deducted until the score is nullified.

(3) Supervision of the river-related projects

Evaluation Criteria for River-Related Project Supervision: Regulatory norms for river-related projects, project licensing refinement, and Well-Maintained Records.

This section is worth 100 points. River-related projects encompass activities such as water extraction, drainage, and construction within river management boundaries. Meeting the evaluation criteria earns a full 100 points; for each identified problem within a project, 20 points are deducted until no points remain. The formula for assigning points is as follows:

$$P_{xm}=\begin{cases} 100-5\times N_{xm} & (N_{xm}<5) \\ 0 & (N_{xm}\geq 5) \end{cases} \quad (5)$$

In this context: P_{xm} is the score assigned to the regulatory status indicator of river-related projects; N_{xm} is the number of river-related projects with existing problems.

2.2.2.8 The water culture

(1) Cultural display

Criteria for Assessing the Presentation of Aquatic Culture: Through diverse media channels, including newspapers and magazines, radio and television, online platforms, brochures, WeChat public accounts, and TikTok, actively promote and disseminate the unique culture of rivers and lakes.

This item is awarded 100 points, contingent upon the number of water culture promotion activities undertaken within the evaluation period of the current year, as specified in Table 6.

(2) Development of cultural, physical, and tourism activities

Each year, a vibrant assortment of cultural and sports events related to water culture is organized, with a comprehensive evaluation determined by the scale, frequency, and impact of these activities; refer to Table 7 for the criteria-based scoring.

2.2.2.9 Hydrophilic implementation

(1) The status of supporting facilities for urban and rural hydrophilic structures

Criteria for Evaluating the Integration of Water-Friendly Public Amenities: ① The arrangement of water-friendly spaces, including parks, squares, riverside walkways, piers, and platforms, is logical; parks and squares are easily accessible, and pathways along urban rivers are unobstructed. ② The provision of user-oriented facilities such as seating, railings, trash receptacles, fitness equipment, lighting, rain shelters, safety warning signs, and directional signboards around rivers and lakes adequately fulfills public needs.

This segment is evaluated on a scale of 100 points, with scores allocated based on the configuration of waterfront recreational areas and the availability of supportive public amenities, as outlined in Table 8.

(2) Riverside-waterfront greenways

Evaluation Criterion for Waterfront Greenways: Length of Waterfront Greenways/the Total Shoreline Length within the Management Zone.

This section is assessed on a scale of 100 points, denoted by the ratio of waterfront greenways. It pertains to the proportion of river and lake waterfront greenways' shoreline length compared to the total shoreline length of rivers and lakes within the designated management area (excluding segments of natural shoreline). The formula for assigning points is as follows, and the scoring table is depicted in Table 9.

TABLE 5 Scoring standard for water economic development.

Average annual growth rate of revenue from water-related tourism(%)	≥15	[10,15)	[5,10)	[1,5)	<1
Average annual growth rate of total output value of aquaculture(%)	≥7%	[5,7)	[3,5)	[1,3)	<1
Annual returns from microhydropower(%)	≥6	[5,6)	[3,5)	[1,3)	<1
Score assignment	100	85	75	60	0

TABLE 6 Scoring standard for the exhibition of water culture.

The frequency of water culture exhibitions (times/year)	0	1	2	≥3
Score assignment	0	40	70	100

$$P_{bs}=\frac{N_{bs}}{N_{zc}} \quad (6)$$

P_{bs} represents the waterfront greenway ratio; N_{bs} is the length of the waterfront greenway; N_{zc} is the total length of river and lake shorelines within the management area.

2.2.2.10 Public Satisfaction

Public satisfaction pertains to the degree of contentment among individuals living near rivers and lakes, particularly regarding water safety, the aquatic environment, the ecosystem, and the cultural significance of these water bodies. This measure is scored on a scale of 100 and is assessed through the distribution of questionnaires or online surveys. Each evaluation unit is required to survey at least 50 individuals, with scores determined by the average of the public's ratings. Refer to Table 10 for further details. Please refer to Attachment 1 for the questionnaire.

3 Evaluation of the happiness of rivers and lakes in Xinchang county

3.1 The scope of evaluation

Xinchang County lies in the upper reaches of the Cao'e River basin, traversed by three chief rivers (Table 11): the Xinchang River, the Chengtan River, and the Huangze River. The Xinchang River meanders through the Changzhao Reservoir (large-scale projects (2) type projects), while the Huangze River courses through the Qincun Reservoir (large-scale projects (2) type projects).

3.2 Evaluation results

3.2.1 The safety rivers and lakes

(1) Flood prevention and disaster mitigation compliance

The compliance rate of the embankment along the Xinchang River stands at 92%, thereby achieving a perfect score of 100 points; the compliance rate along the Chengtan River is 84.5%, which translates to a score of 86.3 points; and the embankment compliance rate for the Huangze River is 100%, hence receiving a score of 100 points.

In alignment with the "Comprehensive Planning Revision for the Cao'e River Basin" (2008-2030), both Changzhao Reservoir and Qincun Reservoir are pivotal in ensuring flood security. As a result, it has been determined that the flood protection and disaster prevention compliance for Changzhao Reservoir is 100%, awarded with a score of 100 points; likewise, the compliance for Qincun Reservoir is 100%, also garnering a score of 100 points.

(2) Operation status of hydraulic engineering projects:

According to the "Xinchang County Chengtan River River Health Assessment Report," there are no regulated water conservancy projects in the upper reaches of the Chengtan River.

Based on the "Xinchang County Huangze River River Health Assessment Report" and the "Xinchang County Qincun Reservoir Water Ecological Health Assessment Report," the Qincun Reservoir project is large-scale projects (2) type reservoir, primarily engineered for water supply and flood control, with supplementary multifaceted applications in irrigation and power generation. Water conservancy facilities function optimally; operation of the water project tasks are completed, and as a result, has been awarded a perfect score of 100.

According to the "Xinchang County Xinchang River River Health Assessment Report" and the "Xinchang County Changzhao Reservoir Water Ecological Health Assessment Report," the Changzhao Reservoir, as a quintessential water conservancy project, is a large-scale project (2) type reservoir that harmoniously combines water supply, irrigation, power generation, fishery, and navigation. It stands as one of the pivotal projects for flood and drought mitigation in the Cao'e River basin. The water conservancy infrastructure operates flawlessly, meeting its designated tasks, and thus has been granted a full score of 100.

3.2.2 Riparian vegetation

According to the survey statistics of the shoreline types in the "Xinchang County Chengtan River Health Assessment Report, the vegetation coverage rate of the shoreline stands at 55.25%, having been awarded a score of 90 points.

According to the Report on the Health Assessment of Rivers, Lakes, and Reservoirs in Xinchang County—Huangze River Section 1, the average vegetation coverage along the Huangze River fluctuates between 72% and 78%, thereby meriting a perfect score of 100. The Report on the Health Assessment of Rivers, Lakes, and Reservoirs in Xinchang County—Xinchang River indicates that the average vegetation coverage of the Xinchang River stands at 78.30%, justifying a score of 100. Based on the Report on the Aquatic Ecological Health Assessment of Qincun Reservoir in Xinchang County, the average vegetation coverage of Qincun Reservoir is recorded at 58.43%, yielding a score of 90. Furthermore, the Report on the Aquatic Ecological Health Assessment of Changzhao Reservoir in Xinchang County reveals that the average vegetation coverage of Changzhao Reservoir is 68.50%, consequently earning a score of 100.

TABLE 7 Scoring standard for the development of cultural, physical, and tourism activities.

The influence of Cultural, Physical, and Tourism endeavors	Substandard	Mediocre	Superior	Outstanding
Score assignment	0	40	70	100

TABLE 8 Scoring standard for hydrophilic public amenities.

The convenience level of implementing hydrophilicity	Score assignment
The configuration of the waterside expanse is judicious, featuring convenient and easily accessible transport options that facilitate seamless pedestrian walkways adjacent to the water's edge; public facilities are thoroughly equipped and maintained in superb condition.	100
The configuration of the waterside expanse is a reasonable layout, featuring convenient and easily accessible transport options that facilitate seamless pedestrian walkways adjacent to the water's edge; public facilities are relatively equipped and maintained in superb condition.	[70,100)
The configuration of the waterfront area is mediocre, offering convenient transportation and largely unobstructed walkways. Fundamental amenities are available for ease, and the facilities are well-maintained.	[40,70)
The configuration of the waterside areas is inefficient, and accessibility proves difficult. The pedestrian pathways bordering the water are unfinished. Furthermore, the supply of public amenities is inadequate, with some of the existing facilities exhibiting signs of damage or neglect.	[0,40)

3.2.3 Biodiversity of river and lake ecosystems

(1) Diversity of fish

According to the results of fish diversity surveys undertaken in March and June of 2024 (Table 12), the diversity index for fish within the Chengtan River has been recorded at 75 points, the Huangze River at 76 points, the Xinchang River at 83 points, the Qinchun Reservoir at 69 points, and the Changzhao Reservoir at 74 points.

(2) Diversity of large benthic invertebrates

According to the comprehensive survey on benthic invertebrate diversity undertaken in March 2024 (Table 12), Chen Tan River was accorded a benthic diversity score of 77, and Huangze River, Xinchang River, Qincun Reservoir, Changzhao Reservoir were 81, 76, 84, and 67 respectively.

(3) Diversity of phytoplankton

According to the findings of the phytoplankton diversity investigation in March 2024 (Table 12), the diversity scores for phytoplankton in the Chengtan River, Huangze River, Xinchang, Qinzhun Reservoir, and Changzhao Reservoir are 84, 82, 84, 77, and 76, respectively.

(4) Diversity of zooplankton

According to the findings of the March 2024 investigation regarding zooplankton diversity (Table 12), the biodiversity scores for zooplankton in Chengtan River, Huangze River, Xinchang River, Qincun Reservoir, and Changzhao Reservoir were recorded at 66, 70, 71, 72, and 70, respectively.

(5) Diversity of periphytic algae

Based on the findings of the investigation regarding phytoplankton diversity conducted in March 2024 (Table 12), the biodiversity scores for periphytic algae in Chengtan River, Huangze River, Xinchang River, Qincun Reservoir, and Changzhao Reservoir were recorded at 84, 86, 81, 81, and 87, respectively.

3.2.4 The aquatic environment of rivers and lakes

(1) The quality of water

Based on the environmental quality levels of water as assessed in the reports titled "Health Assessment Report of Chengtan River and Lakes in Xinchang County," "Health Assessment Report of Huangze River and Lakes in Xinchang County," "Health Assessment Report of Xinchang River and Lakes in Xinchang County," "Ecological Health Assessment Report of Qinkun Reservoir in Xinchang County," and "Ecological Health Assessment Report of Changzhao Reservoir in Xinchang County," an average value was calculated. Accordingly, Chengtan River was awarded a score of 88.3, Huangze River achieved a score of 94.3, Xinchang River received 92.5, Qinkun Reservoir was granted 95, and Changzhao Reservoir also attained 95.

(2) The assurance of ecological flow

Based on the findings detailed in the "Xinchang County Chengtan River Lake Health Assessment Report," the "Xinchang County Huangze River Lake Health Assessment Report," the "Xinchang County Xinchang River Lake Health Assessment Report," the "Xinchang County Qin Cun Reservoir Ecological Health Assessment Report," and the "Xinchang County Zhang Zhao Reservoir Ecological Health Assessment Report," Combined with field visits, ground investigations, and expert consultations, it is evident that the water levels and ecological flow fluctuations of the three rivers and two reservoirs substantially comply with the requisites of the ecological environment. Consequently, it is deemed fitting to accord this criterion the maximum score, resulting in a standardized score of 100.

3.2.5 The economic development related to water

(1) Average annual growth in revenue from water-related tourism

Xinchang County has unveiled the "Top Ten Blissful Rivers and Lakes Waterfront Routes." During the May Day holiday, the premier waterfront tourism route attracted a remarkable influx of 141,500 visitors. In alignment with Xinchang County's fundamental goal of establishing an extensive network of blissful rivers and lakes, the annual growth rate of revenue from aquatic tourism has been set at a targeted 15%. As a result, this accomplishment merits a flawless score of 100.

TABLE 9 Scoring standard for riverside-waterfront greenways.

Waterfront greenway ratio	[30%,100%]	[20%,30%)	[10%,20%)	[0,10%)
Score assignment	100	80	70	30

TABLE 10 Scoring standard for public satisfaction indicators.

Public evaluation	Score assignment
[90,100)	100
[80,90)	90
[60,80)	70
[0,60)	50

(2) The Annual growth in the output value of aquaculture

In Xinchang County, the total output of aquatic products in 2021 attained a remarkable 3,855 tons, comprising 440 tons from freshwater capture and 3,415 tons from freshwater aquaculture; the annual total output value amounted to an impressive 130 million yuan. In 2022, the total aquatic product output witnessed a commendable increase to 3,979 tons, including 468 tons from freshwater capture and 3,511 tons from freshwater aquaculture; the annual total output value ascended to 140 million yuan. By 2023, the total aquatic product output further surged to 4,177 tons, with 498 tons from freshwater capture and 3,679 tons from freshwater aquaculture; the annual total output value ascended to 150 million yuan. The annual growth rate of total output value in aquaculture has consistently surpassed 7% for two consecutive years. In the Xinchang County, freshwater aquaculture focus on propagating species such as the *Acrossocheilus parallens* and the *Opsariichthys bidens*, while the primary species stocked in the reservoirs are *Hypophthalmichthys molitrix* and *Hypophthalmichthys nobilis*. In conclusion, this endeavor merits an outstanding score of 100 points.

(3) The per capita income growth rate from microhydropower

Xinchang is the first county in Zhejiang Province to achieve primary electrification in rural areas, earning the title of "Hometown of Microhydropower." Xinchang is guided by the principle of fostering the green and healthy development of the microhydropower industry, maximizing the value of its water resources, and has pioneered a development path centered on the consolidation of microhydropower assets for village revitalization and wealth generation. According to a report on the path to shared prosperity through microhydropower released by Xinchang County, village collectives can annually secure an annualized return of 6%, thus earning a full score of 100 points.

3.2.6 Drinking water sources

(1) The compliance status of potable water sources

In alignment with the findings presented in the "Report on the Water Quality Status of Urban Centralized Drinking Water Sources in Shaoxing City" (Third Quarter, 2023), the Qincun Reservoir and Changzhao Reservoir located in Xinchang County has been designated as Class II in terms of water quality, thereby fulfilling the requisite functional requirements. As a result, both reservoirs have been bestowed with an impeccable score of 100 points.

3.2.7 The management and protection mechanisms for rivers and lakes

(1) The "River and Lake Chief System" collaboration mechanism situation

Based on the reports entitled "Health Assessment Report of Chengtan River and Lakes in Xinchang County," "Health Assessment Report of Huangze River and Lakes in Xinchang County," "Health Assessment Report of Xinchang River and Lakes in Xinchang County," "Ecological Health Assessment Report of Qinkun Reservoir in Xinchang County," and "Ecological Health Assessment Report of Changzhao Reservoir in Xinchang County," and the county-level river and lake chief's performance report, it is observed that the boundary delimitation for the three rivers and two reservoirs has been accomplished, thereby establishing clear management boundaries and enforcing rigorous social management of activities involving the rivers and lakes. The implementation of the "one river, one strategy" governance plan is in progress, aimed at achieving compliance with river safety standards and enhancing the quality, alongside measures for the ecological protection and rehabilitation of rivers and lakes. Furthermore, the revisions of the "Comprehensive Happiness River and Lake Construction Plan for Xinchang County," "Modern Water Network Construction Plan for Xinchang County," and "Comprehensive Prevention and Control Plan for Mountain Flood Disasters in the Zuoyujiang River Basin of Xinchang County" have been initiated. In consideration of the aforementioned content, the total score for this item is 100 points.

(2) Zoning and classification control situation of river and lake water areas and shoreline spaces

Based on the reports entitled "Health Assessment Report of Chengtan River and Lakes in Xinchang County," "Health Assessment Report of Huangze River and Lakes in Xinchang County," "Health Assessment Report of Xinchang River and

TABLE 11 Evaluation of essential data on rivers and reservoirs.

Type	Name	Length within XinChang County (km)	Basin areas (km^2)
River	Xinchang River	48.9	440
	Huangze River	50.6	375
	Chengtan River	41.1	386.7
Type	Name	Capacity ($\times 10^8$ m^3)	Basin areas (km^2)
Large-scale projects (2) type projects	Changzhao Reservoir	1.86	8.38
	Qincun Reservoir	2.44	9.39

TABLE 12 diversity index in sampling area.

Sampling Area	Fish diversity index in the spring			Fish diversity index in the summer			Large benthic invertebrates diversity		
	D′	*J′*	*H′*	*D′*	*J′*	*H′*	*D′*	*J′*	*H′*
Huangze River	0.910	0.592	0.820	1.941	0.915	2.569	3.338	0.885	2.199
Chengtan River	0.962	0.819	0.900	1.603	0.913	2.167	2.435	0.787	1.795
Xinchang River	1.820	0.887	1.427	1.924	0.936	2.309	2.147	0.902	1.641
Changzhao Reservoir	1.610	0.840	1.352	1.970	0.747	2.368	1.362	0.404	0.785
Qincun Reservoir	1.895	0.831	1.489	0.582	0.258	0.410	4.091	0.933	2.463
Sampling Area	Phytoplankton diversity			Zooplankton diversity			Periphytic Algae diversity		
	D′	*J′*	*H′*	*D′*	*J′*	*H′*	*D′*	*J′*	*H′*
Huangze River	5.331	0.691	2.304	1.460	0.963	1.092	5.658	0.754	2.681
Chengtan River	6.825	0.682	2.474	1.443	1.000	0.693	6.173	0.689	2.453
Xinchang River	5.282	0.716	2.400	1.796	0.975	1.168	4.998	0.628	2.191
Changzhao Reservoir	2.997	0.589	1.669	1.388	0.915	1.004	5.689	0.782	2.721
Qincun Reservoir	3.784	0.526	1.708	1.830	0.971	1.203	5.419	0.599	2.187

Lakes in Xinchang County," "Ecological Health Assessment Report of Qinkun Reservoir in Xinchang County," and "Ecological Health Assessment Report of Changzhao Reservoir in Xinchang County," and field visits, on-site inspections, and expert consultations, the three rivers and two reservoirs have demonstrated the capacity to conduct annual special clean-up operations for river and lake "illegal occupation, unauthorized excavation, indiscriminate dumping, and unauthorized construction," achieving a 100% processing rate and establishing a regularized supervisory mechanism. Consequently, it is deemed appropriate to directly assign the maximum score to this indicator, thus awarding a score of 100 for all instances.

(3) Supervision of the river-related projects

In 2023, Xinchang County embarked upon nine projects related to its rivers, each of which complied with regulatory standards through the possession of comprehensive permits and complete archival documentation; therefore, this item scores 100 points.

3.2.8 The water culture

(1) Cultural display

Based on the reports entitled "Health Assessment Report of Chengtan River and Lakes in Xinchang County," "Health Assessment Report of Huangze River and Lakes in Xinchang County," "Health Assessment Report of Xinchang River and Lakes in Xinchang County," "Ecological Health Assessment Report of Qinkun Reservoir in Xinchang County," authorized departments can utilize a diverse array of platforms such as newspapers, magazines, radio programs, television broadcasts, internet media, flyers, brochures, WeChat official accounts, and Tiktok to promote the unique cultural heritage associated with the three rivers and two reservoirs. Consequently, they have been awarded a perfect score of 100.

(2) Development of cultural, physical, and tourism activities

Xinchang County is abundantly endowed with water resources, and the heritage of its river and lake culture extends back through the ages. The local government and the populace organize numerous historical and cultural activities related to water each year, such as the Garden Festival launched by the banks of Baiyun Lake, along with various family and couple tourism routes along the waterfront, giving rise to a flourishing scene. The water culture journey in Xinchang consistently leads within the province, with poetic routes of the Tang Dynasty, landscapes painted in verse, and numerous tourists drawn by repute to experience the picturesque charm of Xinchang's mountains and waters. Thus, this project is awarded a perfect score of 100.

3.2.9 Hydrophilic implementation

(1) The status of supporting facilities for urban and rural hydrophilic structures

According to the contents of the "Health Assessment Report of Chengtan River and Lakes in Xinchang County," "Health Assessment Report of Huangze River and Lakes in Xinchang County," "Health Assessment Report of Xinchang River and Lakes in Xinchang County," "Ecological Health Assessment Report of Qinkun Reservoir in Xinchang County," and through on-site visits, field surveys, and expert consultations, it has been concluded that the configuration of three rivers and two reservoirs within the waterside expanse was judicious, featuring convenient and easily accessible transport options that facilitate seamless pedestrian walkways adjacent to the water's edge; public facilities are thoroughly equipped and maintained in superb condition.

(2) Riverside-waterfront greenways

Xinchang County has integrated the scattered resources along its rivers and lakes to establish a "waterfront node" database for the

development of waterside tourism. This initiative aims to connect the county's main riverine slow-moving traffic systems, enhancing the open sharing of water spaces and creating a felicitous river-lake waterside route IP where "mountains are visible, water is in sight, and nostalgia is palpable." The coverage rate of the urban and rural 15-minute waterside circle has reached 92%.

In terms of waterside greenways, Xinchang Riverside Park features a 3.53-kilometer-long waterside greenway. The Jingling Riverside Greenway stretches 8.7 kilometers, linking the Nineteen Peaks Scenic Area with scenic villages along the route. The Qiaoying Reservoir ring-reservoir waterside greenway spans 13 kilometers, with observation decks and camping platforms as waterside amenities. The Huangze River Waterside Greenway extends 11.23 kilometers, and the Chengtan River Waterside Greenway covers 7.2 kilometers, resulting in a total waterside greenway length of 43.66 kilometers.

The primary course of the Xinchang River within the county stretches over 48.9 kilometers, the main course of the Chengtan River extends for 44.1 kilometers, and the principal course of the Huangze River measures 50.6 kilometers. Collectively, the aggregate river length totals 143.6 kilometers. Considering that the waterfront greenway encompasses more than 30% of the total river length, this criterion merits a score of 100 points.

3.2.10 Public satisfaction

A public satisfaction survey conducted in April 2024 along the banks of the Xinchang River, Huangze River, and Chengtang River, which engaged riverbank residents, riverway managers, and local citizens, encompassed a total of 50 participants, all of whom successfully returned their questionnaires. The analysis was performed based on the average scores derived from the three areas.

The average public satisfaction score for Chengtan River is 89.47, thus it is assigned a score of 90. Huangze River received an average satisfaction score of 76.67, leading to an assigned score of 70. Xinchang River boasts an impressive average satisfaction score of 95.79, resulting in a perfect score of 100. The overall composite average for the three regions stands at 86.67.

3.3 Comprehensive evaluation results

By the established evaluation index system for the Happiness River and Lake, the overall assessment score for Xinchang County's Happiness River and Lake stands at an impressive 92.66 points (Table 13), categorizing it as Grade I (Exemplary Happy River and Lake).

4 Discussion

Riverscapes function as an indispensable linchpin of ecological environments and human sustenance, embodying a pivotal role in the terrestrial material cycle and equilibrium, as well as in the nourishment and progress of humankind (Shao et al., 2024). The notion of the "River of Happiness" has surfaced amidst the contemporary era of our nation's river management initiatives. In contrast to previous understandings of rivers, the "River of Happiness" is rooted in significant national strategies, approaching the issue through a systemic and comprehensive lens, necessitating elevated standards and embodying more profound connotations (Song, 2024a). The resolution of our nation's complex water challenges demands institutional innovation; therefore, the creation of river and lake systems that serve the public good is of paramount importance. Throughout the country, the construction of Happiness Rivers and Lakes is gradually being initiated. Nonetheless, the scholarly exploration of felicitous rivers remains in its nascent stage (Zuo et al., 2021), characterized by diverse and fragmented perceptions among the populace. The pertinent accomplishments exhibit discrepancies in the selection of indicators, the determination of weights, the assignment of target values, and the evaluation methodologies (Research group of the happy river, 2020; Gong et al., 2022). Numerous mathematical methodologies, including the analytic hierarchy process (Ramanathan, 2001), multivariate analysis (Chau and Muttil, 2007), data envelopment analysis (Zhao et al., 2006), artificial neural network (Liu et al., 2023), fuzzy comprehensive assessment (Zhao and Yang, 2009), and grey correlation analysis (Liu et al., 2024) etc. are utilized in the happy rivers and lakes studies (Anwar Sadat et al., 2020). The evaluation system predominantly selects indicators from dimensions such as Flood Control Capacity, Water Resources Reliability, Water Environment Livability, Aquatic Ecosystem Health, and Water Culture Prosperity (Ju et al., 2022). However, some of these indicators and methodologies fall short in terms of operability and accuracy. It is essential to further delve into the research on the Happy Rivers and Lakes initiative, revising and refining the methodologies through extensive consultations with experts from the relevant regions and sectors, thereby progressively enhancing the adaptability and practicality of the methods.

Given the paramount importance placed on the protection of river and lake water ecosystems as well as hydrobiont in Xinchang County (Department of Water Resources of Zhejiang Province, 2023), this research places a special emphasis on evaluating aquatic biodiversity when constructing the evaluation index system. The assessment results of the "Happy River and Lake" initiative reveal a notable vulnerability in the aspect of river and lake biodiversity indices, attributable to objective issues and shortcomings that persist. As the socio-economic landscape has evolved, the extensive construction of dams along rivers has drastically disrupted natural water flow, resulting in profound, widespread, and severe anthropogenic impacts on riverine ecosystems. The erection of river barrages and other hydraulic structures has hindered the natural migratory paths of aquatic species, including the *Anguilla japonica*, *Anguilla marmorata*, *Coilia mystus*, *Coilia ectenus*, and crabs. Unfortunately, fishways have yet to be established in either the Xinchang River or the Huangze River, leading to fragmented habitat connectivity for aquatic organisms, which impedes their migration and contributes to a decline in both aquatic community numbers and biodiversity. Although a fishway has been installed in the middle section of the Chengtan River, its steep gradient and structural attributes do not facilitate the migration of small fish, necessitating further optimization and renovation.

TABLE 13 Comprehensive evaluation of happy rivers and lakes.

Number	Primary Indicator	Secondary indicators	Chengtan River	Huangze River	Xinchang River	Qincun Reservoir	Changzhao Reservoir	Summation
			Score assignment	Score assignment	Score assignment	Score assignment	Score assignment	
1	the Safety Rivers and Lakes	Flood Prevention and Disaster Mitigation Compliance	86.3	100	100	100	100	4.86
2		Operation Status of Hydraulic Engineering Projects	—	100	100	—	—	5.00
3	Riparian Vegetation	Shoreline vegetative cover	90	100	100	90	100	14.40
4	Biodiversity of River and Lake Ecosystems	Diversity of Fish	75	76	78	69	78	3.76
5		Diversity of Large Benthic Invertebrates	77	81	76	84	67	3.85
6		Diversity of Phytoplankton	84	82	84	77	76	4.03
7		Diversity of Zooplankton	66	70	71	72	70	3.49
8		Diversity of Periphytic Algae	84	86	81	81	87	4.19
9	The Aquatic Environment of Rivers and Lakes	the Quality of Water	88.3	94.3	92.5	95	95	6.98
10		the Assurance of Ecological Flow	100	100	100	100	100	7.50
11	the Economic Development Related to Water	Average annual growth in revenue from water-related tourism	—	—	—	—	—	3.00
12		The Annual Growth in the Output Value of Aquaculture	—	—	—	—	—	3.00
13		The Per Capita Income Growth Rate from Microhydropower	—	—	—	—	—	4.00
14	Drinking Water Sources	the Compliance Status of Potable Water Sources	100	100	100	100	100	5.00
15	the Management and Protection Mechanisms for Rivers and Lakes	The "River and Lake Chief System" Collaboration Mechanism Situation	100	100	100	100	100	5.00
16		Zoning and Classification Control Situation of River and Lake Water Areas and Shoreline Spaces	100	100	100	100	100	2.50
17		Supervision of the River-Related Projects	—	—	—	—	—	2.50
18	the Water Culture	Cultural Display	100	100	100	100	100	1.50
19		Development of Cultural, Physical, and Tourism Activities	—	—	—	—	—	1.50
20	Hydrophilic Implementation	The Status of Supporting Facilities for Urban and Rural Hydrophilic Structures	100	100	100	100	100	2.00
21		Riverside-waterfront Greenways	—	—	—	—	—	2.00
22	Public Satisfaction	Satisfaction Survey	90	70	100	—	—	2.60
Summation								92.66

"—" signifies that the corresponding data remains uncollected.

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Along the upper reaches of the Huangze River, delicate reeds and cattail marshes gracefully undulate in the tender caress of the breeze, while submerged flora such as *Ceratophyllum demersum* purify the aqueous realm. In the distance, aquatic birds engage in playful antics, sketching a tranquil and harmonious tableau of the natural ecosystem. Since the inauguration of the "Happy Rivers and Lakes" initiative across Xinchang County, unwavering endeavors have been pursued to expedite the development of secure, ecologically sound, habitable, prosperous, and intelligent river systems. This encompasses enhancing flood control and disaster preparedness, nurturing cultural and tourism advancements, emphasizing ecological preservation, reinforcing water system governance, and establishing a "river network of shared prosperity, three rivers united in harmony" within the riparian expanse. Through the execution of a series of strategic measures, public consciousness regarding river preservation and care has markedly heightened, and individuals have acquired a deeper sense of accomplishment and felicity from the beautiful river and lake ecology.

5 Conclusion and suggestions

This article delineates a comprehensive evaluation index system for the Happy Rivers and Lakes, articulating a meticulous discourse on the foundational principles governing the assessment framework, methods of quantification, apportionment of weights, and the architectural design of the system. Given the intricate and varied nature of river and lake ecosystems, the development of this evaluation system necessitates further refinement and optimization. This study also has certain limitations, being applicable only to the assessment of mountainous river-lake systems. Moreover, variations in focus and research methodologies give rise to different evaluation outcomes. Additionally, varying focuses and methodologies can yield divergent evaluation outcomes. Consequently, a comprehensive evaluation of happy rivers and lakes necessitate a multi-faceted approach. Prospective research should concentrate on: augmenting the monitoring and forecasting of shifts within river and lake ecosystems; investigating more scientific and rational methodologies for quantification and weight distribution; and fostering the extensive implementation and acceptance of the evaluation system across a broader array of regions and disciplines.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

XL: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. CC: Data curation, Investigation, Writing – original draft. BS: Funding acquisition, Resources, Writing – review & editing. CH: Formal analysis, Writing – review & editing. ZY: Writing – review & editing. YZ: Writing – review & editing.

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Conflict of interest

The authors declare the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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