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Waterfront ecotourism quality evaluation under the water ecological challenge in West Strait, China

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The relationship between tourism activities and water ecological degradation has become a challenge that cannot be ignored. However, only few studies have evaluated the sustainability of waterfront tourism. This paper takes the West Strait of China, which is rich in ecological resources, as the research object, constructs the evaluation framework of waterfront ecotourism through two rounds of expert consultation, and determines the weights of the following indicators based on Fuzzy Comprehensive Evaluation (FCE): Waterfront Tourism Design (0.112), Ecotourism Experience (0.034), Aquatic Ecological Knowledge Sharing (0.147), Pro-Water Culture (0.238), Pro-Water Identity (0.134), Aesthetic Value of Water Landscape (0.128), Pro-Water City Brand (0.036), Infrastructure Construction (0.061), Regional Economic Development (0.046), Folkway Support (0.028), Government Policy Support (0.036). Data collection in the 5 core cities in West Strait shows that Pro-Water Culture (U4) had the most significant impact, followed by Aquatic Ecological Knowledge Sharing (U3). Pro-Water City Brand (U7) and Folkway Support (U10) have negligible effects on waterfront ecotourism. The weight range distribution is relatively average except for the four above mentioned indicators.

KEYWORDS

waterfront ecology, quality evaluation, FCE, west strait, China

1 Introduction

With the continuous improvement of people's living standard, the traditional way of tourism has been unable to meet the needs of tourism industry. People have begun to pursue more diversified tourism experiences. Waterfront tourism is an economic behavior that satisfies residents' demand for leisure, entertainment and sightseeing by utilizing waterfront resources. Waterfront tourism has become one of the fundamental driving forces of coastal economic development (Holden, 2018; Lu et al., 2019; Arabadzhyan et al., 2021). However, it is also one of the main factors causing the degradation of water ecology. In recent years, the relationship between tourism activities and water environment has been deeply studied. These studies mainly focus on the report of the *status quo* of water environment in different tourist destinations, the impact of tourism activities on water quality and flow, and the investigation of water environment management in tourist destinations. For example, Sun and Liu (2020) studied the interference factors of tourism activities on the water quality of reservoirs, Moreira and Santos (2010) analyzed the impact of different types of tourism on the water environment, and Gedik and Mugan-

Ertugral (2019) evaluated the maximum carrying capacity of the water environment of public tourist attractions. Among previous literature, the significant correlations between tourism activities and water quality in China has been well demonstrated. Chen et al. (2021) studied the causes and consequences of water quality deterioration caused by tourism development by taking traditional villages in Huizhou, which is rich in freshwater resources, as the research object. He listed the construction of man-made facilities during tourism development such as: sewage treatment stations, artificial wetlands, coastal resorts and hotels as the main causes of water pollution, which would cause the bay ecology of coastal tourist cities to receive serious damage. Furthermore, tourism water usage is also widely focused. Shen et al. (2020) followed Sánchez-Martín et al. (2020) and studied the tourism water use in China's Tingxi reservoir and demonstrated the significant influence of tourism on local water waste.

Although the correlation between the water environment and tourism has been well studied from many aspects, the ecological development of waterfront tourism has received much resistance in practice. Liu et al. (2017) pointed out that the overall development of China's waterfront tourism is poor due to the large differences in ecological environment and economic composition among different regions and the lack of environmental regulations and governance. The main problems of China's waterfront tourism are the poor performance of ecological service innovation and regional ecological protection (Yang, 2022). More and more Chinese scholars have begun to call for the concept of 'waterfront ecotourism' since the over-exploitation of water resources in tourism areas has harmed regional sustainable development (Shan, 2020). However, there is still no relevant evaluation framework and data collection on the construction of waterfront ecotourism, which constitutes the research objective of the present study.

In order to explore the evaluation of waterfront ecotourism, the West Taiwan Strait City Belt (also called: West Strait) in the southern China is selected as the research area. Affected by the climate, southern China has a lower latitude and a pleasant climate. In particular, the West Strait is rich in water resources, which is the area where tourists like to carry out waterfront and water activities (Zan and Xijun, 2014). In December 2009, China issued the Plan for the Coordinated Development of Urban Agglomeration on the West Strait. In this plan, ecological and environmental protection has been strongly promoted, especially in the five core cities of the West Strait: Fuzhou, Quanzhou, Xiamen, Wenzhou, and Shantou. However, the effectiveness of the ecological governance has not been evaluated so far. Therefore, the five core cities of the West Coast urban agglomeration are selected as the target of the study, and eleven evaluation indexes are constructed for their waterfront ecotourism based on previous research theories on tourism system through fuzzy comprehensive evaluation (FCE) method, and their current situation is measured.

2 Evaluation framework construction

2.1 Framework construction

2.1.1 Fuzzy comprehensive evaluation (FCE)

The fuzzy comprehensive evaluation (FCE) is a method based on membership theory that can transform qualitative evaluation into quantitative evaluation. It is highly systematic with accurate results and can deal with problems that are difficult to be quantified. In 1965, Professor Zadeh developed the theory of fuzzy mathematics by combining mathematics with fuzzy fields. In recent decades, fuzzy mathematics has been widely applied and achieved outstanding outcomes across various disciplines. FCE has been widely used in ecological environment evaluation and sustainability index construction for its superiority in measuring sophisticated influencing factors. FCE has been seen as an ideal way to realize ecotourism evaluation (Zabihi et al., 2020; Wen et al., 2021; Ma and Tang, 2022; Zhu and Jiang, 2022). As with other ecotourism evaluations in the past, the factors drive the high-quality development of waterfront ecotourism are multi-faceted. It is a fuzzy decision to determine which factor has a greater impact on the tourism quality evaluation system, because each tourist and expert's evaluation is different. Therefore, it is appropriate to use FCE method for the intended evaluation. Table 1.

2.1.2 Evaluation indicators

Wu (1998) first introduced the tourism system theory that the tourism system mainly includes four aspects: the market system (also called: tourist source system), the travel system, the destination system, and the support system. This theory has guided the evaluation of tourism quality in the past, and has been used to establish the evaluation frameworks of coastal, marine and ecological tourisms (Ruan et al., 2019; Peihai et al., 2020; Ota et al., 2022). The study most similar to the waterfront ecotourism evaluation is Zheng and Hu's (2022) exploration of marine tourism based on FCE. Thus, the *Marine Tourism High-Quality Development Evaluation Framework*established by Zheng and Hu (2022) is referred in the present study and revised the proposed three evaluation dimensions.

In order to identify and construct the evaluation indicators, first of all, the factors affecting the quality of waterfront ecotourism were qualitatively understood. During the identification process, a total of 16 experts, 6 waterfront tourism researchers, 6 scenic spot managers and 4 staff of the Wenzhou Culture and Tourism Bureau were consulted, and the weight of waterfront ecotourism evaluation index was then obtained. They were also invited to give an unbiased assessment of the identified waterfront ecotourism indicators. The specific process of indicator selection and data collection is as follows. Two rounds of consultation were conducted:

The first round was to screen the evaluation indicators of waterfront ecotourism to confirm the impact factors included in the calculation model. Through evaluation and screening, 11 key evaluation indicators were selected: Waterfront Tourism Design (U1), Ecotourism Experience (U2), Aquatic Ecological Knowledge Sharing (U3), Pro-Water Culture (U4), Pro-Water Identity (U5), Aesthetic Value of Water Landscape (U6), Pro-Water City Brand (U7), Infrastructure Construction (U8), Regional Economic Development (U9), Folkway Support (U10), Government Policy Support (U11). Then, the definition of the indicators is revised to ensure the rigor of the content and prevent ambiguity (The meaning of "pro-water" mainly refers to the fact that tourists' choice of tourist destinations will prefer cities with water resources, such as lakes, rivers, and oceans, as

TABLE 1 Evaluation framework of waterfront ecotourism.

Primary index	Secondary index	Definitions
Waterfront Protection	Waterfront Tourism Design (U1)	The consideration of ecological protection in the design of waterfront tourism routes and tourism products
	Ecotourism Experience (U2)	The ability to strike a balance between tourism experience and waterfront ecological conservation
	Aquatic Ecological Knowledge Sharing (U3)	The ability to communicate and share waterfront ecotourism knowledge with tourists through multiple media channels, methods and means
Ecological Value	Pro-Water Culture (U4)	The ability of tourists to understand the cultural connotation of water protection after traveling
	Pro-Water Identity (U5)	Tourists' identification of 'pro-water' identity after travelling
	Aesthetic Value of Water Landscape (U6)	Tourists' recognition of the aesthetic value of water landscape
	Pro-Water City Brand (U7)	Tourists' recognition of the city's brand value brought by waterfront ecology and water environment protection
Social-Economic Support	Infrastructure Construction (U8)	The construction of basic infrastructures for appealing tourists
	Regional Economic Development (U9)	The perceived regional economic support for waterfront ecotourism
	Folkway Support (U10)	Tourists' cognition and recognition of local water-related folk customs
	Government Policy Support (U11)	The perceived governmental policy support for waterfront ecotourism

the main tourist resources). The pro-water concept here was derived from the studies of pro-environmental psychology (Liu et al., 2020; Chen and Zhang, 2021; Zhang et al., 2022).

In the second round, were asked to rate the importance of each of the 11 indicators on a 5-Point Likert Scale. Specifically, each indicator was measured with five points [5,4,3,2,1]. A range from five to one indicates a difference in importance, with the importance decreasing in turn. The collected data are normalized to obtain the weight set of evaluation indicators A, where:

A = [0.112.0.034.0.147.0.238.0.134.0.128.0.036.0.061.0.046.0.028.0.036].

2.2 Mathematics expression

Indicator weights can be determined by subjective or objective assignment methods. The entropy method is one of the objective assignment methods and has been widely used in studies related to indicator systems. The entropy method is one of the objective assignment methods and has been widely used in studies related to indicator systems (Tang and Liu, 2014).

If we let Z represents the quality of waterfront ecotourism, the fuzzy function for Z is:

$$Z = W^{*}C \tag{1}$$

Where: W is the weight set of waterfront tourism evaluation indicators, C is the comment sets of consulted experts to the indicators.

The weight set W is determined as following equations:

$$W = \left(\frac{m_1}{\sum_{i=1}^{n_1} m_i}, \frac{m_2}{\sum_{i=1}^{n_1} m_i} \cdots\cdots \frac{m_n}{\sum_{i=1}^{n_1} m_i}\right) \tag{2}$$

$$m_i = \frac{1}{w}\sum_{j=1}^{n_2} m_{ij} \tag{3}$$

Where: n_1 is the number of waterfront ecotourism evaluation indicators, m_{ij} is the comment of the ith evaluation indicator from the jth expert, n_2 is the number of experts.

The comment sets are determined as follows:

$$C = \begin{pmatrix} c_{11} & c_{12} & \cdots & c_{1q} \\ c_{21} & c_{22} & \cdots & c_{2q} \\ \cdots & \cdots & \cdots & \cdots \\ c_{n1} & c_{n2} & \cdots & c_{nq} \end{pmatrix} \tag{4}$$

Where: n is the number of waterfronts tourism evaluation indicators, q is the evaluation score from the expert to waterfront ecotourism, c_{ij} is the degree of membership of ith index to jth evaluation score, and $\sum_{j=1}^{q} c_{ij} = 1, i = 1, 2, \cdots, n; j = 1, 2, \cdots, q$.

3 Result and discussion

Based on the above methods, we take Fuzhou, Quanzhou, Xiamen, Wenzhou, Shantou as the object of study. Among the selected cities, Fuzhou has the highest GDP, which can reflect the impact of economic aggregate on waterfront ecotourism. The waterfront economy of Wenzhou has been developing for the longest time, but the local waterfront ecotourism started late. Although Xiamen has a relatively small economic aggregate, its *per capita* GDP is the highest among the five cities and it is well known as a tourist city. Although Shantou is also a tourist city, its tourism is not famous for seaside tourism, but for its unique food resources. According to 11 indicators, we designed a questionnaire for tourists and invited them to evaluate five waterfront tourist destinations (the respondents answered the questions according to their last travel experience in a certain place, if none of the five places are available, they did not fill in the questionnaire). A 5-Point Likert Scale questionnaire was designed to ask tourists to make a single choice. In this

TABLE 2 Comment sets.

Object	Rank	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11
Weight		0.112	0.034	0.147	0.238	0.134	0.128	0.036	0.061	0.046	0.028	0.036
Fuzhou	5	38	19	20	4	40	53	43	31	24	20	46
	4	61	51	61	55	69	60	73	53	57	49	57
	3	52	70	62	71	35	40	35	56	55	76	52
	2	7	9	4	21	7	9	7	9	13	13	5
	1	7	16	18	14	14	3	7	16	16	7	5
Quanzhou	5	41	28	33	35	32	43	41	32	26	31	44
	4	66	61	63	57	71	75	77	58	56	52	61
	3	52	68	63	71	60	45	51	67	71	68	58
	2	18	18	22	16	14	12	8	18	18	20	16
	1	8	10	4	6	8	10	8	10	14	14	6
Xiamen	5	34	19	16	27	27	22	26	28	25	28	33
	4	42	39	46	36	49	54	57	50	36	35	44
	3	35	52	53	53	40	43	38	37	49	46	45
	2	13	13	11	9	8	4	3	8	10	11	2
	1	4	5	2	3	4	5	4	5	8	8	4
Wenzhou	5	38	19	18	27	31	24	27	32	9	27	40
	4	47	41	52	41	46	51	61	47	42	40	46
	3	39	52	50	52	45	45	38	38	55	52	42
	2	6	16	14	12	8	8	6	11	18	5	4
	1	8	10	4	6	8	10	6	10	14	14	6
Shantou	5	46	31	24	39	28	50	46	37	29	15	50
	4	70	75	70	63	79	77	84	68	58	67	68
	3	58	58	70	68	58	49	18	56	79	76	65
	2	9	19	24	16	18	11	35	20	19	22	6
	1	9	9	4	6	9	5	9	11	7	12	3

survey, members of the research team pushed the electronic questionnaire link to the we-media in their hometown, and invited respondents to fill in the questionnaire. A total of 808 valid questionnaires were collected, among which 165 were evaluated in Fuzhou, 185 in Quanzhou, 128 in Xiamen, 138 in Wenzhou and 192 in Shantou. The comments set of five regions were collected, as shown in Table 2. The comment sets in Table 2 were then normalized respectively to obtain the membership degree and the normalized membership degree (weight), as shown in Table 3.

By analysing the result vector, it can be found that when the index is summed up with the total evaluation membership degree of 3 and above, the scores of each city are 0.61, 0.665, 0.687, 0.672 and 0.706 respectively. After summing the total evaluation membership degree of 4 and above, the scores of each city are 0.372, 0.427, 0.449, 0.434 and 0.441 respectively. It can be seen that Shantou and Xiamen have the highest overall evaluation and Fuzhou has the lowest score. In general, from the perspective of tourist cognition, it can be observed that the positive evaluation of tourism in the five cities is mostly, with scores above 0.6 for each city and 0.4 for scores above 4, and the highest value is 0.449, which is less than half, indicating that the performance of waterfront ecotourism in service quality is not satisfactory. According to the observation of the membership degree of 2 and below, it can be found that Xiamen and Quanzhou have the lowest proportion of poor evaluation, followed by Shantou. The overall evaluation of Fuzhou is poor, which indicates that the economic aggregate has no obvious help to waterfront ecotourism. The overall evaluation of tourism in Fuzhou city is poor, indicating that the economic

TABLE 3 Degree of membership.

City	Membership indexes	5	4	3	2	1
Fuzhou	Membership degree	0.134	0.238	0.238	0.127	0.109
	Weight	0.158	0.281	0.281	0.15	0.129
Quanzhou	Membership degree	0.189	0.238	0.238	0.119	0.054
	Weight	0.226	0.284	0.284	0.142	0.064
Xiamen	Membership degree	0.211	0.238	0.238	0.102	0.046
	Weight	0.253	0.285	0.285	0.122	0.055
Wenzhou	Membership degree	0.196	0.238	0.238	0.101	0.072
	Weight	0.231	0.281	0.281	0.12	0.086
Shantou	Membership degree	0.203	0.238	0.238	0.125	0.057
	Weight	0.236	0.276	0.276	0.145	0.067

aggregate does not guarantee satisfactory waterfront tourism. The membership degree distribution of the five cities has the characteristics of the normal distribution with a mean of 3. Meanwhile, through the analysis of the weight set of indicators, it can be known that among the 11 indicators, Pro-Water Culture (U4) has the most significant impact on the overall tourism industry, followed by Aquatic Ecological Knowledge Sharing (U3). Pro-Water City Brand (U7) and Folkway Support (U10) have the most negligible impact on eco-tourism.

4 Conclusion

Ecotourism is one of the development directions of tourism in the future. Developing ecotourism in waterfront cities plays an important role in promoting the coordinated and sustainable development of economy, society and environment. At present, waterfront ecotourism is developing rapidly in China, but many tourism project planning is still in the initial stage, especially in the process of development, how to strengthen the publicity of the existing water culture of waterfront cities, while preventing blind development caused by waste and destruction of resources and other problems. The study on the development impact of the five core waterfront tourism cities on the west coast of the Taiwan Straits shows that, in the ecotourism development planning and environmental assessment in coastal areas, it is necessary to consider the dissemination factors of hydrophilic culture as comprehensively as possible, analyze and predict the impact degree and scope of infrastructure and policy support under different circumstances, and take timely environmental protection measures. Make waterfront tourism really sustainable development.

In order to systematically evaluate the factors affecting the development of waterfront ecotourism, this paper establishes the evaluation framework of waterfront ecotourism by fuzzy comprehensive evaluation method. The weight set of the identified indicators was obtained by consulting experts. Based on the weight set of indicators, questionnaire was designed with 5-Point Likert Scale to collect tourists' evaluation of the waterfront ecotourism in Fuzhou, Quanzhou, Xiamen, Wenzhou and Shantou on the West Strait. The main findings are as follows:

1) The evaluation indicators of waterfront ecotourism is constructed by "Waterfront Tourism Design (U1), Ecotourism Experience (U2), Aquatic Ecological Knowledge Sharing (U3), Pro-Water Culture (U4), Pro-Water Identity (U5), Aesthetic Value of Water Landscape (U6), Pro-Water City Brand (U7), Infrastructure Construction (U8), Regional Economic Development (U9), Folkway Support (U10), Government Policy Support (U11)", the corresponding weight set is 0.112, 0.034, 0.147, 0.238, 0.134, 0.128, 0.036, 0.061, 0.046, 0.028, 0.036].
2) Among the five studied cities, Shantou and Xiamen have the highest overall evaluation, while Fuzhou has the lowest. It shows that there is no direct correlation between the development of waterfront ecotourism and the economic aggregate. Cities that take tourism as the main development direction tend to get higher tourist evaluations regardless of whether waterfront tourism is the main publicity direction.
3) Pro-Water Culture (U4) had the most significant impact, followed by Aquatic Ecological Knowledge Sharing (U3). Pro-Water City Brand (U7) and Folkway Support (U10) have negligible impact on waterfront ecotourism. The overall weight range distribution is relatively average except for the four indicators mentioned above.

As an exploratory study, limitations need to be clarified. In this paper, only fuzzy comprehensive evaluation method is used to analyse the influencing factors, which may lead to sample bias. At the same time, a relatively simple method is adopted in the aspect of data standardization, and the weight calculation method has room for further research in the future. In addition, in order to expand the sample size, this paper did not ask the demographic data of tourists in the process of questionnaire survey. And the influence factors of stakeholders were not added to the evaluation system as important reference indicators (Wondirad et al., 2020). Therefore, in future studies, more extensive data will be collected for quantitative analysis and contribute to the waterfront ecotourism evaluation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by CW and XH. The first draft of the manuscript was written by CW and ZL, and all authors commented on previous versions of the manuscript. CS and XH performed the data collection and final draft editing. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that 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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