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Environmental and Social Impact Assessment for the Tourism Industry: A Case Study of Coastal Recreation Areas in Hualien Taiwan

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Abstract

Although the over-development of a tourist attraction can attract a huge number of tourists to boost local economic prosperity, it can also consume tourism resources and reduce recreational quality. This study used relevant studies on ecotourism and recreational carrying capacity and applied the Delphi-fuzzy analytic hierarchy process to identify the critical factors affecting the recreational carrying capacity of the Hualien Qixingtan coastal recreational areas, including 4 primary factors, namely, recreational environment, natural landscape, coastal animals and plants, and cultural assets, and 13 secondary factors, such as public infrastructure. The research results can be provided as reference for relevant government authorities and operators to develop measures taking into account both the resource conservation and recreational management of coastal recreational areas.

JEL classification numbers: Z3Z32
Keywords: Recreational carrying capacity, Delphi-fuzzy analytic hierarchy process, Coastal recreational areas, Evaluation indices

1 Introduction

According to the analysis report published by the World Travel and Tourism

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Council (WTTC) in 2014, the output value of the global tourism industry in 2013 was approximately USD 7.3 trillion, and accounted for 9.5% of global GDP. The output value of global tourism industry is predicted to reach USD 10.8 trillion by 2024(WTTC, 2015). The tourism industry has become the second largest industry globally (WTTC, 2015). In recent years, with government authorities' construction of transportation and tourism facilities and infrastructure, private operators' continuous construction of hotels and recreational attractions, and the implementation of open-door policy to Mainland Chinese tourists visiting Taiwan, government authorities and operators face the challenge of how to concurrently develop tourism to pursue maximum economic benefit, minimize the impacts on local culture and the environment, maintain the resource integrity of ecological landscapes, and maximize the satisfaction of tourists.

With the improvement of human beings' standards of living, the need for coastal recreational areas has been increasing (Saveriades, 2000; Zacarias et al., 2011; Vinals et al., 2014; Bera et al., 2015; Zhang et al., 2015). However, although the over-development of a tourist attraction can attract a huge number of tourists to boost local economic prosperity, it can also consume tourism resources and reduce recreational quality. According to recent media reports, the Knkreyan tribe of the Taroko people in Hualien have used approaches, such as road closures and firing rifles into the air, to prevent tourists from breaking into "Mukumugi", the tourist attraction where they live. This phenomenon reflects that, although the development of tourism attracts tourists, it also creates unhealthy tourism development, such as environmental impacts, overburdened roads, air pollution, littering, incorrect environmental introduction offered by tour guides, and disrespect for local cultures. Therefore, the evaluation of recreational carrying capacity can help government authorities and the managers and operators of tourist attractions to develop effective measures, giving consideration to both resource conservation and recreational management, and it can also be provided as a basis for regulations governing the number and behavior of tourists (LaPage, 1963; Dasmann, 1964; Lime and Stankey, 1971; Shelby and Heberlein, 1984; Stankey et al., 1985; Hammitt and Cole, 1998; Andrew, 1999; Manning, 2001; Clivaz et al., 2004; Dobrica and Vanja, 2007; Manning, 2010; Whittaker et al., 2011; Jurado et al., 2012).

Based on the research background and motivations mentioned above, this study systematically collected studies concerning ecotourism and the carrying capacity of coastal recreational areas, and used the Delphi method, expert interviews, the fuzzy analytic hierarchy process (FAHP), and a questionnaire survey to perform investigations, identify critical factors affecting the carrying capacity of coastal recreational areas, and provide research results to act as a reference for subsequent studies and to assist government authorities and private sector bodies to implement effective management measures.

2 Literature Review

Human beings' involvement in the ecotourism of coastal recreational areas is based on the premise of them being responsible for environmental maintenance. Therefore, firstly, this study systematically reviewed relevant studies and investigated the issues concerning ecotourism, recreational resources, and environmental carrying capacity. This section selected and compared relevant studies according to the ideas and perspectives discovered during the research process and summarized them into two categories for investigation, namely, ecotourism and recreational carrying capacity, as the basis for research model development and empirical analysis.

2.1 Ecotourism and economic development

According to the literature review, the concept of ecotourism originated from Hetzer (1970) in 1965. Hetzer found tourism activities caused damage to natural resources, and appealed to people to rethink the relationship among culture, the environment, and tourism, in order to create a new tourism concept to minimize the damage to environmental resources caused by tourism activities, as well as to enable tourists to maximize their satisfaction, which is the earliest origin of the idea of ecological tourism (LaPage, 1963; Lime and Stankey, 1971; Burch, 1984; Shelby & Heberlein, 1984; Andrew, 1999; Dobrica and Vanja, 2007). After the concept of ecological tourism had been proposed, it attracted the attention of many experts and scholars. However, the definition and the meaning of ecotourism are still unclear, including participation, conservation, and interests (LaPage, 1963; Burch, 1984; Coccossis and Mexa, 2004; Bimonte & Punzo, 2005; Loannides et al., 2006; Manning, 2010).

Coastal recreational tourism activities will affect or damage the ecological environment and local residents to a certain extent. Indeed, tourism development has several impacts on the ecological environment: it damages wildlife habitats; introduces exotic dominant species leading to changes in the local flora (Godschalk & Parker, 1975; Odum, 1989; Abernethy, 2001; Oh et al., 2002); damages soil and plants, leading to the gradual disappearance of greenbelts; affects visual landscapes (Odum, 1989; Hof & Lime, 1997; Loannides et al., 2006); leads to the influx of a large number of tourists, creating problems in transportation, food and accommodation, air, water, noise, and garbage processing of tourist attractions; interferes with ecological environment; and creates a burden for conservation (Mathieson & Wall, 1982; May, 1991; Casagrandi & Rinaldi, 2002; Gossling & Hall, 2005; Saarinen, 2006). In terms of economic impacts, the economic benefits of most of the tourist attractions are obtained not by local residents, but by financial groups or immigrants from other places (Khan, 1998; Manning, 2002). Indeed, managers and operators cannot properly provide residents with participation opportunities and give-back initiatives, but instead create a negative social cost, which leads to residents' low cooperation with or rejection of tourism policies (Casagrandi & Rinaldi, 2002; Gossling & Hall, 2005;

Saarinen, 2006; Bimonte & Punzo, 2005). Where operators lack the concept of environmental protection, in order to obtain economic benefits, they do not develop well-thought out land planning, and thus their actions lead to ecological damage, an upsurge in land prices, and the expansion of transportation construction. External costs incurred are transferred to the ecological environment and local residents, which results in damage to natural resources and a reduction in the recreational quality (Casagrandi & Rinaldi, 2002; Gossling & Hall, 2005; Mathieson & Wall, 1982; Saarinen, 2006).

In terms of social impacts, a strong cultural invasion and lack of respect for the local culture leads to the sacrifice of natural resources and traditional cultures to obtain economic benefits (Abernethy, 2001; Godschalk & Parker, 1975; Oh et al., 2002; Guerra and Dawson, 2016; Wu and Chen, 2016). In addition, a lack of professional tour guides and planning personnel leads to the failure to implement the actual ecotourism (Loannides et al., 2006), and the intervention of financial groups interferes with the consensus of local residents and affects the direction of the development of ecotourism (May, 1991; Ceballos-Lascurain, 1996; Zacarias et al., 2011; Vinals et al., 2014; Zhang et al., 2015; Wu and Chen, 2016). In terms of the impacts on policy, the lack of a concept of “tourist carrying capacity” may easily cause the consumption of and damage to tourist attractions (May, 1991; Tourism Bureau, 2002; Zhang et al., 2015; Guerra and Dawson, 2016) while the lack of any monitoring mechanism of Ecotourism attractions leads to the failure to accurately evaluate the overall influence of the ecotourism development on tourist attractions (May, 1991; Tourism Bureau, 2002; Vinals et al., 2014; Zhang et al., 2015; Wu and Chen, 2016). Furthermore, the damages to environmental resources and the lack of professional talent result in the dependence on government authorities’ proposal of limited management methods, and the failure to develop an evaluation and grading framework of tourist attractions of ecotourism means managers and operators rarely make any provision for local residents with participation opportunities and proper give-back (Tourism Bureau, 2002; Vinals et al., 2014; Zhang et al., 2015).

2.2 Recreational carrying capacity and tourism development

The concept of carrying capacity was proposed as early as 1936 (LaPage, 1963; Stankey, 1981). Summer (1942) further proposed that, to achieve the purpose of long-term maintenance, the maximum amount of recreational utilization that can be tolerated by a field environment should be termed “recreational saturation point”. After 1960, the term ‘carrying capacity’ was comprehensively applied to leisure and recreation. For example, LaPage (1963) suggested that, during the determination of recreational carrying capacity, it is necessary to take into account two factors – biological carrying capacity and aesthetic recreational carrying capacity. The concept of biological carrying capacity suggests that, during the development and utilization of recreational resources, the volume of use of the natural ecological environment should be maintained without affecting tourists’ satisfactory experiences, while the concept of aesthetic recreational carrying capacity suggests that, during the development and utilization of recreational resources, it is necessary to satisfy most of the tourists to a certain extent. Lime and Stankey (1971) further used the concept of natural science carrying capacity to develop the concept of "recreational carrying capacity." Andrew (1999) suggested that ecological carrying capacity refers to the maintenance of the maximum number of a species under the conditions of the existing ecological system. Graefe et al. (2011) took into account the differences between human beings and animals to expand the field of recreational carrying capacity and develop a social psychological carrying capacity to facilitate the investigation into the interactive relationship of human beings in a recreational environment and its balance. Dobrica and Vanja (2007) suggested that the definition of tourism carrying capacity can be slightly altered to prevent the occurrence of unacceptable changes or changes that would lead to irreversible consequences for the natural ecological environment and for social, cultural, and economic structures, which may reduce the maximum number of tourists using a space under the premise of recreational experience quality. In other words, environmental carrying capacity can be divided into economic carrying capacity and ecological carrying capacity.

Consideration of the relevant dimensions of carrying capacity has been interpreted as a feasible method for evaluating the level of tourism development that takes into account the environmental, social, and economic characteristics of a location (Clivaz et al., 2004). Although the dimensions concerning carrying capacity have been investigated for many years and have been provided for planners and decision-makers to help them control the over-development of tourism, the difficulties of implementation in individual regional environments and calculations limit their effectiveness. Shelby and Heberlein (1986) summarized the differences in impact parameters proposed by past scholars, and defined four types of recreational carrying capacity that have been comprehensively used to date: (1) ecological carrying capacity; (2) physical carrying capacity; (3) facility carrying capacity; (4) social carrying capacity. The level of influence or change in the amount of recreational use of tourists' satisfactory experiences is used to analyze the recreational carrying capacity.

For studies investigating the factors affecting recreational carrying capacity, recreational carrying capacity is not only used to calculate the allowable number of tourists in a recreational area, but also has been developed into an indicator for monitoring an area (Stankey et al., 1985; Manning, 2001). The methods for studying recreational carrying capacity include the use of systematic analysis to integrate relevant planning factors, as well as the use of an objective planning method to develop a land-use objective model for a recreational area (Stankey et al., 1985; Manning 2001); the use of the perspective of limits of acceptable change (LAC) to calculate the recreational carrying capacity limits of acceptable change (Shelby & Heberlein, 1984; Hetzer, 1970); the use of fuzzy set theory to deal with the issues of multi-objective planning; and the use of questionnaire survey data to develop a multi-objective planning model or Multi-Criteria Decision Analysis to determine the most appropriate recreational carrying capacity(Conestrelli and Costa, 1991; Pourahmad et al., 2015; Michailidou et al., 2016).

In terms of the identification of factors affecting the ecotourism carrying capacity, Saveriades (2000), McCool and Lime (2001), and Jovicic and Ivanovic (2007) used a literature review to discover the factors affecting recreational carrying capacity, and then used a questionnaire survey to determine the most appropriate carrying capacity. Manning et al. (1996) used the Scenic Beauty Estimation Method or observation method, as well as a questionnaire survey to determine the most appropriate carrying capacity. Chan (1993) and Chu (1998) used a time series to estimate the number of tourists and used a questionnaire survey to evaluate the most appropriate carrying capacity. Jackson (1965) and Miller (1997) used the perception of crowding to investigate social carrying capacity, satisfaction, loyalty, etc. to identify the factors affecting ecotourism carrying capacity while Canestrelli and Costa (1991) used fuzzy linear programming to estimate the most appropriate carrying capacity for Venice, Italy, and the objective function of the model was the maximization of the number of tourists.

At present, the evaluations on carrying capacity in Taiwan mainly use single ecological or social carrying capacity for investigation and empirical research. The factors affecting the carrying capacity of coastal recreational areas are seldom investigated, and nor are carrying indices developed according to their characteristics as the basis for determining ecotourism carrying capacity. Therefore, this study selected coastal recreational areas as the research targets and used the Delphi-Fuzzy *analytic hierarchy process (DFAHP) combining the* Delphi method and the FAHP as the research method. This study obtained consensus through the brainstorming of a panel of experts, and then used an expert questionnaire survey to develop the hierarchical structure and to calculate the weight of various critical factors affecting the carrying capacity of ecotourism areas. This study used various evaluation dimensions and the weight of evaluation indices to understand the relationship among various critical factors and their importance.

3 Models for Tourism Environmental Evaluation

3.1 Areas of empirical study and issue backgrounds

This study selected Qixingtan Coastal Recreational Area as the research object; it extends from DeYan Set Fishnet Fishery in the north to QiLaiBi Lighthouse in the south. The Pacific Coast is to the east, and County Road 193 is to the west at a distance of 10 meters. Qixingtan Coastal Recreational Area mainly includes DeYan Set Fishnet Fishery, (Star Gazing Square, 48 Viewing Deck, and roads and bicycle lanes in the coastal environment, with an area of 896,500m^2. As shown in Figure 1, Qixingtan is rich in natural landscapes and plant and animal ecology, and has a fixed-net fishing culture with the features of a traditional fishing village; these have become the main tourist resources of this specific area and provide

Qixingtan with important recreational value.

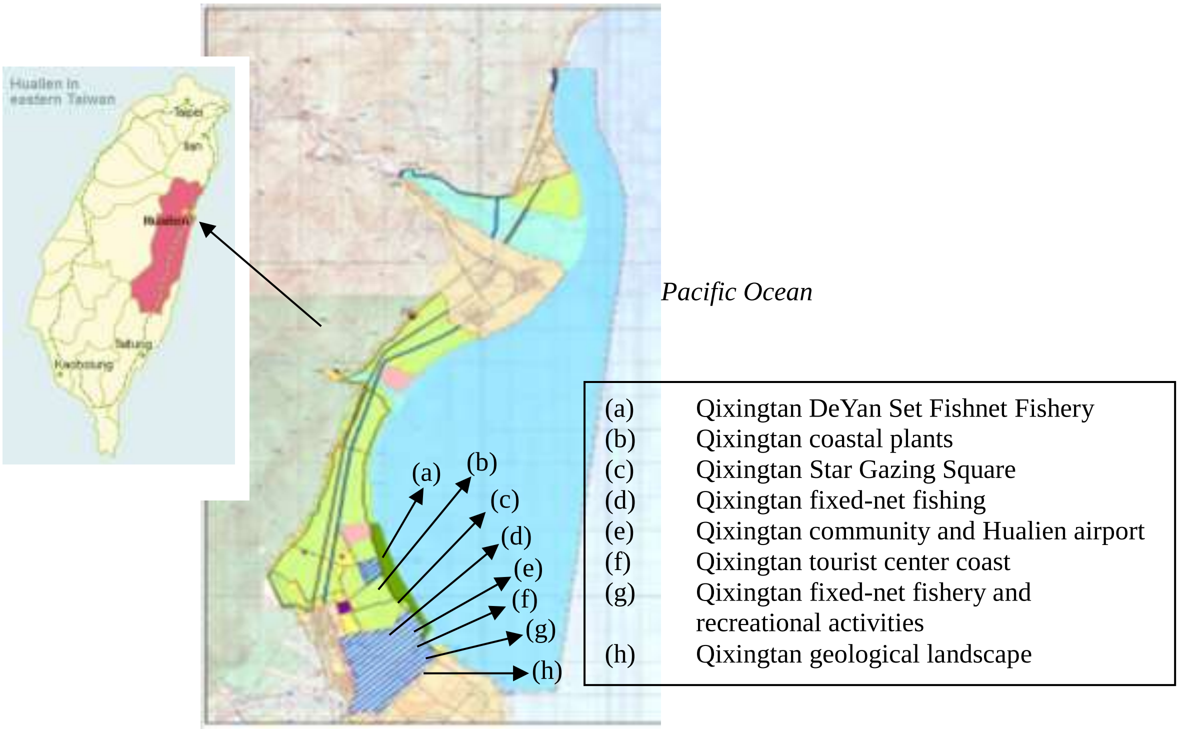

Figure 1: Recreational Resources of Qixingtan Coastal Recreational Area

3.2 Evaluation procedures

3.2.1 Decision-making Panel

This study mainly investigated the factors affecting the environmental carrying capacity of coastal recreational areas. Therefore, this study enrolled 5 groups, namely, scholars and experts with backgrounds of tourism, geological landscape, and animals and plants; industry; government authorities; local residents; and tourists; with a total of 25 experts to assist in this study.

3.2.2 Delphi method and confirmation of factors affecting the carrying capacity of coastal recreational areas

The questionnaire return rate of the Delphi questionnaire was 100% (25 questionnaires), and all of them were valid. After the questionnaires were returned, this study calculated the mean (*M*), standard deviation (*SD*) and consensus deviation index (*CDI*), and set up the threshold of consensus difference (decision threshold) ε=0.3 as the standard for measuring whether experts reached a consensus.

This study used the following equations, where *n* denotes the number of rounds of the Delphi survey, *h* denotes the ordinal number of experts, *j* denotes the number of the item scored by the experts, and X_{jht} denotes the score. Therefore, $\overline{X_{jt}}$ and S_{jt} are used to denote the score and standard deviation of round *n* of the Delphi survey of *r* experts on Item *j*:

$$\overline{X_{jt}} = \frac{1}{r}\sum_{h=1}^{r} X_{jht}, \forall j,t \tag{1}$$

$$S_{jt} = \sqrt{\frac{1}{r-1}\sum_{h=1}^{r}\left(X_{jht} - \overline{X_{jt}}\right)^2}, \forall j,t \tag{2}$$

The coefficient of variance (*CV*) could be used as the judgment standard to determine whether the judgments of experts reached a consensus. Therefore, CV_{jt} is used to denote the coefficient of the variance of round *n* on Item *j*:

$$CV_{jt} = \frac{S_{jt}}{\overline{\overline{X_{jt}}}}, \forall j,t \tag{3}$$

The smaller the CV_{jt} is, the smaller the variance in each average score is and the more consistent the opinions of *r* experts are. Consensus deviation index (*CDI*):

$$CDI_{jt} = CV_{jt}\frac{\overline{X_{jt}}}{\max_j\left\{\overline{\overline{X_{jt}}}\right\}}, \forall j,t \tag{4}$$

$$CDI_{jt} = \frac{S_{jt}}{\max_j\left\{\overline{\overline{X_{jt}}}\right\}}, \forall j,t \tag{5}$$

3.2.3 Fuzzy AHP questionnaire design and survey

After the preliminary hierarchy had been developed, because there was a fuzzy space between the dimensions and the indices of the evaluation system, this study used fuzzy theory and AHP to confirm the various factors affecting the carrying capacity of ecotourism areas and their weight. This study adopted expert panel decision-making to use experts' familiarity with the ecological environment of Qixingtan and their professional knowledge to measure the relative level of influence between recreational activities and various substantial factors affecting the ecological environment, as well as the acceptable tourist density. The corresponding triangular fuzzy number of the linguistic scale in this questionnaire survey is shown in Table 1:

Table 1: Evaluation Scale of Fuzzy Analytic Hierarchy Process

Fuzzy number	Linguistic scale	Scale of fuzzy number
$\tilde{1}$	Equally important	(1, 1, 3)
$\tilde{3}$	Slightly important	(1, 3, 5)
$\tilde{5}$	Quite important	(3, 5, 7)
$\tilde{7}$	Extremely important	(5, 7, 9)
$\tilde{9}$	Absolutely important	(7, 9, 9)

Source: Mon, D. L., C. H. Cheng & J. C. Lin. (1994).

3.2.4 Fuzzy pairwise comparison matrixes

This study used fuzzy number to denote the values in traditional AHP pairwise comparison matrix as follows:

$$\tilde{a}_{ij} = \lfloor L_{ij}, M_{ij}, R_{ij} \rfloor \tag{6}$$

$$\tilde{a}_{ij} = 1/\tilde{a}_{ij}, \forall_{ij} = 1,2,\ldots,n \tag{7}$$

$$\tilde{A} = [\tilde{a}_{ij}] = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix} \tag{8}$$

L_{ij}: The left value of the triangular fuzzy number during the comparison on relative level of importance between factor *i* and factor *j*.

M_{ij}: The middle value of the triangular fuzzy number during the comparison on the relative level of importance between factor *i* and factor *j*.

R_{ij}: The right value of the triangular fuzzy number during the comparison on relative level of importance between factor *i* and factor *j*.

$\tilde{a}_{ij}$: The triangular fuzzy number at row *i* and column *j* in the fuzzy pairwise comparison matrix.

3.2.5 Integration of experts' opinions

This study divided the subjects into five groups: scholars and experts, industry, government authorities, local residents, and tourists. The evaluation of experts or various expert panels on different dimensions or criteria might not be the same, and there were differences in the perception of scale of the fuzzy number for evaluating semantics. To avoid attaching too much importance to the opinions of a certain group, the judgments of every expert had to pass the consistency test. Afterwards, the opinions of the exert panel were integrated. This study adopted the geometric mean recommended by Saaty (1990) to integrate the judgments and opinions of *r* experts. The equation is as follows:

$$\tilde{A} = \left(\tilde{a}_{ij}\right) \tag{9}$$

$$\tilde{a}_{ij} = \left(\prod_{h=1}^{r} \tilde{a}_{ij}^{h}\right)^{1/r}, i = 1,2,\cdots,n \tag{10}$$

3.2.6 Calculation of fuzzy weight

This study used the vector geometric mean to calculate the fuzzy weight of each evaluation criterion $\tilde{w}$i, because this method can increase the accuracy and consistency of the evaluation criteria (Buckley, 1985). The equation of $\tilde{w}_i = \left(W_iL, W_iM, W_iU\right)$ is as follows:

$$\tilde{w}_i = \frac{\left(\prod_{j=1}^{n} \tilde{a}_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} \tilde{a}_{ij}\right)^{1/n}}; i, j = 1,2,\cdots,n \tag{11}$$

$$\tilde{w}_i = \begin{bmatrix} \tilde{w}_1 \\ \tilde{w}_2 \\ \vdots \\ \tilde{w}_n \end{bmatrix} \tag{12}$$

$\tilde{w}_i$: denoted the weight of criterion *i* in the fuzzy pairwise comparison matrix, and *i*=1, 2, …, *n*; $\tilde{a}_{ij}$ was pairwise comparison matrix.

3.2.7 Calculation of maximum eigenvalue

The calculation of maximum eigenvalue is as follows:

$$\tilde{A} \otimes \tilde{w}_i = \tilde{w}_i' \tag{13}$$

$$\tilde{\lambda}_{\max} = \sum_{i=1}^{n} \frac{\tilde{w}_i'}{n\tilde{w}_i} \tag{14}$$

3.2.8 Defuzzification

A fuzzy number is not a specific value, and it cannot be directly used for scheme comparison. Therefore, a fuzzy value has to be defuzzificated to convert a fuzzy set into a specific value. The common defuzzification methods include Center of

Gravity Defuzzification, Center of Sum Defuzzification, Center of Largest Area Defuzzification, and First of Maximum Defuzzification. Center of Gravity Defuzzification is the most common and most rational method, but the calculations are more cumbersome. Center of Sum Defuzzification is also rational. However, the calculations simpler than those of the former one. This study adopted the Center of Gravity Defuzzification proposed by Klir and Yuan (1995). The equation is as follows:

$$DW_i = [\,(W_iR - W_iL) + (W_iM - W_iL)\,]/3 + W_iL \qquad (15)$$

3.2.9 Normalization

After the defuzzification, the sum of the weight of each evaluation criterion was not equal to 1, but was close to 1. The defuzzificated weight had to be normalized. The equation is as follows:

$$NW_i = \frac{DW_i}{\sum_{i=1}^{n} DW_i} \qquad (16)$$

3.2.10 Consistency test

The order of factors was determined according to pairwise comparison. Comparisons and judgments made by experts might not be consistent, which would lead to differences in the order. Therefore, Saaty (1980) suggested the use of a Consistency Index (*CI*) and Consistency Ration (*CR*) to test whether the evaluation results are consistent. Thus, if the questionnaire result did not pass the consistency test, the questionnaires would be viewed as invalid ones.

(1) *CI*

$$CI = (\lambda_{max} - n) / (n-1) \qquad (17)$$

If $CI \leqq 0.1$, the weight was consistent. If $CI = 0$, the judgment of the relative level of importance of *n* factors under a single criterion was consistent. If $CI > 0$, the former judgement and latter judgement of experts were not consistent, and experts had to be requested to revise their judgements. Saaty (1990) suggested that it is preferable that $CI < 0.1$.

(2) *CR*

$$CR = CI / RI \qquad (18)$$

If $CR \leqq 0.1$, the consistency was satisfactory. *CR* is the ratio of *CI* to the Random Index (*RI*). *RI* is a consistency coefficient randomly generated from the matrix. The *RI* value is associated with the matrix coefficient. The corresponding *RI* values can be found in Table 2.

Table 2: Random Index

Number of Hierarchies (*n*)	1	2	3	4	5	6	7	8	9	10
RI value	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1990), Decision Making for Leaders, p.84.

4 Results and Discussion

4.1 Sample attributes

This study mainly investigated the factors affecting the environmental carrying capacity of coastal recreational areas. To achieve comprehensiveness of the expert panel samples, this study enrolled five groups, namely, scholars and experts with backgrounds in tourism, geological landscape, and animal and plants; industry; government authorities; local residents, and tourists; with a total of 25 experts to assist in this study. The questionnaire return rate was 100%. The returned questionnaires all passed the consistency test and were valid questionnaires.

4.2 Development of evaluation hierarchy for environmental carrying capacity of coastal recreational areas

This study used a literature review, expert interviews, and a Delphi survey to summarize the dimensions and factors affecting ecological environments. Because there is a fuzzy space between the dimensions and the indices of the evaluation system, this study used FAHP to confirm the various factors affecting the carrying capacity of ecotourism areas and their weight. After the questionnaire survey and modification, this study eventually obtained four primary evaluation factors: "recreational environment $D_{1,}$" "natural landscape $D_{2.}$" "coastal animals and plants $D_{3,}$" and "cultural assets $D_{4;}$" as well as 13 secondary factors, such as "public infrastructure $C_{1,}$" as shown in Figure 2.

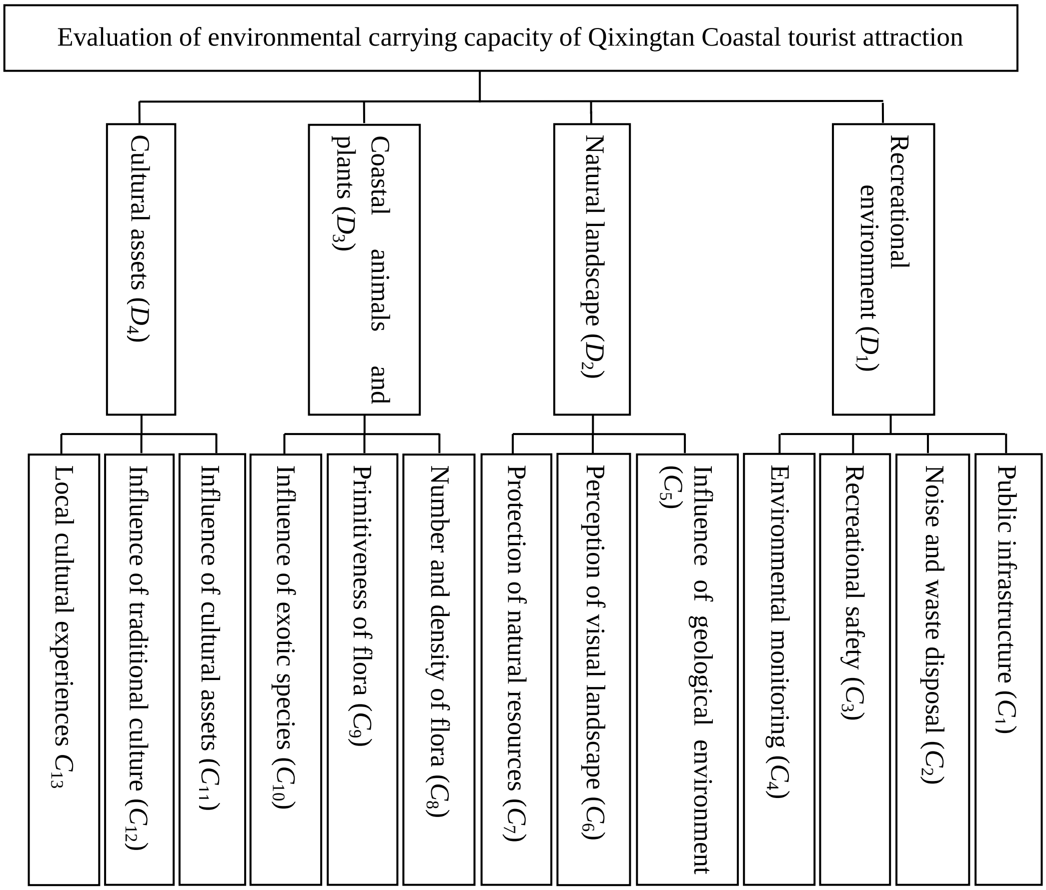

Figure 2: Evaluation Hierarchy for Environmental Carrying Capacity of Qixingtan Coastal Recreational

4.3 Weight of various factors affecting ecological environment

This study integrated fuzzy theory into the expert questionnaire, and used face-to-face interviews and emails to confirm the evaluation factors and to distribute questionnaires. For the returned questionnaires, this study used Eqs. (6)-(14) to perform a consistency test on each subject's weight of evaluation criteria. To see if the evaluation criteria passed the consistency test, this study used a fuzzy analytic hierarchy to calculate the weight and order of the various factors affecting the ecological environment, as shown in Tables 3.

Table 3: Overall Weight and Order of Qixingtan Coastal Recreational Area's Recreational Carrying Capacity

Primary factors	Fuzzy weight	Normalized weight	Order	Secondary factors	Fuzzy weight	Normalized weight	Overall weight	Order
Recreational environment (D_1)	(0.091995,0.187429,0.499251)	0.2078	3	Public infrastructure (C_1)	(0.087811,0.173893,0.464463)	0.1915	0.0397	12
				Noise and waste disposal (C_2)	(0.113801,0.258176,0.657724)	0.2715	0.0564	10
				Recreational safety (C_3)	(0.140714,0.36652,0.80508)	0.3461	0.0719	6
				Environmental monitoring (C_4)	(0.071747,0.209397,0.442841)	0.1909	0.0396	13
Natural landscape (D_2)	(0.160456,0.350273,0.840259)	0.3605	1	Influence of geological environment (C_5)	(0.745646,1.424498,3.335919)	0.3911	0.1409	1
				Perception of visual landscape (C_6)	(0.475512,0.937001,2.292167)	0.2631	0.0948	4
				Protection of natural resources (C_7)	(0.596785,1.464344,2.807552)	0.3458	0.1246	2
Coastal animals and plants (D_3)	(0.106902,0.261912,0.584169)	0.2543	2	Number and density of flora (C_8)	(0.133405,0.285058,0.679004)	0.2900	0.0737	5
				Primitiveness of flora (C_9)	(0.204771,0.482613,1.044069)	0.4575	0.1163	3
				Influence of exotic species (C_{10})	(0.113079,0.265304,0.577415)	0.2525	0.0642	8
Cultural assets (D_4)	(0.072526,0.200386,0.391782)	0.1774	4	Influence of cultural assets (C_{11})	(0.152739,0.308214,0.83507)	0.3444	0.0610	9
				Influence of traditional culture (C_{12})	(0.164277,0.380859,0.891357)	0.3818	0.0677	7
				Local cultural experiences (C_{13})	(0.1114,0.310927,0.607757)	0.2738	0.0485	11

5 Conclusion

Although the application of the carrying capacity concept is a tool for measuring human activities and environmental management, it retains a high quality and quantity of coastal resources. It not only takes into account the current needs, but also ensures long-term economic and ecological benefits. This study used studies concerning ecotourism and carrying capacity, a Delphi survey, and FAHP to identify the critical factors affecting the carrying capacity of recreational areas, including 4 primary factors and 13 secondary factors.

This study found that the order of weight of primary factors affecting Hualien Qixingtan coastal recreational area's recreational carrying capacity was natural landscape (0.3605), coastal animals and plants (0.2543), recreational environment (0.2078), and cultural assets (0.1774). For the secondary factors, the top five overall weights were influence of geological environment (0.1409), protection of natural resources (0.1246), primitiveness of flora (0.1163), perception of visual landscape (0.0948), and number and density of flora (0.0737). The research results can be provided as a reference for relevant government authorities, managers, and operators to develop measures giving consideration to both the resource conservation and the recreational management of coastal recreational areas.

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