

Study on the optimization of Erhai health assessment index system

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Objectives

The Erhai Lake stands as the second largest freshwater lake in Yunnan Province and one of the nine plateau lakes in Yunnan. It's not only the most integral scenic spot in Dali, but also the main source of water for the living and production of the surrounding people. The Erhai Lake is a typical inland fault-depressed lake, which has certain closed and semi-closed characteristics. Over the past 20 years, with the surging economic development and population growth in the lake area, human exploitation of its natural resources has intensified, resulting in accelerated eutrophication, declining water quality, and gradually deteriorating ecological environment. It's part of the Cangshan Erhai Lake Nature Reserve, and the water quality protection target is Class II. It's suggested by the monitoring data in 2017 that the water quality of the Erhai Lake is generally in Class III, and the nutrient level of the lake is at the medium nutritional level. Given the status quo of the ecological environment of the Erhai Lake, it's of vital importance to build a health assessment system suitable for the Erhai Lake, which can provide a scientific basis for the protection and management of the Erhai Lake, and can also serve as a reference for the health assessment of other plateau lakes in Yunnan Province.

Methods

The Erhai Lake health assessment work is based on the constructed lake health assessment index system in Yunnan Province and the "Lake Health Assessment Index, Standards and Methods (for Pilot Work) (Version 1.0)" provided by the Water Resources Department of the Ministry of Water Resources, building the index system structure for the health assessment of the Erhai Lake. The Erhai Lake health evaluation index system takes a four-level system, namely the target layer (health status of rivers and lakes), criterion layer, sub-criteria layer and index layer. The criterion level included the ecological integrity and socio-economic value of the Erhai Lake, and the sub-criteria level included five aspects of hydrology and water resources, physical structure, water quality, aquatic organisms and social service functions. There were 20 indexes in the index layer, including 14 mandatory indicators in Yunnan Province and 6 characteristic indicators in the Erhai Lake. The Erhai Lake health assessment index system must fully consider the actual characteristics of the region in the assessment process, and highlight the operability of the evaluation index system, the index system was upgraded and analyzed, and a health assessment index system suitable for the Erhai Lake was established.

Results

The preliminary evaluation result of the health status of the Erhai Lake was healthy, the target score of lake health was 65.0 points, the score of ecological integrity was 63.6 points, and the score of social service function was 68.1 points, all of which were in the lower limit of health. After the optimization of the indexes, the evaluation result in 2017 was healthy, the lake health score was 63.8 points, and the ecological integrity score was 62.0 points; the evaluation result in 2020 was also healthy, and the lake health score was 67.8 points, the ecological integrity score was 69.8 points; the conclusions of the two evaluation results were the same as those of the preliminary evaluation results, and there was a little change in the score, which was still at the lower limit of health.

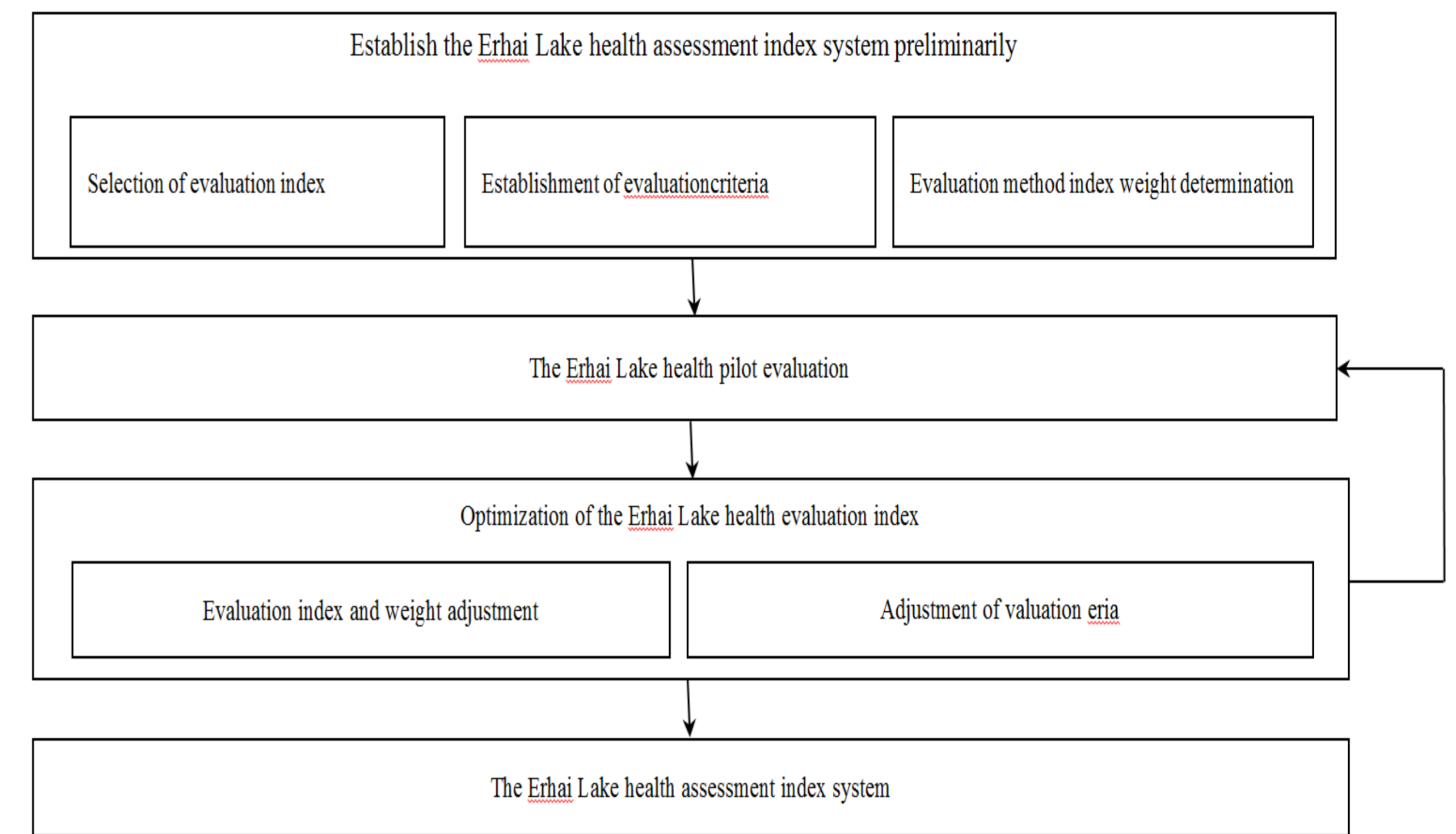


Fig. 1 Technical roadmap for optimizing the Erhai Lake health assessment index system

Conclusions

The conclusions of the two evaluation results were the same as those of the preliminary evaluation results, and there was a little change in the score, which was still at the lower limit of health. As such, it could be judged that the optimized index system was reasonable. The optimized indexes were reduced from 20 to 13 (Table 5), which was beneficial for the long-term and effective development of the Erhai Lake health assessment work. This Erhai Lake health assessment work has explored and constructed an assessment system suitable for the plateau lake the Erhai Lake. It's recommended to continue to conduct the Erhai Lake health assessment work, enhance the assessment system in the follow-up work process, and evaluate the impact and effect of a series of protection and management measures for the Erhai Lake in a more scientific, objective and fair way. Also, suggestions can be proposed in a targeted way, and a reference can be provided for the health assessment of other plateau lakes in Yunnan Province.

Table 1 Preliminary Indicator System of the Erhai Lake Health Assessment

Target layer	Standard layer	Sub-criteria	Index layer	Quantitative indexes	Remark		
The Erhai Lake health	Hydrology and water resources (H2)	Satisfactory status of minimum ecological water level	Minimum ecological water level determined by the Erhai Lake Protection and Management Regulations in lake as the minimum ecological water level of the lake	Required indexes in Yunnan	Characteristic indexes of the Erhai Lake		
			Variation degree of inflow into the lake	The average deviation between the sum of the monthly measured runoff and the natural monthly runoff of the main inflowing rivers around the lake		Required indexes in Yunnan	
		Lake water level variability	Water level indices in wet seasons, water level indices in dry seasons, maximum monthly water level index, minimum monthly water level index, continuous high flow level index, continuous low flow level index, continuous minimum water level index and water level seasonal change index	Required indexes in Yunnan	Lakeshore stability (bank slope height, bank substrate inclination angle, erosion intensity), lakeside vegetation coverage, degree of artificial disturbance in the lakeside zone	Required indexes in Yunnan	
			Lakeshore status	The modification of water flow between the river surrounding the lake and the wetlands of the lake, the objects are the main rivers entering the lake and the direct outlet of the lake		Required indexes in Yunnan	
	Physical structure (P2)	Connectivity of rivers and lakes	Stranding state of the lake	Comparison of the Erhai Lake surface area, comparison of water storage capacity of the Erhai Lake	Required indexes in Yunnan	Dissolved oxygen	
			DO water quality status	Permanganate index, chemical oxygen demand, ammonia nitrogen, five-day biochemical oxygen demand	Required indexes in Yunnan		
	Water quality (W2)	Heavy metal pollution status	Eutrophication status of lakes and reservoirs	Asenic, Mercury, Lead, Chromium	Required indexes in Yunnan	Characteristic indexes of the Erhai Lake	
				Total nitrogen, total phosphorus, permanganate index, chlorophyll a, transparency	Required indexes in Yunnan		
	Aquatic Biology (A2)	Phytoplankton	Zooplankton	Algae cell density	Required indexes in Yunnan	Characteristic indexes of the Erhai Lake	
				Zooplankton diversity index and evenness index	Required indexes in Yunnan		
		Large aquatic plants	Benthic animal	The fish	Large aquatic plant coverage	Required indexes in Yunnan	Characteristic indexes of the Erhai Lake
					Population structure, biomass, Shannon-Wiener diversity index, Pielou evenness index	Required indexes in Yunnan	
	Socioeconomic value	Social Service Function (S2)	Water function zone compliance indexes	Water resources development and utilization indexes	Utilization rate of water resources development	Required indexes in Yunnan	
				Flood control indexes	Flood control standard compliance of the lakeshore	Required indexes in Yunnan	
Water source compliance indexes			Public satisfaction index	Water quality index of water sources, water volume up-to-standard rate	Characteristic indexes of the Erhai Lake	Required indexes in Yunnan	
				All types of public weight scores	Required indexes in Yunnan		

Table 5 Erhai Lake Health Assessment Optimization Index System Table

Target layer	Standard layer	Sub-criteria	Index layer	Quantitative indicators	Single sort weight	Total sort weight
Erhai Lake health	Hydrology and water resources (H2)	Variation degree of inflow into the lake	Lake water level variability	The average deviation between the sum of the monthly measured runoff and the natural monthly runoff of the main inflowing rivers around the lake	0.30	0.042
				Water level indices in wet seasons, water level indices in dry seasons, maximum monthly water level index, minimum monthly water level index, continuous high flow level index, continuous low water level index, continuous minimum water level index and water level seasonal change indexes	0.70	0.088
		Lakeshore status (H3)	Connectivity of rivers and lakes (H4)	Lakeside vegetation coverage	0.70	0.0294
				Degree of artificial disturbance in the lakeside zone	0.30	0.0126
	Physical structure (P2)	Stranding state of the lake	The status of cut-off and barrier of rivers entering the lake	0.50	0.038	
			Water quality compliance status of rivers entering the lake	0.50	0.038	
	Water quality (W2)	Eutrophication status of lakes and reservoirs	Phytoplankton	Comparison of Erhai Lake surface area, comparison of water storage capacity of Erhai Lake	0.30	0.042
				Tenyl nitrogen, total phosphorus, permanganate index, chlorophyll a, transparency	0.20	0.14
	Aquatic organisms (A2)	Phytoplankton	Zooplankton	algae cell density	0.50	0.14
				Zooplankton diversity index and evenness index	0.50	0.14
Socioeconomic value (S2)	social service function	Water function zone compliance indexes	Water resources development and utilization indexes	Compliance rate of water function zone	0.20	0.06
				Utilization rate of water resources development	0.20	0.06
		Flood control indexes	Water source compliance indexes	Flood control standard compliance of the lakeshore	0.20	0.06
				Compliance rate of water quantity and quality in water sources	0.20	0.06
Water source compliance indexes	Public satisfaction index	Public satisfaction index	Various public weight scores	0.20	0.06	
			Various public weight scores	0.20	0.06	