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Fuzzy Group Decision-Making in the Measurement of Ecotourism Sustainability Potential

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Abstract Both theoretical and practical efforts to evaluate ecotourism development often neglect alternative characteristics that may interact with and mutually influence the primary indicators. To evaluate the sustainability of an ecotourism site, this study utilizes subjective measures to analyze the relationships among tourism, resources, community, economy and society. Yangshan Ecological Park in Kinmen is examined to demonstrate the implementation of the proposed integrated framework in ecotourism development. First, the Fuzzy Delphi Method was applied to select the critical factors. Local residents, tourists and resource administrators were interviewed to explore each group's perception of relationships. Then, Interpretive Structural Modeling was employed to determine the interrelationship among the critical factors. A Fuzzy Analytic Network process model was constructed to evaluate the potential sustainability of ecotourism and the relative importance the weights of the criteria and sub-criteria. The study provides a valuable integrated tool for sustainable destination management.

Keywords Fuzzy group decision-making · Ecotourism sustainability · Integrated framework

1 Introduction

Ecotourism has been identified as a form of sustainable tourism that is expected to contribute to both conservation and development (Honey 2008). Unfortunately, because of inadequate environmental assessments and audits, many ecotourism destinations tend to be both hazardous and self-destructive. Few practical assessments of the status

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of ecotourism have been conducted at specific locations, partly because standardized, evaluative criteria have yet to be developed (Ross and Wall 1999a). Valid measurements of all aspects and implications of ecotourism are almost impossible to acquire, given the multitude of interrelated variables involved (Wall 1996; Vincent and Thompson 2002; Weaver and Lawton 2007; Zhang and Lei 2012). Therefore, this study develops an integrated framework and method to evaluate the sustainability of an ecotourism site.

Traditionally, measurement indicators have been categorized as either "objective" or "subjective." Objective indicators generally refer to quantitative data, and the majority of them could be described through various equations (Sanchis et al. 2008; Hsu et al. 2009; Prusty et al. 2010). Subjective indicators are based on personal feelings and attitudes, and are usually qualitative in nature. Objective indicators have been widely used because they have been perceived as being more rigorous. However, (Schneider and Donaghy 1975, p. 308) argued that "the use of objective measures alone as quality of life indicators is highly suspect". The World Tourism Organization (1995, p. 7; quoted in Miller 2001) revealed the true position of qualitative measures by stating, "Indicators of sustainability are not always quantifiable and may necessarily be somewhat subjective". This limitation, in many ways, detracts from the utility of these indicators as management information in promoting sustainability.

Hisdal (1988) classified the subjective information into three parts: (1) the unquantified information, (2) the incomplete information and (3) the unobtained information. Such subjective information can be indicators of sustainable tourism development. This study will assess local residents, tourists and resource administrators and the influence their perceptions have on the relationships among ecotourism indicators. Therefore, the resident attitude surveys may account for location differences and enable local input to a standardized set of indicators.

Based on these viewpoints, this study proposes an evaluation framework using subjective measures to investigate stakeholders' perceptions, thus forming the basis for predicting ecotourism sustainability. The process of ecotourism development is first reviewed through an examination of the literature, and experts in the field are interviewed. The ecotourism indicators of the criteria and sub-criteria that influence the development of ecotourism are identified. Because the collected sub-criteria are numerous and experts are not capable of handling pairwise comparisons with too many elements in an analytic network process, it is essential to know the importance of each sub-criterion and to select the essential ones for further analysis. Although the Delphi method can accomplish the task, it requires repetitive questionnaires and evaluations, and it cannot handle the uncertainty of stakeholders' expressions. Thus, the Fuzzy Delphi Method (FDM), which can handle fuzziness and vagueness in stakeholders' expressions and reduce the number of rounds in facilitating the formation of a group judgment (Kuo and Chen 2008; Shen et al. 2010; Tsai and Lin 2012), is applied to select the critical sub-criteria. For the analytic process, the network with the interrelationship among the elements must first be constructed. Interpretive Structural Modeling (ISM) is employed to incorporate stakeholders' opinions to determine the interrelationships among the criteria and among the sub-criteria (Rouse and Putterill 2003;

Bolanos et al. 2005). Finally, a Fuzzy Analytic Network Process (FANP) model, which can consider the uncertainty of stakeholders' expressions (Tseng et al. 2009), is constructed to evaluate the ecotourism development. The relative significant weights of the criteria and sub-criteria are calculated, and a ranking is generated.

2 Literature Review

2.1 The Definition and Dimensions of Ecotourism

The first appearance of the term ecotourism gave rise to a long scientific and academic discussion concerning its precise conceptual definition. This dialogue, in which the contributions of ecologists, environmentalists and economists should be stressed, is ongoing. Hence, a range of definitions has been created reflecting the potentially active or passive stance of all parties involved in the ecotourism venture and how this venture contributes to the improvement of the environment. A passive stance relates simply to minimizing the negative repercussions of tourism on the natural, cultural and social environments. An active stance, in contrast, entails the promotion of activities that enhance the health of the environment and make a positive contribution to the sustainable development of the target area within the context of tourism (Orams 1995; Buckley 2000; Weaver 2001; Cater 2006; Donohoe and Needham 2006; Kontogeorgopoulos and Chulikavit 2010).

From among the host of definitions of ecotourism (including those offered by Wallace and Pierce 1996; Wearing and Neil 1999; Björk 2000; Weaver 2001; Epler Wood 2002; Fennell 2002; Donohoe and Needham 2006), the definition produced by the International Union for Conservation of Nature and Natural Resources (IUCN) was used. According to this definition, Ceballos-Lascuráin (1996) was arguably the first to establish the term ecotourism. The IUCN defines ecotourism as follows:

> Environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features-Dboth past and present) that promotes conservation, has low visitor impact, and provides for beneficially active socio-economic involvement of local populations.

Regardless of the various definitions, researchers agree that the core dimensions of the definitions of ecotourism are essentially the same (Björk 2000; Donohoe and Needham 2006). In a study of a large number (85) of definitions of ecotourism produced over the past 15 years, Fennell (2002) found that the words that were encountered and recurred most often in these definitions were (in order of frequency): natural areas, conservation, culture, community, society and sustainability. Similarly, Hvenegaard and Dearden (1998) considered that most of the widely used definitions of ecotourism contain three common elements: nature-based environment, environmental education and sustainable management. Ross and Wall 1999a,b established a structure of indicators regarding local community, tourism, resources, economy and society and studied the developing conditions of

ecotourism by measuring the relationships among these elements. In addition, many scholars have noted that changes in the dimensions of tourism, resources, community, economy, and society are the main factors influencing sustainability and that these five dimensions influence one another (Ross and Wall 1999a,b; Briassoulis 2001; Twining-Ward and Butler 2002; Sanchez and Jaranillo-Hurtado 2010; Jaafar and Maideen 2012).

The above elements are widely discussed at major international conferences on the environment, where it is noted that the initiatives that relate to these elements, such as ecotourism, which aims at the development of an area, depend largely on public acceptance by local residents and their readiness to cooperate in environmental protection and management (United Nations Conference on Environment and Development 1992). In this sense, ecotourism can be characterized as a resident-centric issue, can make a substantial contribution to conserving the features of environmentally and culturally sensitive areas, and can serve as a guide for sustainable social and economic development, provided that local communities are supportive. Accordingly, evaluation of the relevant attitudes and perceptions of members of local communities is a basic prerequisite for the successful implementation of ecotourism ventures.

2.2 The Evaluation of Ecotourism Development

An examination of local attitudes toward the key dimensions of ecotourism development can help planners and project managers understand how community members feel about using ecotourism as a means to balance conservation and development. However, measuring community attitude regarding the sustainability of an ecotourism site is sometimes highly complex because it incorporates a variety of uncontrollable and unpredictable factors that affect the local people involved (Heinen 1996; Newmark and Hough 2000; Walpole and Goodwin 2001; Bruyere et al. 2009; Ezebilo and Mattsson 2010). Attitude is an individual's subjective favorable or unfavorable disposition toward an object, action, or event of interest (Ajzen and Fishbein 1980; Fishbein and Manfredo 1992; Lai and Nepal 2006; Lepp 2008) and is "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly and Chaiken 1993). Several factors that may complicate local residents' attitudes and preference processes, such as incomplete information, additional qualitative criteria and imprecise preferences, are often not considered (Ajzen and Fishbein 1980; Jennings 2005).

Conflicts between local people and administrators are often the consequences of externally imposed ecotourism regulations, suggesting that successful ecotourism management will not be achieved without the cooperation and support of local communities. Moreover, local communities must be empowered and involved in making important conservation decisions (Chi and Wang 1996; Nyaupane et al. 2006; Somarriba-Chang and Gunnarsdotter 2012). In other words, the measurement of the community attitude and intention were developed primarily as a tool to diagnose ecotourism development performance and to understand indigenous people's behaviors, but incentive-driven programs that can support the guidelines and principles of ecotourism development have not been actively considered.

Specifically, this paper explores how to organize an integrated perspective of communities toward the key dimensions of ecotourism and tourism guidelines of the management authority. The Fuzzy Hierarchy Analysis system is adopted to investigate the ill-defined nature of the preferences of local residents, tourists and resource administrators as required in the proposed framework. The case of Kinmen National Park is presented to demonstrate the implementation of the proposed integrated framework in ecotourism development. Effective and appropriate management directions for ecotourism development are acquired by applying the proposed approach, and thus these directions can enable the national park authority to establish environmental, social, and tourist conditions to support sustainability.

3 The Evaluation Framework for Tourism Sustainability

An evaluation framework of the integrated approach for ecotourism sustainability is constructed as depicted in Fig. 1. Upon a comprehensive review of the literature and consultation with experts, the critical criteria for achieving the goal of ecotourism sustainability are first defined, and the sub-criteria under each criterion are collected. Next, the FDM is adopted by collecting data from experts by use of a questionnaire, and experts' opinions on the importance of the sub-criteria are generalized. The sub-criteria that are stressed by the experts are then selected. ISM, by administering another set of questionnaires, is then executed to understand the relationships among the criteria and among the selected sub-criteria. Based on the results of ISM, a network is constructed. Next, the FANP is used to generalize the experts' opinions on the relative importance of the criteria and sub-criteria and to determine the degree of sustainability of the ecotourism site under consideration.

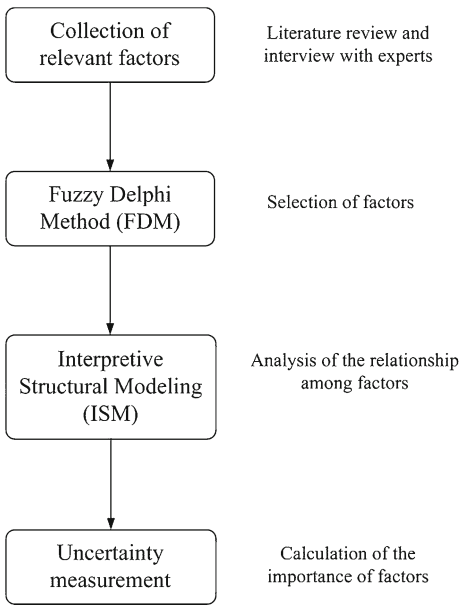

Fig. 1 The evaluation framework for ecotourism sustainability

3.1 FDM for Selecting Appraisal Indicators

Since its development by Dalkey and Helmer in 1963, the Delphi method has been widely applied in many management areas. However, the method does have shortfalls (Chang et al. 2000; Chang and Wang 2006). The incorporation of fuzzy set theory in the Delphi method is one approach used to tackle the problems. Under this proposed framework, numerous sub-criteria of ecotourism sustainability are downsized into a limited number of more important sub-criteria by using the FDM. The procedures proposed by Lee et al. (2010) for executing the method are as follows (Ishikawa et al. 1993; Chang et al. 1995; Dzeng and Wen 2005; Hsiao 2006; Shen et al. 2010):

(1) Administer a questionnaire that ask experts to rank (using a scale from 1 to 10) each sub-criterion in the possible sub-criteria set S as it relates to ecotourism sustainability. A score is denoted as $c_i = (l_{ik}, u_{ik}), i \in S$, where l_{ik} is the pessimistic index of sub-criterion i rated by expert k, and u_{ik} is the optimistic index of sub-criterion i rated by expert k.

(2) Select the minimum (pessimistic) and maximum (optimistic) values and calculate the geometric mean of the group's most pessimistic (minimum) index and the values of the most optimistic (maximum) index for each sub-criterion. A group average is calculated for the pessimistic index of sub-criterion i, and the abnormal value, which is outside of two standard deviations, is eliminated. The same calculation is performed for the optimistic index of sub-criterion i. For the remaining values, select the minimum (maximum) value of the most pessimistic (most optimistic) values as the minimum group pessimistic value l_l^i (group optimistic value l_u^i). Calculate the geometric mean (l_m^i) of the remaining group pessimistic values l_k^i. Obtain the minimum (u_l^i), geometric mean (u_m^i) and maximum (u_u^i) of the remaining group optimistic values in the same way.

(3) Determine the triangular fuzzy numbers for the most pessimistic index and the most optimistic index for each sub-criterion. The triangular fuzzy number for the most pessimistic index is $l^i = (l_l^i, l_m^i, l_u^i)$, and for the most optimistic index, it is $u^i = (u_l^i, u_m^i, u_u^i)$.

(4) Inspect the consensus of the experts' opinions and calculate the significance value for each sub-criterion. As shown in Fig. 2, the gray zone, that is, the overlap section of l^i and u^i, is used to inspect the consensus of experts in each sub-criterion and to calculate the consensus significance value of the sub-criterion s^i (Ishikawa et al. 1993; Hsiao 2006).

$$s^i = \{Y \,|\, u_{F^i(p)}(Y)\} \tag{1}$$

a. If there is no overlap between l^i and u^i, that is, $l_u^i \le u_l^i$ and no gray zone exists, experts' opinions in sub-criterion i are in consensus, and the consensus significance value of the sub-criterion is

$$s^i = \frac{l_m^i + u_m^i}{2} \tag{2}$$

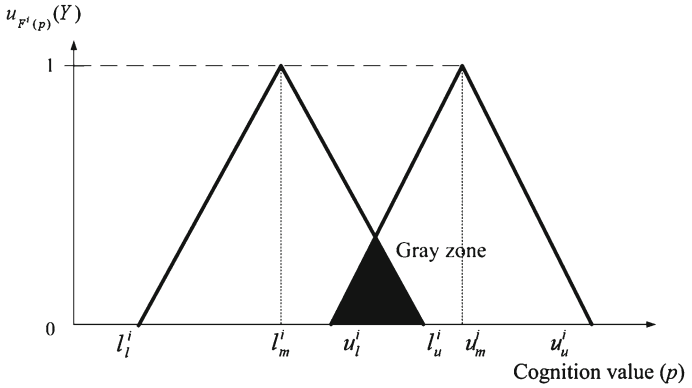

Fig. 2 Gray zone of l^i and u^i

b. If the gray zone exists and the gray zone interval value g^i is equal to $l_u^i - u_l^i (g^i = l_u^i - u_l^i)$, g^i is less than the interval value of l^i and $u^i (d^i = u_m^i - l_m^i)$, that is, $g^i \leq d^i$, then the consensus significance value of the sub-criterion is calculated by Eqs. (3) and (4).

$$F^i(p) = \left\{ \int_p \left\{ \min[l^i(p), u^i(p)] \right\} dp \right\}, \qquad i \in S \tag{3}$$

$$s^i = \{ Y \,|\max u_{F^i(p)}(Y) \}, \qquad i \in S \tag{4}$$

Equation (3) is used to advance the minimization operation of the intersection for the two triangular fuzzy numbers, and the result is applied to calculate the maximum membership grade through Eq. (4). We can then successfully obtain the consensus significance value of sub-criterion i.

c. If the gray zone exists and $g^i > d^i$, there are significant discrepancies among the experts' opinions. Repeat step (1) through step (4) until a convergence is attained.

(5) Extract the sub-criteria from the candidate list. Comparing consensus significance value with a threshold value T, which is subjectively determined by experts based on the geometric mean of all s^i (Hsiao 2006; Kuo and Chen 2008). If $s^i \geq T$, select sub-criterion i for further analysis.

3.2 ISM for Building a Network Relation Structure

Interpretive Structural Modeling (ISM), proposed by Warfield (Warfield 1974a,b, 1976), is often used to provide a fundamental understanding of complex situations and to create a course of action for solving a problem. In this proposed framework, ISM is applied next to understand the interaction among the criteria and among the sub-criteria of ecotourism of sustainability. The procedures of the binary matrix

manipulation of ISM are as follows (Huang et al. 2005; Warfield 1973; Malone 1975; Sage 1977; Yang et al. 2008; Lee et al. 2010):

(1) List criteria (sub-criteria) considered for the problem and define each criterion (sub-criterion) as x_i, $i = 1, 2, \ldots, n$.

(2) From the criteria (sub-criteria) identified in step (1), establish an adjacency (relation) matrix that shows the relationship among the criteria (sub-criteria). Questions are asked to identify the relationship between any two criteria (sub-criteria). Let x_i be the ith criterion, x_j be the jth criterion, and π_{ij} and π_{ji} be the relation between ith and jth criteria. The relationship between any two criteria can be from x_i to x_j, from x_j to x_i, in both directions between x_i and x_j, or x_i and x_j can be unrelated. If x_j is reachable from x_i, then $\pi_{ij} = 1$; otherwise, $\pi_{ij} = 0$. Likewise, if x_i is reachable from x_j, then $\pi_{ji} = 1$; otherwise, $\pi_{ji} = 0$. The adjacency matrix A is presented as follows:

$$A = \begin{array}{c} \\ x_1 \\ x_2 \\ \vdots \\ x_n \end{array} \begin{array}{c} \begin{array}{cccc} x_1 & x_2 & \cdots & x_n \end{array} \\ \begin{pmatrix} 0 & \pi_{12} & \cdots & \pi_{1n} \\ \pi_{21} & 0 & \cdots & \pi_{12} \\ \vdots & \vdots & \ddots & \vdots \\ \pi_{n1} & \pi_{n2} & \cdots & 0 \end{pmatrix} \end{array}, \quad i = 1, 2 \ \ldots, \ n; \quad j = 1, \ 2, \ldots, n \tag{5}$$

where π_{ij} denotes the relationship between the ith row and jth column criteria.

(3) Develop a reachability matrix. The initial reachability matrix M is calculated by adding A from step (2) with the identity matrix I:

$$M = A + I \tag{6}$$

The transitivity of the contextual relationship means that if a criterion x_i is related to x_j and x_j is related to x_p, then x_i is necessarily related to x_p. Because the final reachability matrix M^* is under the operators of the Boolean multiplication and addition (i.e., $1 \times 0 = 0 \times 1 = 0$, $1 + 0 = 0 + 1 = 1$), a convergence can be met:

$$M^* = M^b = M^{b+1}, \quad b > 0 \tag{7}$$

$$M^* = \begin{array}{c} \\ x_1 \\ x_2 \\ \vdots \\ x_n \end{array} \begin{array}{c} \begin{array}{cccc} x_1 & x_2 & \cdots & x_n \end{array} \\ \begin{pmatrix} \pi_{11}^* & \pi_{12}^* & \cdots & \pi_{1n}^* \\ \pi_{21}^* & \pi_{22}^* & \cdots & \pi_{2n}^* \\ \vdots & \vdots & \ddots & \vdots \\ \pi_{n1}^* & \pi_{n2}^* & \cdots & \pi_{nn}^* \end{pmatrix} \end{array}, \quad i = 1, 2 \ \ldots, \ n; \ j = 1, \ 2, \ldots, n \tag{8}$$

where π_{ij}^* denotes the relationship between the ith row and jth column criteria.

Note that in this study, the ecotourism sustainability relationships among the criteria and among the sub-criteria are analyzed separately. Because the study focuses only on the network structure rather than on the hierarchical structure of the criteria (sub-criteria), the procedure of ISM for determining the levels is ignored (Huang et al. 2005; Ma and Li 2006). Therefore, the researchers simply use the adjacency matrix

and reachability matrix to construct the relationships of all of the criteria and then plot the network structure. The same procedure is performed for the sub-criteria.

3.3 Finding the Influential Weights by FANP Based on ISM

The Analytic Network Process (ANP), which is a generalization of the Analytic Hierarchy Process (AHP) and a multi-criteria decision support methodology, was introduced by Saaty to decompose a complex problem into a network (Saaty 1980, 1996). Because a good decision-making model must tolerate vagueness and ambiguity, fuzzy set theory can be introduced into the conventional ANP, which is thus termed FANP. In this proposed framework, a network for ecotourism sustainability is constructed with the consideration of the interaction among the criteria and among the sub-criteria from ISM. The procdures of the FANP are as follows (Kahraman et al. 2006; Tseng et al. 2008; Chen and Chen 2010; Lee et al. 2010; Liou et al. 2011):

(1) Decompose the ecotourism sustainability problem into a network. The overall objective is to evaluate the sustainability of an ecotourism site. The second level includes criteria. Under each criterion are sub-criteria. The dependencies and feedback among the criteria and among the sub-criteria are considered. The last level includes the ecotourism site that is under evaluation.
(2) Prepare a questionnaire based on the constructed network, and ask experts to complete the questionnaire. The questionnaire is prepared based on pairwise comparison with Saaty's nine-point scale (Saaty 1996). The consistency index and consistency ratio for each comparison matrix are calculated to examine the consistency of each expert's judgment (Saaty 1996). If the consistency test is not passed, the original values in the pairwise comparison matrix must be revised by the experts.
(3) Collect the results of the experts' questionnaires. The scores of pairwise comparison are transformed into linguistic variables by the transformation concept, as listed in Table 1.

Table 1 Triangular fuzzy variables

Linguistic variables	Positive triangular numbers	Positive reciprocal triangular fuzzy numbers
Extremely strong	(9, 9, 9)	(1/9, 1/9, 1/9)
Intermediate	(7, 8, 9)	(1/9, 1/8, 1/7)
Very strong	(6, 7, 8)	(1/8, 1/7, 1/6)
Intermediate	(5, 6, 7)	(1/7, 1/6, 1/5)
Strong	(4, 5, 6)	(1/6, 1/5, 1/4)
Intermediate	(3, 4, 5)	(1/5, 1/4, 1/3)
Moderately strong	(2, 3, 4)	(1/4, 1/3, 1/2)
Intermediate	(1, 2, 3)	(1/3, 1/2, 1)
Equally strong	(1, 1, 1)	(1, 1, 1)

According to Buckley (1985), the fuzzy positive reciprocal matrix can be defined as

$$\tilde{A}^k = [\tilde{a}_{ij}]^k \tag{9}$$

$\tilde{A}^k$ is a positive reciprocal matrix of decision maker k; $\tilde{a}_{ij}$ is the relative importance between decision elements i and j;

$$\tilde{a}_{ij} = 1, \ \forall i = j \quad \text{and} \quad \tilde{a}_{ij} = 1/\tilde{a}_{ji}, \ \forall i, \quad j = 1, 2, \ldots, n$$

If there are k experts $P_1, P_2, \ldots, P_k$, each pairwise comparison between two criteria has k positive reciprocal triangular fuzzy numbers. By employing the geometric average approach to aggregate multiple experts' responses, the aggregate fuzzy positive reciprocal matrix is

$$\tilde{A}^* = [\tilde{a}_{ij}]^* \tag{10}$$

where $\tilde{a}^*_{ij} = (\tilde{a}^1_{ij} \otimes \tilde{a}^2_{ij} \otimes \cdots \tilde{a}^k_{ij})^{1/k}$

(4) Defuzzy the synthetic triangular fuzzy numbers $\tilde{a}^*_{ij} = (x_{ij}, y_{ij}, z_{ij})$ into crisp numbers using the centroid method.

$$\tilde{a}^*_{ij} = x_{ij} + y_{ij} + z_{ij}/3, \qquad \forall i, \quad j = 1, 2, \ldots, n \tag{11}$$

(5) Form pairwise comparison matrices using the defuzzificated values, and calculate the priority vector for each pairwise comparison matrix (Saaty 1980, 1996).

(6) Form an unweighted supermatrix, as shown in Table 2, by applying software, such as Super Decisions, to form a weighted supermatrix to ensure column stochastic.

(7) Calculate the limit supermatrix by taking the weighted supermatrix to $2k + 1$ powers so that the supermatrix converges into a stable supermatrix. That is, raising the supermatrix M to the power $2k + 1$ where k is an arbitrarily large number allows convergence of the interdependent relationships among criteria and among sub-criteria. Obtain the priority weights of the criteria and the sub-criteria from the limit supermatrix.

Table 2 Generalized supermatrix

	Goal	Criteria	Sub-criteria	Alternatives
Goal	I			
Criteria	W_{21}	W_{22}		
Sub-criteria		W_{32}	W_{33}	
Alternatives			W_{43}	I

4 Research Setting in Yangshan Ecological Park of Kinmen

Kinmen National Park, the sixth national park to be established (October 1995), has a total area of 3,720 ha and is involved in ecological conservation and protection of the natural landscape as well as the preservation of historically and culturally important sites and battlefield monuments. Kinmen is located off the southeastern coast of Fujian Province in Xiamen Bay at the outlet to the Jiulong River. This area includes Kinmen Island, Liehyu (also known as Little Kinmen), DaDan, and ErDan and has a total of 12 islands and islets. These islands and islets cover an area of 150 km^2. To the west, at a distance of approximately 10 km, is the Xiamen outport, and to the east, at a distance of 277 km, is Taiwan (see Fig. 3).

Kinmen National Park is home to many endangered species, such as the Eurasian otter, magpie robin, blue-tailed bee eater, lesser pied kingfisher, black-collared starling, black-winged hawk, Dicrurus hottentottus (Falcated teal), Litsea glutinosa, Pyrus betulifolia, Abelia chowii Hoo, and the evening primrose species Oenothera drummondii (Forestry Bureau 2011). Based on survey data and a review of the literature, Kinmen National Park is home to at least 8 species of mammals, 283 species of birds, 13 species of reptiles, 5 species of amphibians, 45 species of butterflies, 32 species of mollusks and 6 species of crustaceans (Kinmen County Government 2011).

Kinmen is not only rich in biodiversity but also in the cultural heritage of the Chinese people over hundreds of years. Most of the early inhabitants came from the Zhangzhou and Quanzhou areas of Fujian Province. The architectural style of the dwellings and local customs follow in the old traditions because forty years of military control

Fig. 3 The natural ecology of Kinmen National Park

have slowed the pace of Kinmen's urbanization, thus enabling its historical heritage to be preserved. Therefore, it can be said that Kinmen National Park possesses a rich culture and history, expressed in its historical sites and traditional architecture. Within the park are 11 registered historical monuments. Traditional villages and architecture are the richest cultural assets of Kinmen National Park, and the seven representative traditional settlements of Oucuo, Jhushan, Shueitou, Cyonglin, Shanhou, Nanshan and Beishan have mostly retained their southern Fujian architecture in the Zhangzhou and Quanzhou styles.

KinSha and ShanHo, the villages under study, are two primary communities on the periphery of the Kinmen National Park. KinSha is located adjacent to the natural barrier to development of Kinsha Reservoir, and ShanHo is a short distance away. The Zhangzhou and Quanzhou people compose 75 % of the resident population in KinSha and 80 % in ShanHo. Since the 1980s, tourism has become one of the major economic and social activities in KinSha and ShanHo. Out-migration, combined with the aging of the resident population, has compelled the local government to search for better livelihood opportunities. Hence, a tourism development project in and around Yangshan Bay, which is located within the reserve near Kinsha Reservoir, was proposed to help advance the local economy.

Yangshan Ecological Park, famous for its conservation of rare fish species, has been a tourist attraction since the 1980s. According to the park's administration, the number of visitors grew from 30,661 in 2001 to 147,056 in 2009, and the number of visitors once reached 2,500 on a single-day holiday, causing traffic congestion and recreational facility overload. This phenomenon not only reduced the recreational quality for the tourists, but it also harmed the local environment and its natural resources. The tourism destination lifecycle model postulates that destinations go through well-ordered stages of tourism development (Johnson and Snepenger 1993), which include exploration, involvement, development, consolidation, stagnation, and finally, a series of choices ranging from rejuvenation to decline. With reference to Yangshan, the site may now be in the stagnation stage. Any failure to evaluate the destination's tourism development situation would most likely negatively affect its sustainability and allow Yangshan to slip into further decline.

5 Empirical Evaluation of Ecotourism Sustainability

In this paper, the methodology adopted is applied to a sustainable tourism development project, which refers to a major ecotourism sustainablity operation in Yangshan Ecological Park in Kinmen. Upon a comprehensive review of the literature (Ross and Wall 1999a,b; Briassoulis 2001; Twining-Ward and Butler 2002) and consultation with the project committee, five critical criteria were determined: *tourism, resources, community, economy,* and *society*. Under each of the five criteria are numerous sub-criteria, thus a candidate list of 19 sub-criteria was prepared (see Table 4 for a list of the sub-criterion candidates).

5.1 Data Collection

This study selected two groups of respondents. The first group included 3 scholars, 2 government officials, and 2 representatives from the Taiwan Ecotourism Association. The members of the committee were regarded as the qualified respondents based on the following criteria: (1) the members' positions required them to participate in the decision-making process with respect to ecotourism management, and (2) the members had sufficient experience in or knowledge about issues relevant to the tourism industry and the study of the ecotourism development. In addition, the second group included local opinion leaders, consisting of members of the Yangshan Regional Development Association, members of the local authoritative agencies, local police officers and teachers from the elementary school. All members had over 10 years of experience in the ecotourism development domain. In total, 60 members participated in the survey.

The three-round procedure for data collection was applied using the FDM, ISM and the FANP. During the first round, the authors delivered the questionnaire to the first group of experts, asked the members of the committee to answer a given question item, collected all members' answers, tabulated the answers and developed the pessimistic (optimistic) index, and then showed the geometric means of all sub-criterion candidates to all members. The second round included administering the questionnaire to the same group and asking all members to answer the relationship of one criterion (sub-criterion) to another, from which we determined whether the criteria (sub-criteria) were dependent. Finally, during the third round, the authors investigated the weights of interdependent criteria and sub-criteria by distributing questionnaires to the second group and conducting face-to-face interviews with the local opinion leaders. Table 3 lists the sample sizes of respondents and the rate of returns (or effectiveness) for each round.

This study invited three professionals who were familiar with FDM, ISM, and FANP analysis and who had published related research papers, including a university professor, a planner and a member who had been involved in ecotourism development for more than ten years. These professionals were engaged to confirm the validity of the criterion (sub-criterion) and the naming of the categories and themes. According to the inter-subjective principle, they assisted with the coding of themes. After the description of definitions and coding rules, the researchers invited the three professionals to indicate their agreement with the criterion (sub-criterion) and the naming of the categories and themes under the categories. Finally, the researchers used the stated criterion and sub-criterion of ecotourism development as a basis for defining a

Table 3 Sample data collecting lists

Sample	Method		
	FDM	ISM	FANP
Questionnaires	7	7	60
Respondents	6	7	50
Invalid samples	1	2	3
Effectiveness (%)	71.4	71.4	78.3

total of five criteria and 16 sub-criteria, corresponding to the individual elements of FDM analysis.

5.2 Selecting the Sub-Criteria from the Sustainable Tourism List

The incorporation of all sub-criterion candidates into the FANP evaluation is impossible because respondents are not capable of handling such a complicated pairwise comparison evaluation process (Saaty 1996). Thus, the FDM was applied in this study to extract the sub-criteria from the candidate list, and a questionnaire was prepared to evaluate the importance of each sub-criterion. Seven experts were invited to contribute their knowledge. A group average was calculated for the pessimistic (optimistic) index of sub-criterion i, and an abnormal value that was outside of two standard deviations was eliminated. Table 4 shows the minimum and maximum values for the most pessimistic importance ranking (l_{ik}) and the most optimistic importance ranking (u_{ik}) of each sub-criterion. The geometric mean of the pessimistic (l_m^i) and the optimistic (u_m^i) importance rankings of each sub-criterion, the difference between d^i and g^i, and the consensus significance value (s^i) were calculated as shown in Table 4.

The geometric mean of the consensus significance values (s^i) of all sub-criterion candidates was calculated to be 7.43. Because the selected sub-criteria would be used to develop a comprehensive evaluation network, an adequate number of sub-criteria was required to reflect the complexity of the ecotourism sustainability evaluation problem. To include more sub-criteria in the evaluation model, a threshold value that was lower than the geometric mean was set, and the sub-criterion candidates whose s^i was higher than the threshold value were selected. Based on the opinions of the experts and authors, in this case, the threshold value was set at seven, thus 70 % of the total sub-criterion candidates were selected. In fact, a total of 16 sub-criteria (84.21 %) were selected from a list of 19 candidates. In this way, a minimum of three or four sub-criteria were selected for each criterion. The finalized criteria and sub-criteria are listed in Table 5.

5.3 Clarifying Interrelationships Among Criteria and Among Sub-Criteria for Ecotourism Sustainability

After the criteria and sub-criteria were determined, ISM was applied to analyze the interrelationship among the criteria and among the sub-criteria. A questionnaire was prepared to determine the relationship of one criterion (sub-criterion) to another. The geometric mean of experts' opinions on the relationship between a pair of criteria (sub-criteria) was calculated, and a threshold value of 0.5 was used to determine whether the criteria (sub-criteria) were dependent (Yang et al. 2008. In other words, an adjacency matrix was first prepared for each expert, and a mean adjacency matrix was calculated using the geometric mean method to combine the adjacency matrices from all experts. If the geometric mean value between two criteria (π_{ij}^*) in the mean adjacency matrix was higher than the threshold value, x_j was deemed reachable from x_i, and we let π_{ji}=1 (Yang et al. 2008). The integrated adjacency matrix between criteria was obtained and is shown in Table 6.

Table 4 Selection of sub-criteria

Sub-criterion candidates	Pessimistic value (l_{ik})		Optimistic value (u_{ik})		Geometric mean		$d^i - g^i$	Consensus significance value (s^i)
	min	max	min	max	l_m^i	u_m^i		
Tourism (O_1)								
Participating in conservative activities	5	8	8	10	6.93	9.13	2.2	8.03
Providing experiential opportunities	4	8	7	10	5.83	8.35	1.53	7.38
Providing diverse cultural experiences	3	8	5	10	4.60	7.64	0.05	6.31
Promoting good interactions between residents and tourists	5	8	7	10	6.58	8.47	0.89	7.51
Resources (O_2)								
Providing educational opportunities	7	9	9	10	7.67	9.68	2.01	8.67
Improving living environment and quality	6	8	8	10	7.59	9.43	1.84	8.51
Participating in resource management and planning	3	8	5	10	4.60	7.64	0.05	6.31
Conserving natural resources	4	7	7	10	5.93	8.65	2.72	7.29
Community (O_3)								
Participating in interpretation services	4	9	7	10	6.42	8.48	0.06	7.73
Employing local residents	5	9	8	10	6.70	9.20	1.49	8.34
Providing satisfying interpreter services	2	9	6	10	5.92	8.93	0.01	7.46
Providing cultural exchange opportunities	5	8	7	10	6.12	8.63	1.01	7.54
Economy (O_4)								
Making economic contributions for conservation	6	9	8	10	7.40	9.29	0.88	8.45
Improving regional construction	6	9	8	10	7.08	9.11	1.03	8.37
Distribution of tourism revenue	4	8	8	10	6.77	9.13	1.36	8.34
Society (O_5)								
Improving environmental consciousness	3	8	8	10	6.40	9.13	2.73	7.77
Increasing tourists' environmental awareness	6	9	8	10	7.38	9.43	1.05	8.48
Supporting resource conservation	5	8	7	10	6.27	8.42	1.15	7.45
Promoting social welfare	3	7	5	10	5.55	7.98	0.44	6.34

Table 5 Criteria and sub-criteria for sustainable tourism development

Criteria	Sub-criteria
Tourism (O_1)	Participating in conservative activities (S_{11})
	Providing experiential opportunities (S_{12})
	Promoting good interactions between residents and tourists (S_{13})
Resource (O_2)	Providing educational opportunities (S_{21})
	Improving living environment and quality (S_{22})
	Conserving natural resources (S_{23})
Community (O_3)	Participating in interpretation services (S_{31})
	Employing local residents (S_{32})
	Providing satisfying interpreter services (S_{33})
	Providing cultural exchange opportunities (S_{34})
Economy (O_4)	Making economic contributions for conservation (S_{41})
	Improving regional construction (S_{42})
	Distribution of tourism revenue (S_{43})
Society (O_5)	Improving environmental consciousness (S_{51})
	Increasing tourists' environment awareness (S_{52})
	Supporting resource conservation (S_{53})

Table 6 Adjacency matrix between criteria

A	O_1	O_2	O_3	O_4	O_5
O_1	0	1	1	0	1
O_2	1	0	1	0	1
O_3	1	1	0	0	1
O_4	0	0	0	0	0
O_5	1	1	1	0	0

The final reachability matrix M^* for criteria was calculated.

$$M = A + I = \begin{pmatrix} 0 & 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \end{pmatrix} + \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 \end{pmatrix}$$

$$M^* = M^5 = M^7 = \begin{pmatrix} 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 \end{pmatrix}$$

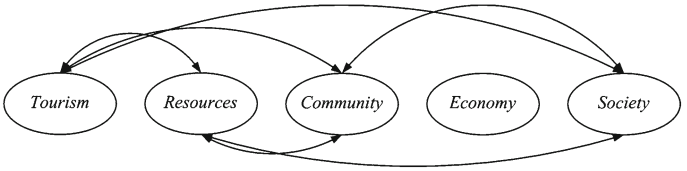

Fig. 4 Interrelationships among criteria

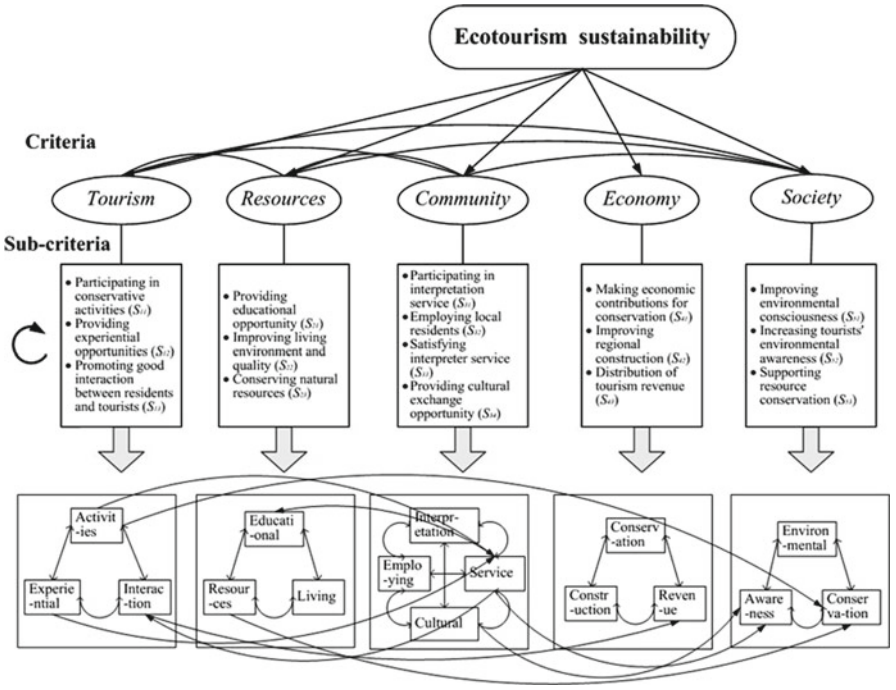

Fig. 5 The network structure of ecotourism sustainability

Based on M^*, the interrelationship among the five criteria can be depicted as in Fig. 4. According to the experts' opinions through ISM analysis, *tourism, resources, community* and *society* were mutually interrelated. This is evidenced from the double-sided arrows among the four criteria in Fig. 4.

For example, considering "the influence of resources on community" and "the influence of community on resources", according to Fig. 4, the former implied that resources and community demonstrated a good interrelationship. Resource administration would recycle the benefits derived from recreational use to regional construction, including social welfare, infrastructure and cultural preservation. In addition, the administration would also be concerned with resource protection, such as the water source and the disposal of litter. These actions would also contribute to a more comfortable living environment for the residents. The latter indicated that the residents were willing to support resource conservation and participate in resource administration activities. Furthermore, the "environment dimension" indicated that the residents should reduce

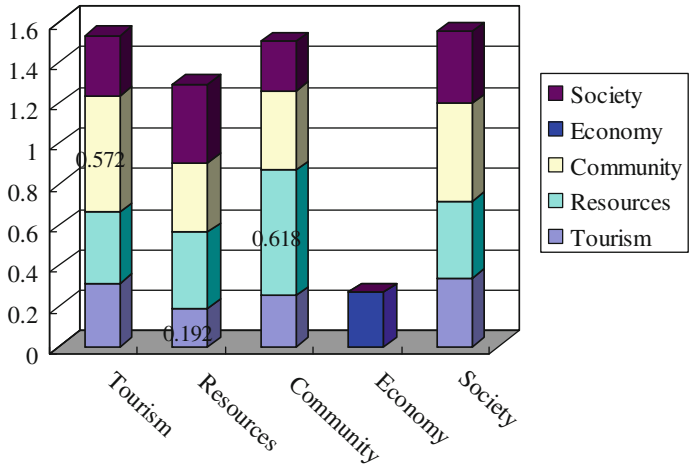

Fig. 6 Sustainability achievement of Yangshan Ecological Park in interrelationships

land development and use and pay more attention to environmental pollution. Note that *economy* was independent from the other criteria. Although such an outcome might seem surprising, it was generated from the experts' opinions through ISM. The result was reconfirmed after the network was formed. A possible explanation for this result could be that the interrelationships among economy and other criteria were not significant and thus could be neglected at the criteria level.

Part of Fig. 5 shows the interrelationship among the sub-criteria obtained from ISM. Using *satisfying interpreter service* (S_{33}) as an example sub-criterion, its interrelationship with other sub-criteria can be seen from the arrows entering and leaving S_{33} in Fig. 5. The performance of *satisfying interpreter service* (S_{33}) was influenced by *participation in conservative activities* (S_{11}) and *providing experiential opportunities* (S_{12}). This implies that with a good understandable interpretative facility and more opportunities to participate in the interpretation service, the implementation of satisfaction in the interpreter service could be conducted more easily and effectively. However, *satisfying interpreter service* (S_{33}) had an impact on *providing educational opportunities* (S_{21}), *increasing tourists' environmental awareness* (S_{52}), and *good interaction between residents and tourists* (S_{13}), thus suggesting that a satisfying interpreter service could lead to a better performance of these sub-criteria. Note that even though criterion economy (O_4) was deemed independent from the other criteria, one of its sub-criteria, *distribution of tourism revenue* (S_{43}), was in fact influenced by *good interaction between residents and tourists* (S_{13}). Thus it was concluded, based on the above reasoning, that only significant interrelationships among the criteria and among the sub-criteria were considered in the network.

5.4 Calculating the Weights by a FANP Model

The complete network for ecotourism sustainability is constructed in Fig. 5. The network and the factors for determining the overall evaluation of tourism sustainability are also organized as shown in Fig. 5. The first level is the objective, which aims to

facilitate ecotourism sustainability, the second level comprises the ecotourism sustainability criteria and their interrelationships and the third level includes the sub-criteria and their interrelationships. An ecotourism site found in the final level was highly recommended for conservation and development.

Based on the network in Fig. 5, a questionnaire using Saaty's nine-point scale of pairwise comparison was prepared, and the study targeted local opinion leaders who participated in community planning and were familiar with community affairs to complete the questionnaire. A total of 47 usable responses were obtained from a population of 60.

The consistency property of each matrix for each resident was first checked to ensure the consistency of judgments in the pairwise comparison. The scores of the pairwise comparison were then transformed into linguistic variables based on Table 1. Fuzzy positive reciprocal matrices were formed, and a geometric average was applied to combine the fuzzy positive reciprocal matrices of the local residents. The centroid method was applied to defuzzy the fuzzy numbers of the aggregate fuzzy positive reciprocal matrices. A priority vector of each crisp-valued aggregate positive reciprocal matrix was then calculated, and to obtain global priorities in a system with interdependent influences, the local priority vectors were entered in the appropriate columns of the unweighted supermatrix, where each matrix segment represented a relationship between two nodes (components or clusters) in a system (Meade and Sarkis 1999; Chung et al. 2005). For example, the priorities of the criteria (O_1 to O_5) with respect to the goal were 0.204, 0.254, 0.279, 0.182 and 0.158, respectively, and they were entered into the (2, 1) block of the unweighted supermatrix in Table 7. These priorities represented the importance of the criteria when the interrelationships among criteria were not considered. The (3, 2) block shows the priorities of the sub-criteria with respect to the criteria when the interrelationships among the sub-criteria were not considered. The interrelationships among the criteria and among the sub-criteria are depicted in the (2, 2) and (3, 3) block, respectively. Each zero entry in the supermatrix implies that there was no relationship between the two elements.

Figure 6 reveals that the influence of resources on the community reached 0.618, followed by the influence of the community on tourism at 0.572. The aspect with the poorest sustainability was the influence of tourism on resources at 0.192. This indicated that tourists' behavior was perceived to negatively impact the preservation of natural resources. Additionally, an excessively high volume of tourists also had a negative impact on tourism. Therefore, it is recommended that management adopt the use of environmental education to raise tourists' environmental awareness or implement carrying capacity strategies to ensure the sustainable use of local resources.

The unweighted supermatrix was weighted first. The weighted supermatrix was then raised to limiting powers to capture all of the interactions and to obtain a convergence outcome. Raising the supermatrix to the power $(2k + 1)$ where k is an arbitrarily large number allows the convergence of the interdependent relationships. In this study, convergence is reach at M^{27}. The overall evaluation for the ecotourism site is the limited supermatrix, and the overall sustainability score for Yangshan Ecological Park was 0.645. A detailed evaluation of the sustainability index of the Yangshan Ecological Park under different criteria and sub-criteria is presented in Table 8.

Table 7 Unweighted supermatrix of the interdependency in sustainable tourism development

	G	O_1	O_2	O_3	O_4	O_5	S_{11}	S_{12}	S_{13}	S_{21}	S_{22}	S_{23}	S_{31}	S_{32}	S_{33}	S_{34}	S_{41}	S_{42}	S_{43}	S_{51}	S_{52}	S_{53}
G	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O_1	0.204	0.314	*0.192*	0.251	0	0.339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O_2	0.254	0.351	0.374	*0.618*	0	0.379	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O_3	0.279	*0.572*	0.341	0.393	0	0.483	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O_4	0.182	0	0	0	0.267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O_5	0.158	0.294	0.386	0.241	0	0.354	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_{11}	0	0.227	0	0	0	0	0	0.421	0.371	0	0	0	0	0	0.39	0	0	0	0	0	0	0.43
S_{12}	0	0.342	0	0	0	0	0.36		0.269	0	0	0	0	0	0.27	0	0	0	0	0	0	0
S_{13}	0	0.453	0	0	0	0	0.26	0.312	0	0	0	0	0	0	0	0	0	0	0.284	0	0	0
S_{21}	0	0	0.314	0	0	0	0	0	0	0	0.20	0.454	0	0	0	0	0	0	0	0	0	0
S_{22}	0	0	0.262	0	0	0	0	0	0	0.32	0	0.241	0	0	0	0	0	0	0	0	0	0
S_{23}	0	0	0.129	0	0	0	0	0	0	0.41	0.28	0	0	0	0	0	0	0	0	0	0	0
S_{31}	0	0	0	0.322	0	0	0	0	0	0	0	0	0	0.117	0.31	0.40	0	0	0	0	0	0
S_{32}	0	0	0	0.209	0	0	0	0	0	0	0	0	0.24	0	0.321	0.34	0	0	0	0	0	0
S_{33}	0	0	0	0.263	0	0	0	0	0.381	0	0	0	0.22	0.27	0	0.29	0	0	0	0	0.38	0
S_{34}	0	0	0	0.237	0	0	0	0	0	0	0	0	0.33	0.21	0.42	0	0	0	0	0	0.41	0
S_{41}	0	0	0	0	0.297	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.231	0	0	0
S_{42}	0	0	0	0	0.194	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0	0.256	0	0
S_{43}	0	0	0	0	0.252	0	0	0	0	0	0	0	0	0	0	0	0	0.19	0.257	0	0	0
S_{51}	0	0	0	0	0	0.288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32	0.27
S_{52}	0	0	0	0	0	0.305	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19	0	0.33
S_{53}	0	0	0	0	0	0.211	0	0	0	0	0	0	0	0	0	0	0	0	0	0.23	0.25	0

Table 8 Supermatrix for sustainable tourism development resulting in convergence (M^{27})

	G	O_1	O_2	O_3	O_4	O_5	S_{11}	S_{12}	S_{13}	S_{21}	S_{22}	S_{23}	S_{31}	S_{32}	S_{33}	S_{34}	S_{41}	S_{42}	S_{43}	S_{51}	S_{52}	S_{53}
G	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.545	0.545	0.545
O_1	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171
O_2	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387	0.387
O_3	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361
O_4	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179
O_5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
S_{11}	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383
S_{12}	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423
S_{13}	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405	0.405
S_{21}	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322
S_{22}	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341	0.341
S_{23}	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469	0.469
S_{31}	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364
S_{32}	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622	0.622
S_{33}	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566
S_{34}	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638
S_{41}	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
S_{42}	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295
S_{43}	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271
S_{51}	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541	0.541
S_{52}	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455
S_{53}	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333

Table 9 Priorities of the sub-criteria in sustainable tourism development

Objective	Criteria	Sub-criteria	Priorities
Ecotourism sustainability (0.645)	Tourism (0.171)	Participating in conservative activities (0.383)	0.316
		Providing experiential opportunities (0.423)	0.349
		Promoting good interactions between residents and tourists (0.405)	0.334
	Resources (0.387)	Providing educational opportunities (0.322)	0.284
		Improving living environment and quality (0.341)	0.301
		Conserving natural resources (0.469)	0.414
	Community (0.361)	Participating in interpretation services (0.364)	0.166
		Employing local residents (0.622)	0.284
		Providing satisfying interpreter services (0.566)	0.258
		Providing cultural exchange opportunities (0.638)	0.291
	Economy (0.179)	Making economic contributions for conservation (0.311)	0.355
		Improving regional construction (0.295)	0.336
		Distribution of tourism revenue (0.271)	0.309
	Society (0.246)	Improving environmental consciousness (0.541)	0.407
		Increasing tourists' environmental awareness (0.455)	0.342
		Supporting resource conservation (0.333)	0.250

The values denote the degree of sustainability of all criteria and sub-criteria within the relationship in Table 9. This study adopted the barometer of sustainability proposed by Prescott-Allen (1997). Evaluation results of a destination's sustainable development were divided into designations of sustainable and unsustainable along the neutral interval. According to the degree of sustainability, four levels were derived, and ordinal scales were used to denote indicator scores between 0 and 1, where 0.00- to 0.20 denoted un-sustainability, 0.21 to 0.40 denoted potential un-sustainability, 0.41 to 0.60 denoted intermediate sustainability, 0.61 to 0.80 denoted potential sustainability, and 0.81 to 1.00 denoted sustainability. According to Table 9, the overall sustainabil-

ity score (0.645) for Yangshan Ecological Park means that the nature of the resources reflected sustainable tourism development and "potential sustainability". Additionally, resources and community demonstrated a good interrelationship. For example, resource administration would recycle the benefits derived from recreational use to regional construction, including social welfare, infrastructure and cultural preservation. In addition, the administration would be dedicated to resource protection, such as the water source and the disposal of litter. These actions would also contribute to a more comfortable living environment for the residents.

5.5 Discussion

The factors that management should stress in the tourism sustainability development should be understood so that more effort can be placed on improving the performance of these factors. As shown in the (2, 1) block of the unweighted supermatrix in Table 7, the priorities of the five criteria, *tourism, resources, community, economy,* and *society,* with respect to the goal and under the assumption that the criteria were independent were 0.204, 0.254, 0.279, 0.182 and 0.158, respectively. The result was a pure AHP analysis. However, when the interrelationships among the criteria were considered and the supermatrix operation was conducted, the priorities changed to 0.171, 0.387, 0.361, 0.179, and 0.246, respectively. Among the five criteria, *resources*, at 0.387, was identified as having the highest priority, followed by *community,* at 0.361. This is apparently because the number of tourists is continuously rising, and accordingly, the administration has stated that facilities must be increased to safeguard tourists and trails must be established to provide recreation space. However, these developments may cause resource overloads in the absence of any restrictions on incoming numbers of tourists.

Economy, which is usually a major concern for local residents, ranked fourth and had a similar level of importance as *tourism*. Also note that the rankings of the priorities varied with and without the consideration of the interdependence among the criteria. When the criteria were assumed to be independent, *community* (0.279) ranked first, followed by *resources* (0.254). However, after considering interdependence, the opposite was true. That is, *resources* (0.387) was ranked as the highest priority, followed by *community* (0.361). A similar outcome occurred for *tourism* and *economy*, with *economy* ranking third and *tourism* ranking fourth when the criteria were assumed to be independent. When interdependence was considered, however, *economy* ranked fourth, followed by *tourism*, thus indicating that interdependence among criteria may lead to different rankings and priorities of elements. Such a difference in the results between the AHP and the ANP is the major attribute of the ANP, which considers the interdependence among elements, thus resulting in a more comprehensive analysis.

The priorities of the sub-criteria are listed in Table 9. Under the *tourism* criterion, *providing experiential opportunities*, with a priority score of 0.349, was the most important sub-criterion. In social terms, many people who travel to natural/cultural areas do so specifically to enjoy experiences with nature/culture, and accordingly, it is the responsibility of the protected area to ensure the quality of the available natural experience and to work toward instilling "transformative values", which, through

a learning experience with nature, yields to higher environmental awareness and an appreciation and respect for nature. With respect to the *resource* criterion, *conserving natural resources* ranked first, with a priority score of 0.414. Generally speaking, a tourist destination must establish a resource administration to administer resource conservation, use and management. Through appropriate conservation measures, resource administrators provide residents with sustainable agricultural and fishery use, as well as effective monitoring of pollutant emissions. Regarding the *community* criterion, *providing cultural exchange opportunity* was the most important sub-criterion, with a priority score of 0.291. The local community influences tourists mainly through social interactions. For example, by providing tourists adequate interaction opportunities with the residents in certain specific regions, tourists are able to experience different cultures in ways that reduce the disruption of the residents' daily lives as much as possible. With respect to the *economy* criterion, *making economic contribution for conservation*, with a priority score of 0.355, was the most important sub-criterion. From the economic standpoint, if there were no tourism income to support conservation, then the resource would be unprotected, and the destination would be unable to provide adequate recreational opportunities for tourists. Finally, regarding the *society* criterion, *improving environmental consciousness* was the most important sub-criterion (0.407). Regarding the social perspective, high-quality environmental education can contribute to visitors' experiences, direct people toward appropriate behaviors and encourage an appreciation for natural areas, all of which can result in environmental advocacy.

6 Conclusion and Suggestions

6.1 Conclusion

From the perspective of the FDM, ISM, and the FANP, the study used stakeholder perceptions to evaluate the destination's tourism sustainability. Thus, this study could avoid the researcher's subjective judgments and decrease the interviewees' biases by incorporating suitable evaluation criteria and a substantial number of subjects. According to the results, the influence of resources and the community was most significant regarding the natural and cultural resources. Furthermore, experts in the Fuzzy Delphi Method were most concerned about the environmental issues. This implied that *resources* and *community* are the most important factors in ensuring the sustainability of tourism development.

In the "21 Century Taiwan Tourism Development Plan" drafted by the Taiwan Tourism Bureau, ecotourism was identified as an important direction for future tourism development. Activities such as whale watching and bird watching and resources such as natural hiking trails, wetlands, and indigenous destinations are becoming increasingly popular. Although more people are beginning to pay attention to ecotourism development, the corresponding systems and supporting measures are still underdeveloped. Many destinations are suffering from the phenomenon of "honoring the name of ecotourism on the surface but destroying the environment in reality". The issues of whether good interactions with local residents can be maintained, whether the

environment will be overloaded, and whether the sustainability of natural resources can be maintained are not considered. From the practical viewpoint, the management of ecological resources, community residents and tourists are all facing urgent problems that must be addressed.

This study applied the FDM, ISM, and the FANP to explore the interrelationships among resources, community, tourism, economy and society to examine a destination's sustainability. While the indicators system, as an evaluation tool for sustainable ecotourism development, reflects local economic, social and environmental concerns, empirical findings can be used for suggestions regarding tourism development in Yangshan Ecological Park of Kinmen. The demands for sustainability are more stringent for ecotourism sites than those for general destinations. The successful interaction among resources, community and tourism is a critical component for destinations that aim for sustainability. The administration of such destinations should regularly monitor the interactions among stakeholders and avoid making bad decisions that could lead to an imbalance between these stakeholders and their relationships.

6.2 Suggestions

Although this paper focuses on one destination as a basis for empirical research, the content of the evaluation variables can be generalized and applied to other destinations. However, if certain types of destinations, such as historic or coastal destinations, were the focus of study, other corresponding indicators should be included to conduct a proper assessment. We propose the following strategies for the management of sustainability in Yangshan Ecological Park of Kinmen:

(1) The main concern regarding ecotourism development is its contribution to the degradation and destruction of the environment. With respect to resource administration, resource use must be based on considerations related to sustainable development. Management strategies include implementing recreational carrying capacity, restricting the scope of recreational use and avoiding unnecessary development. Accordingly, the first priority of the administration is to address the issue of inappropriate resource usage through resource protection and conservation strategies.

(2) For the community and the residents, the main concern is to protect the residents' livelihoods and to maintain the quality of the living environment. Ryan (2002) stated that for sustainable tourism, it is necessary to add value by involving the community in an equitable process. Therefore, in the resource development process, the administration should initiate efforts to ask for resident recommendations and to encourage their participation in planning ecotourism development in the community. In addition to establishing infrastructure, the administration can also provide tourism-related job opportunities for residents, such as interpretation services and traditional culture and crafts opportunities.

(3) For tourists, in addition to allowing tourists to enjoy high-quality travel activities, the administration should provide them with an interpretative service based on environmental education. This measure could raise the quality of experience for

tourists at the spiritual level and facilitate awareness regarding the conservation and protection of resources.

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