



# Island Ecological Tourism: Constructing Indicators of the Tourist Service System in the Penghu National Scenic Area

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### Specialty section:

This article was submitted to  
Conservation and Restoration  
Ecology,  
a section of the journal  
Frontiers in Ecology and Evolution

**Received:** 18 May 2021

**Accepted:** 07 September 2021

**Published:** 15 October 2021

### Citation:

Hsiao CY, Kuo CM and Tuan CL  
(2021) Island Ecological Tourism:  
Constructing Indicators of the Tourist  
Service System in the Penghu  
National Scenic Area.  
*Front. Ecol. Evol.* 9:708344.  
doi: 10.3389/fevo.2021.708344

It is critical to develop a sustainable ecotourism service system for the fragile Penghu National Scenic Area in Taiwan. This study, therefore, adopted the fuzzy Delphi method and analytic hierarchy process (AHP) to establish an index framework. The results identified four dimensions with 21 service factors. The findings are as follows. Safety management capability is found to be the main factor in the ecotourism service system. Ecological diversity is essential for the marine environment and the core resource for ecotourism; the transportation capacity and environmental quality need to be improved. Marine environmental resources are indispensable to the development of ecotourism. In addition, the local community must support ecotourism, natural resources should be protected, and the development of ecotourism needs to support the sustainability of local conservation. Therefore, encouraging local residents and stakeholders to attend and promote ecotourism, establishing a safety management system for ecotourism, developing environmental protection regulations for tourists in ecotourism, and improving tourist satisfaction are vital. The government needs to develop guidelines for the protection of marine resources, plan an ecotourism service system, and improve public and transportation infrastructure to make it safe and accessible.

**Keywords:** ecotourism, sustainability, island tourism, Penghu National Scenic Area, tourist service system, ecotourism indicator

## INTRODUCTION

Tourism, local resources, the environment, and residents have a close relationship with each other. Tourism development is a catalyst for economic growth in island regions in developing countries (Buultjens et al., 2017). According to the United Nations World Tourism Organization (UNWTO), in 2013, 40.83 million tourists stayed overnight on islands, and generated USD 5.3148 million

in revenue (United Nations World Tourism Organization, 2014). Island tourism has an essential role in economic development. However, island tourism has environmental consequences (Sundra, 2011). It has dried up coral reefs (Kurniawan et al., 2019) and collapsed the seagrass ecosystem (Cullen-Unsworth et al., 2014). Therefore, the concept of sustainable tourism should apply to islands.

Ecotourism is a travel style of sustainable tourism, which is a growing development trend of recent years, contributing to the jobs and revenue for the local community, conservation, and preservation of such areas (Page and Dowling, 2002; United Nations World Tourism Organization (UNWTO), 2018). Local residents can use the ecological and cultural heritage resource to provide experience and learning activities for tourists in the area (Tuan, 2016). According to the UNWTO forecast, an estimated 1.8 billion tourists around the world wish to be sustainable tourists (United Nations World Tourism Organization (UNWTO), 2018). Meanwhile, tourists' demands are changing to include new traveling styles, such as agritourism, ecotourism, and green tourism.

Thus, the tourism industry needs to adapt to tourists' expectations while protecting natural resources (Blancas et al., 2015). There are many elements of ecotourism to consider, depending on the quality of the natural resources, cultural heritage, and biodiversity. The community should have an awareness of the environment and cultural heritage (Shelly and Wall, 2001; Weaver and Lawton, 2007; Tuan, 2016). However, these elements raise concerns about nature and culture, environmental education, the understanding of environmental protection, the shared benefits for the community and stakeholders, and the relationship between the environment, society, economy, and tourists (Chen, 2015; Tuan, 2016; Chao and Chao, 2017; Ng et al., 2017). Consequently, for ecotourism to be sustainable, careful planning and management are necessary (Baral, 2015). In addition, it must meet tourists' expectations, be connected with the local community, and effectively use local resources to achieve the goal of sustainable ecotourism development.

Recently, some scholars argued that the rapid growth of ecotourism is not sustainable, they suggested that ecotourism only caused slower resource degradation than mass tourism (Regmi and Walter, 2017). Some ecotourism sites are located in a fragile environment with less infrastructure (Butler, 1999). Too many tourists will damage the local environment and reduce income diversity (Honey, 2008; Weaver, 2001). In contrast, Gunter et al. (2017) argued that ecotourism-led growth has promoted comprehensive economic development. The sustainable development of ecotourism is needed to find the balance between environment and economy. Despite ecotourism's important role, it is still inadequately defined so its guidelines are unclear (Sander, 2012).

Island ecotourism, which aims at sustainable development, is one way to develop the economy using the local community, tourist activities, and environmental resources. Some scholars discuss the sustainability of island ecotourism in terms of vulnerable island environments (Hall, 2012), environment

destroyed by overtourism (Kuo and Chen, 2009), social and ecological resilience (Cheer et al., 2017), island governance (Luthe and Wyss, 2016), local residents' attitude to tourism (Pennington-Gray et al., 2005), and entrepreneurship's responsibility (Russell and Faulkner, 2004).

In early studies, Stem et al. (2003) defend sustainability as the key indicator that distinguished ecotourism from mass tourism. One popular way to examine the sustainability of ecotourism is to use measurable indicators to represent the functional characteristics of a system (Gallopín, 1996). Most indicators can provide sufficient information for decision-makers based on the type of action that has been implemented (Layke, 2009). Agyeiwaah et al. (2017) argue for sustainable tourism indicators on a case-by-case basis.

The coastline of the Penghu archipelago is 448 km long, and like other forms of ecotourism, it has been a primary source of revenue for Taiwan's government. Many tourists still take multiple-day trips to the archipelago, even though transportation is limited. According to the Penghu government statistics, more than 1 million tourists visit every year. In this regard, the Taiwanese Tourism Bureau Republic of China (2018) announced Ecotourism Year. It offered 42 ecological package tours, including to Penghu. However, although tourism can increase island revenue, it can also damage its marine resources.

There are many studies of ecotourism in the Penghu archipelago. Liang and Tsai (2008) studied 364 ecotourists, and the effect of their activities on their intention to revisit. Hsieh et al. (2016) compared the attitudes of residents and tourists and pointed out that positive economic and cultural resources will upgrade tourism development. Chao and Chao (2017) argue that the visitors to the Wang-An Islands need to enhance environmental concerns of visitors, and have carefully managed "deep experience" activities and small-scale tours. At the same time, the residents need to acquire the environmental knowledge to become de facto interpreters for the visitors. According to Yu et al. (2015), communities need to protect their environmental resources and promote the willingness of tourists' impressions. Wu and Tsai (2015) pointed out that the local community is the crucial element for tourists' activities in the Penghu National Scenic Area. Thus, most of the literature discusses ecotourism development from just one perspective instead of from several.

Ecotourism requires interaction between residents and tourists. The residents take advantage of environmental features and design experience activities for attracting tourists to increase income (Wu and Tsai, 2015; Tuan, 2016; Chao and Chao, 2017). While reviewing the previous studies on the Penghu National Scenic Area, we can see that they focus on revisit intention (Liang and Tsai, 2008), tourism development in resident and tourist attitude (Hsieh et al., 2016), experience activities (Chao and Chao, 2017), and resident operating intention (Wu and Tsai, 2015), rather than discussing the service system and combining ecotourism and service indicators. The purpose of this article is to construct a sustainability and service system to maintain the Penghu National Scenic Area.

The United Nations Commission on Sustainable Development (UNCSD) has recognized the use of criteria and indicators in measuring sustainable development. The sets of criteria

and indicators are used to track all changes at ecotourism destinations. These sets can explain whether destination tourism is improving or deteriorating (Tsaur et al., 2006). Since various indicators of ecotourism must be considered in the evaluation process, a multi-criteria decision-making (MCDM) method is proposed. In addition, to solve the uncertainty related to data collection and judgment elicitation in the MCDM method, the evaluation process uses the fuzzy set theory (Zadeh, 1965). The fuzzy Delphi method (FDM) is used to classify sustainable tourism indicators.

This article describes marine ecological resources, local community, operating system, and tourist activities in the Penghu National Scenic Area, then discusses each criterion and indicator of the ecotourism service system.

## LITERATURE REVIEW

### Sustainability in Island Tourism

Islands attract tourists because of their high scenic value, exotic wildlife, and culture (Hall, 2010). Tourists can enjoy a sense of freedom, a peaceful environment, and unique cuisine (Sharpley, 2015). In developing countries, income from island tourism is a very important source of revenue (Kurniawan et al., 2019). Island tourism creates jobs for residents and contributes to economic development (Cheng et al., 2013; Kurniawan et al., 2019). However, island resources and environments are very fragile (Douglas, 2006), and those limited resources are vulnerable to environmental damage (Lovelock et al., 2010) from tourism development (Cullen-Unsworth et al., 2014; Kurniawan et al., 2019). Therefore, the discussion of resources, environment, and tourism activities have been an important management issue for island tourism development (Kurniawan et al., 2017, 2019; Mai and Smith, 2018).

Early studies of island tourism have mostly explored its development and sustainability. For example, Mai and Smith (2015) measured sustainable tourism using a system dynamics model with indicators of tourist numbers, investment, tourism infrastructure, waste, pollution, and attractiveness. Ng et al. (2017) assessed sustainable tourism on islands using the Sustainable Ecotourism Indicator System (SEIS). The SEIS has three dimensions (social, environmental, and economic) which are interdependent on communities, tourism, and resources. The resilience of island tourism is discussed by disentangling resources and environmental and social dimensions from the social-ecological system. For example, Becken and Khazai (2017) discussed the role of tourism in assisting post-disaster recovery and the resilience of coral reefs in tropical regions (Phillips, 2015).

There are multiple perspectives on the sustainability of island tourism. The theories can be resource-based (McKercher, 1993), activity-based (Carlsen and Butler, 2011), or community-based (Hughes, 1995). However, there are no ecotourism indicators in the literature. To fill this gap, it is necessary to use Penghu to construct indicators for the sustainable development of island ecotourism.

### Ecotourism and Sustainability

Ecotourism is a sustainable and responsible way of engaging and encouraging tourists' behavior. It protects the biodiversity, natural environment, and historical and cultural heritage. Tourists can learn to strengthen protection of the environment and ecological resources (Lin, 2008). Miller and Kaae (1993) argued that there are two types of ecotourism based on a responsible traveling continuum. The purpose of passive tourism is to reduce environmental impacts while providing tourists with subjective experiences. In contrast, active ecotourism limits activities with negative environmental impacts and instead focuses on environmental ethics. There is a need to develop and manage activities that protect the cultural and natural resources of a site (Blancas et al., 2015). To reduce environmental impact and enhance ecological efficiency, local ecological resources and tourist activities need to be considered. For the most part, the local community or residents have been neglected in evaluations of ecotourism development (Mathis and Rose, 2016; Thompson et al., 2018). However, some practices have considered the factors of the local community on ecotourism development (Gezon, 2014; Hunt et al., 2015). Das and Chatterjee (2015) argue that local communities often receive low net benefits, and sometimes suffer from ecotourism.

Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). The UNWTO defines sustainable tourism as "meeting the needs of present tourists and host regions while protecting and enhancing opportunities for the future." It envisages the process as "leading to management of all resources in such a way that economic, social, and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity, and life support systems" (United Nations World Tourism Organization, 2004). Sustainable tourism involves agritourism, green tourism, and ecotourism, and has to be determined by the economic, social, community, cultural, environmental, and institutional perspectives, to achieve long-term cooperation among stakeholders in protecting the ecosystem while promoting tourism (United Nations World Tourism Organization, 2015). United Nations World Tourism Organization (2017) declared the *International Year of Sustainable Tourism for Development* in 2017, suggesting 17 indicators for sustainable development, plus sustainable development goals (SDGs), to assist in evaluating sustainable ecotourism across five categories: inclusive and sustainable economic growth; social inclusiveness, employment and poverty reduction; resource efficiency, environmental protection, and climate change; cultural values, diversity, and heritage; and mutual understanding, peace, and security.

Despite the popularity of indicator building and the growing interest in sustainable ecotourism, there have been few studies. In the field of island ecotourism, these studies include Wang et al. (2016) on Taiwan coastal areas; Bhuiyan et al. (2016) on Kenyatta Lake, Malaysia; and Ng et al. (2017) on Tioman Island, Malaysia. Sustainable ecotourism indicators are limited by geographical location. As noted by Ocampo et al. (2018), the construction of such indicators is strongly correlated with the case study and

its geopolitical, climatic, cultural, and social conditions (Ocampo et al., 2018). A review of more than 2,500 ecotourism studies by Liu and Li (2020) shows that the construction of indicators for case studies is rapidly growing.

Marsh (1993) listed four indicators to evaluate ecotourism criteria: ecology, society, economy, and regulation. Ross and Wall (1999) used these indicators to construct ecotourism criteria for tourists, the local community, and ecological resources, to evaluate the North Sulawesi Scenic Area in Indonesia and Amazonas in Brazil. Sung (2003) used operation management, local community, environmental resources, and tourism to construct an ecotourism indicator (Figure 1).

Sung (2003) argued that ecotourism development needs the cooperation of government, the residents, and tourists. Residents need to support ecotourism in terms of operating intention, attitude, resource utilization, and feedback. Tourism is the scope of the interaction between tourists and residents, and environmental conservation. The local organization can manage transportation safety, the interpretation system, communication with the residents, protection of environmental resources, and improvement of service quality. Thus, this article applies Sung's (2003) indicators.

## Service System

To meet tourists' expectations, service quality is significant. The service system should meet the tourists' demands. The service systems focus on the customer, activities, environment, technology, labor, and organization (Glynn and Barnes, 1995; Chen, 2010). Hornoiu et al. (2009) argued that three objectives are required to upgrade the quality of ecotourism services: environment, economy, and society; service quality and labor training; and tourists' safety protection and information safety. The four indicators are the reduction of environmental resources, prevention of social and cultural collapse, the wise use of local resources, and quality management of ecotourism.

Weng (2014) lists eight management indicators to improve the ecotourism service system:

**Organization:** to promote ecotourism planning, business management, environmental education, and ecotourism.

**Transportation:** to maintain the road and trail system.

**Resource:** to protect biological and water resources.

**Facilities:** to maintain the infrastructure.

**Environmental:** to keep the environment clean.

**Interpretation service:** to host the interpretation location, to train interpreters.

**Tourist safety:** to ensure tourist safety.

**Financial:** to balance the budget and ensure the benefit to stakeholders and the community.

We constructed the service system of ecotourism in terms of institutions, the local community, environment, tourism industry, and tourist satisfaction.

This research combines the ecotourism system (Sung, 2003) and service system indicators (Weng, 2014) to construct the service system of ecotourism in the Penghu National Scenic Area. Hornoiu et al. (2009) considered improvement in service

quality and tourist satisfaction in Romania, using four indicators: decreasing environmental pollution, improving the relationship with the local community, upgrading the environment, and enhancing the quality of management.

## METHODOLOGY AND IMPLICATIONS

### Penghu Archipelago and Tourism

Island ecotourism is managed by the Penghu National Scenic Area. Penghu is Taiwan's archipelago. It has received destination recognition for its island ecotourism, which utilizes the local natural resources of fish, sea turtle, coral reef, the intertidal zone, seashore plant ecology, migratory birds, and basalt cliffs (Chao and Chao, 2017; Penghu National Scenic Area Administration, 2018). From May 2003, the Penghu Fireworks Festival has been held by the Penghu County government and has become a magnet for tourists. According to the Penghu County Government Tourism Department, 1,326,216 tourists visited Penghu in 2018; of these, 63.56% engaged in ecotourism, including visiting the basalt cliff, intertidal zone, and learning about seashore plant ecology.

The Penghu archipelago has three ecotourism systems (Figure 2). Most of Magong's residents have a strong Taiwanese culture. Magong is the economic, cultural, and political center of Penghu. The Northern ecotourism system consists of seven islands with fish, coral reefs, intertidal zones, seashore ecology, and migratory birds. The stone weirs are a famous destination. The Southern ten islands are home to fish, sea turtles, coral reefs, and basalt cliffs. The green sea turtle is an essential resource.

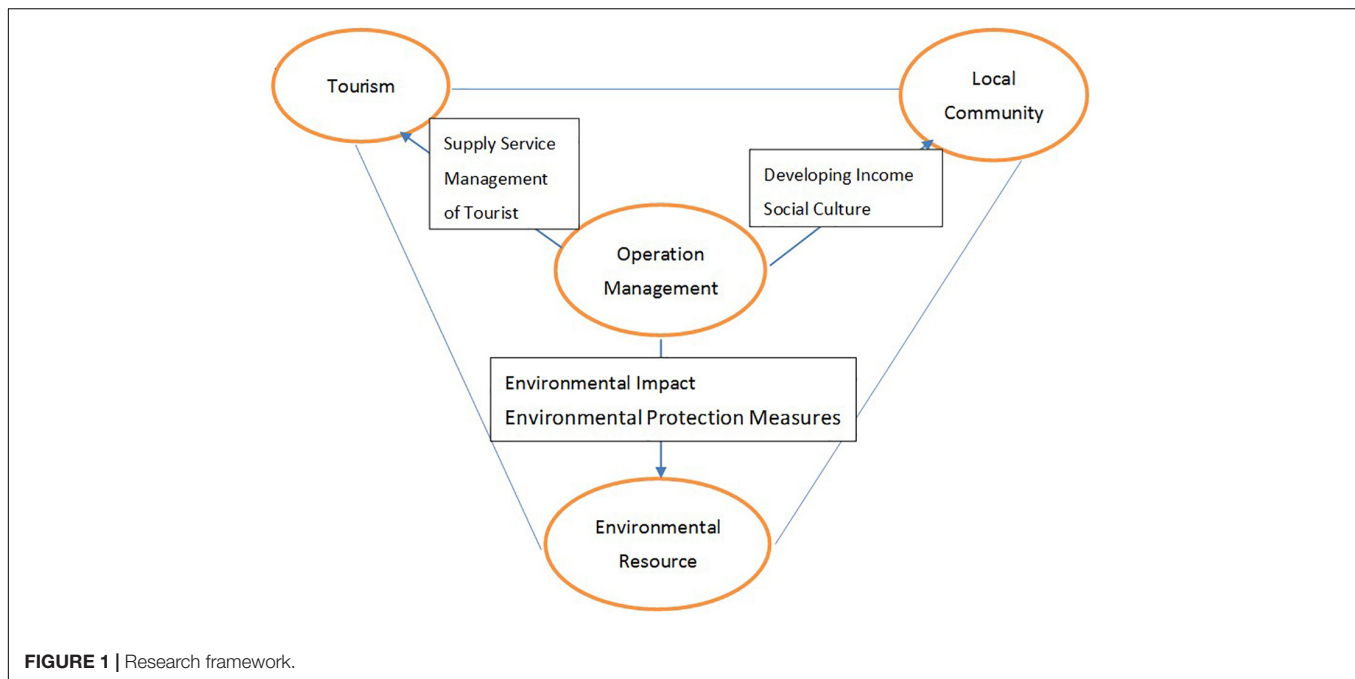
Numerous scholars discuss resources in the Penghu National Scenic Area, including tourists' satisfaction of experience activities based on the sustainable perspective (Ni, 2000); experience activities (Hung, 2004; Wu, 2007; Chao and Chao, 2017); and tourism development viewpoints (Lin, 2002; Xue, 2002; Hu, 2009; Wu and Tsai, 2015; Hsieh et al., 2016).

Tourists learn about environmental conservation through educational activities. Some scholars have discussed customer behavior (Liang and Tsai, 2008) and marketing strategy (Hu, 2009). The objective of ecotourism is to balance environmental conservation with tourism (Chao and Chao, 2017; Tuan, 2019). With rapid tourism development, overtourism can reduce the quality of ecotourism and at worst, destroy the island's ecosystem (Hillery et al., 2001; Wu et al., 2005; Chao and Chao, 2017; Ng et al., 2017). Thus, to sustain ecotourism development, an ecotourism service indicator system is important.

### Fuzzy Delphi Method

The iterative Delphi method and non-parametric consensus measures were used to extract the final criteria and indicators set. The Delphi method is useful for seeking group consensus.

A comprehensive review of the methodology of the Delphi method has been conducted by Zarthia Sossa et al. (2019). Although it has a wide range of applications, the field of tourism is more commonly used. In the absence of exact knowledge, San-Jose and Retolaza (2016) insisted that the Delphi method has



the ability to compare individual mental maps of experts who integrate the data into future scenarios.

Although the Delphi method has considerable advantages, there is still uncertainty or ambiguity in surveys (Sackman, 1974). The shortcomings of the Delphi method include the time-consuming and costly collection of expert opinions, the low recall rate of questionnaires, the tendency to distort expert opinions, and the failure to take ambiguity into account.

Therefore, the FDM was developed to use the advantages of questionnaires and meetings (Linstone, 1978). The FDM theory developed by Zadeh (1965) can address situations where humans cannot precisely describe something. Fuzzy Delphi is used in team communication by gathering consensus and opinions through anonymous opinions. For instance, team members speak only to the researcher, not to each other. It avoids the distortion of expert opinions, capturing the semantic structure of predicted items, and considers the ambiguity of the data gathering and interview process (Lee and Hsieh, 2016).

To construct island ecotourism, it is necessary to set indicators. The island ecotourism indicator requires consideration of the key elements for all stakeholder groups in the Penghu National Scenic Area. These representatives need knowledge and experience to understand the ecotourism indicators. Dalkey and Helmer (1963) suggested that the group error can be minimized when there are at least 10 experts by implementing the FDM. A large number of experts may find it difficult to reach consensus (Brody, 2016). Delbecq et al. (1975) suggested 15–30 members for a high-homogeneity Delphi group and 5–10 for a heterogeneous Delphi group. Lee and Hsieh (2016) employed a Delphi survey in which 13 experts assessed 143 indicators to measure their importance.

The triangular fuzzy number (N), denoted as (l, m, and u), is one of the most commonly used fuzzy numbers. **Figure 3**

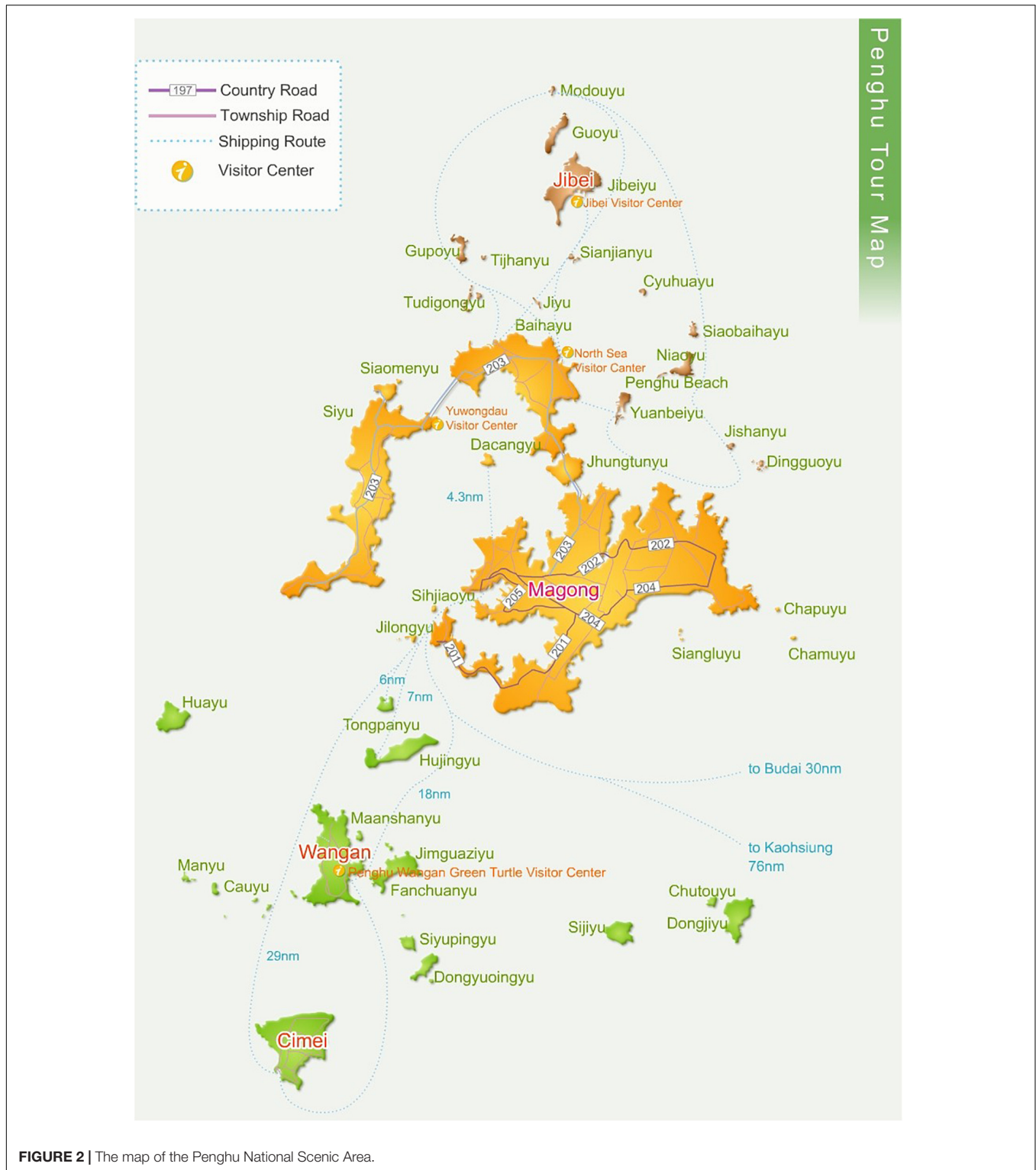
indicates (N). The parameters l, m, and u present the minimum, middle, and the maximum value, respectively. M represents the consensus. If the geometric mean of the factor is greater than or equal to the threshold value ( $M \geq S$ ), the factor is accepted as the evaluation factor; if not ( $M < S$ ), the factor is deleted. If the decision-maker finds that there are too few factors, the threshold value (S) can be lowered; in contrast, the threshold value (S) can be raised. The membership function can be defined by Equation 1. The rest of the fuzzy set theory procedure is explained in the literature (Kim and Chung, 2013).

$$\begin{cases} N = (l_i, m_i, u_i) \\ l_i = \min(X_{ik}), k = 1 \sim n \\ M_i = \left[ \prod_{k=1}^n X_{ik} \right]^{1/n}, k = 1 \sim n \\ u_i = \max(X_{ik}), k = 1 \sim n \end{cases} \quad (1)$$

In constructing a service system of traveling into the Penghu National Scenic Area, no consensus has been reached as to how each indicator contributes to ecotourism in Penghu. Thus, to assess the indicator of the service system of traveling in Penghu, this article used a FDM to elicit expert feedback. This study followed Dalkey and Helmer's (1963) suggestion, selected 12 members into three groups in the first round, and 18 members in the second to decrease group error.

## Analytic Hierarchy Process

The analytic hierarchy process (AHP) structured by Saaty (1974) handles complex decision problems. It establishes a hierarchical structure to simplify the evaluation process and constructs the pairwise comparison matrix to indicate the importance of alternatives, and finally calculates the priority



**FIGURE 2 |** The map of the Penghu National Scenic Area.

weights of alternatives according to a pairwise comparison matrix (Beskese et al., 2015).

However, the AHP method has some shortcomings. Buckley (1985) argued that using the fuzzy analytic hierarchy process (FAHP), which combines fuzzy theory and AHP, can improve the

decision-making process. FAHP has been useful for the planning of ecotourism indicators. Ocampo et al. (2018) used fuzzy AHP to obtain a sustainable ecotourism indicator in the Philippines. Yilmaz and Surat (2015) also determined the tourist activities of ecotourism by FAHP.

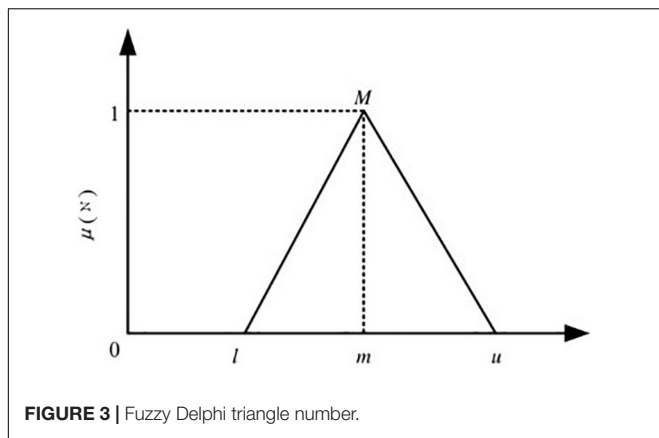


FIGURE 3 | Fuzzy Delphi triangle number.

To ensure the efficiency of the pairwise comparisons, two requirements are established when using the questionnaire to collect experts' judgments. First, each expert should only assign an integer score that ranges from 1 to 9 to a factor. Second, each expert is encouraged to assign different scores to different factors in the same layer. These two requirements ensure that all scores can be assigned to as many different factors as possible to differentiate the importance of the factors in the same layer (Castro-Pardo et al., 2019; Fernández Martínez et al., 2020). Saaty (1994) argued that scores reflect importance.

Gogus and Boucher (1998) developed the calculation for the inconsistency ratio of fuzzy pairwise comparison matrices. There are three steps:

Step 1. The fuzzy triangle matrix is applied to two matrices, assuming the fuzzy triangular fuzzy number (N) is presented as follows:

$$N = (l_i, m_i, u_i) \tag{2}$$

Then, the first matrix can be created by the middle numbers of the fuzzy triangular matrix, that is:

$$M_i = \left[ \prod_{k=1}^n X_{ik} \right]^{1/n}, k = 1 \sim n \tag{3}$$

Likewise, the second matrix can be created by the geometric mean (GM) of the upper and lower bounds of the fuzzy triangular matrix, that is:

$$l_i = \min(X_{ik}), k = 1 \sim n \tag{4}$$

$$u_i = \max(X_{ik}), k = 1 \sim n \tag{5}$$

Step 2: The weight vector is computed based on the Saaty method and calculation of lambda max (λ max).

Step 3: Consistency Ratio (C.R.) is used to measure the consistency of the comparison array, if C.R. ≤ 0.1, then the consistency of the matrix is acceptable. The C.R. and C.I. values are calculated as follows:

$$C.I = \left( \frac{\lambda_{\max} - n}{n - 1} \right) \tag{6}$$

$$C.R = \left( \frac{C.I.}{R.I.} \right) \tag{7}$$

Consistency Ratio (C.R.) is the ratio of the Consistency Index (C.I.) to the Random Index (R.I.); Consistency Index (C.I.) is the ratio of (λ<sub>max</sub> - n) to (n - 1), λ<sub>max</sub>: maximum eigenvalue, n: order of the matrix. When C.I. = 0, it means the decision is consistent, while C.I. > 0 means the decision is inconsistent, Saaty (1980) suggests C.I. ≤ 0.1 as the allowable deviation value.

According to the questionnaire survey, the views of experts on the relative importance of each level of indicator were obtained, and the weights of each indicator were integrated and summarized. The weight of each level is obtained by establishing a relative comparison matrix, calculating the priority matrix and the maximum eigenvalue, and checking for consistency. In the three-level metric system, the weight of the bottom metric is obtained by multiplying the weight of the second major component by the weight of the third metric to obtain the weight of the overall metric. The overall weight value calculated represents the relative priority of a decision solution to the decision goal, and the higher the value, the higher the priority of the adopted solution.

This study obtained consensus through a panel of experts and used an expert questionnaire survey to develop the hierarchical structure and calculate the weight of critical factors affecting the service system of traveling in Penghu. This study used evaluation dimensions and weighted evaluation indices to understand the relationship among critical factors and their importance.

### Delphi Group Selection

In this study, the FDM was used. Brody (2016) stated that variation included expert self-evaluation, amount of professional experience, peer evaluation, expert's source of information, responsibility, authority, competent problem-solving, education, objective standard indicators, and previous performance, etc., which were then used in this study. As such, island ecotourism consists of environmental resource management, local residents, and tourism activities. The selection of experts involves tourism industry personnel, government officials, and academic experts. Based on the characteristics of island ecotourism on Penghu, the Delphi group must be one of the following:

- Local tourism operators
- Representatives of local associations
- Ecotourism operators
- Director of the Tourism Bureau
- Fishery supervisors
- County government authorities
- Island tourism experts
- Ecotourism experts
- Tourism experts

Based on these criteria, 12 members were selected from industry, government, and academia for the first round. To make the indicator more credible, the members of the tourism industry had more than 20 years of experience. The government members

had more than 10 years of experience managing the Penghu National Scenic Area. The scholars had more than 10 years of domestic ecotourism-related experience (see **Table A1**).

For the second round, 18 members were selected from industry, government, and academia. Each category had six members. For industry, this study added the chairman of the local community association and the executive manager of an ecotourism association. For the government members, this study added the section director in the tourism central authority and the associate research fellow of the Fishery Research Institute in Penghu. However, this study replaced the supervisor of leisure in Penghu National Scenic Area Administration with the section director of the tourism central authority. For the academic members, this study added an assistant professor in the leisure management department of Mingxin University of Science and Technology, and the director of the Taiwan Leisure Agriculture Association (**Table A2**).

## Identification of the Service System of Traveling Indicators

The purpose of this article is to construct the service system of traveling in Penghu. Penghu is an island ecotourism area managed by the Penghu National Scenic Area Administration. Rose and Wall (1999) used tourism, local community, and environmental resources to construct the indicator on the service system of ecotourism. Sung (2003) has claimed that operating management can offer ecotourism activities, and the organization's target should change from "operating orientation" to "customer orientation" (Weng, 2014).

The researchers identified the first level of the target as the ecological tourists' service system. This study combines Sung's (2003) ecotourism system and Weng's (2014) service system to comprise four dimensions, which are marine environmental resource, local community, operating system, and island tourist activity.

Marine environmental resources consist of resources such as biodiversity, resources in substitutability, resource rareness, ecological originality, ecological suitability, and environmental protection (Rose and Wall, 1999; Sung, 2003). The local community, or residents, support ecotourism by utilizing operating intention, attitude, resource utilization, and the fund of feedback to the local community (Sung, 2003), it involves operation aspiration, community and resource co-prosperity, growing revenue, community stability, and developing the community. The operating system defined as the local organization can manage transportation safety, maintain the interpretation system, communicate efficiency to the resident, protect the environmental resource, and improve the service quality (Sung, 2003; Weng, 2014). The operating system included island-to-island communication, traffic transportation, safety management, environmental quality, interpretation quality, and service quality. Island tourist activity is "the scope of the interaction process between tourist and resident in environmental conservation." (Sung, 2003). Tourist expectation, tourist satisfaction, participation in conservation, industry and conservation co-prosperity, the integrity of package

tours, tourism industry, and corporate social responsibility comprise island tourist activities (Sung, 2003; Weng, 2014; **Table 1** and **Figure 4**).

In this study, the fuzzy analytical hierarchy process (Buckley, 1985) was used to find the fuzzy weights because it is easy to implement and is reliable. Essentially, FAHP is used to determine the weights of multiple criteria through pairwise comparison, the weights of importance of the criteria were first determined by the decision-maker and then sub-criteria were pulled using pairwise comparisons. The criteria/sub-criteria were first distinguished using a cumulative frequency distribution function, which involved the acceptable maximum  $[F1(x)]$  and minimum  $[F2(x)]$  of indicator identity, respectively. Then the values of the first quartile, median, and third quartile in  $F1(x)$  and  $F2(x)$  were calculated and named as  $(C1, M1, D1)$  and  $(C2, M2, D2)$ , respectively. Finally,  $(C1, D1)$  and  $(C2, D2)$  were used to measure the importance of criteria,  $X^*$ . The linguistic scale and corresponding triangular fuzzy numbers  $(C1, M1, X^*)$  were identified to be "just equal" by  $(1, 1, 1)$ , "equally important" by  $(1, 1, 3)$ , "weakly important" by  $(1, 3, 5)$ , "essentially important" by  $(3, 5, 7)$ , "very important" by  $(5, 7, 9)$ , and "absolutely important" by  $(7, 9, 9)$ . The threshold value "S" needs to be 7 or higher for the individual indicator (Saaty, 1980; Buckley, 1985; Kaganski et al., 2018).

## Survey Questionnaire

The questionnaires were divided into two categories: the expert questionnaire of the FDM for the construction of the indicators of the ecological tourism service system in the Penghu National Scenic Area; and the expert questionnaire of the hierarchical analysis method for the construction of the indicators of the ecological tourism service system in the Penghu National Scenic Area.

The expert questionnaire of the FDM was designed by reviewing the literature and developing the 4 dimensions and 24 indicators of the Penghu National Scenic Area ecotourism service system index. Each indicator had its own explanation, so that the respondents could understand the meaning and get the most appropriate opinions. The fuzzy theory was used to solve the group decision problem, and the selection of indicators was carried out to solve the problem of ambiguity in expert consensus.

The importance of the indicators was measured on a scale of 0–10, with higher scores indicating greater importance. Each factor was evaluated with three values: the "best value" of importance; and the "minimum" and "maximum" values of acceptable range.

The expert questionnaire of the hierarchical analysis method was designed based on the results of the first stage of the FDM. After removing the indicators that did not fit the criteria, the constructed and obtained indicators were used in the second round of the expert questionnaire design by the hierarchical analysis method. The terms marine environmental resource, local community, operating system, and island tourist activity



**TABLE 1** | The dimension and factors employed in assessing the ecological tourists service system.

Dimension	Indicator	Description	Reference
Marine environmental resource	Biodiversity	Animal, plant, and ecological diversity of marine, coastal, and wetland systems.	Rose and Wall, 1999; Sung, 2003
	Resources in substitutability	The ecological resources, natural resources, and cultural resources are representative.	
	Resources rareness	Rarity of the species or landscape.	
	Ecological originality	The original extent to which natural or cultural resources are maintained.	
	Ecological suitability	Appropriateness of the area used for the tour.	
Local community	Environmental protection	The facilities of environmental protection, the system of environmental monitoring, and the degree of marine pollution control.	Sung, 2003
	The operation aspiration	Local communities initiate activities to solve ecotourism problems independently.	
	Community and resource co-prosperity	The attitude of local residents toward environmental resources has a positive effect on future development.	
	Feedback fund to the community	Ecotourism tour revenue can contribute to the conservation fund.	
	Growing revenue	Ecotourism development can provide local residents with employment opportunities and appropriate income.	
Operating system	Community stability	The growth of income is in line with the current price level; satisfaction with the provision of appropriate employment opportunities; increase in industrial structure diversity; and community welfare enhancement.	Sung, 2003; Weng, 2014
	Developing the community	Integration of community management programs and ecotourism activities, including training and technical assistance to the community.	
	Island-to-island communication	The communication degree of strategy, technology, and information between the islands.	
	Traffic transportation	Accessibility of inter-island public transportation system.	
	Safety management	Island planning safety activity locations, safety of tour facilities, and warning signs in dangerous areas.	
	Environmental quality	Ecotourism site's recreation project, accommodation and dining facilities, water supply and electricity supply facilities, telecommunication facilities, public toilet facilities; animal, plant, and water resources maintenance and management capabilities; environmental cleanliness, and garbage sorting and disposal completeness.	
	Interpretation quality	Completeness of interpretation staffing, interpretation publications, and interpretation board configuration.	
Service quality	Evaluation of ecological tour interpretation services, number of ecological experience activities, diversity of tour packages, customer relationship management, and service quality certification.		
Island tourist activity	Tourist expectation	Assessment of visitors' expectations for ecotourism experience.	Sung, 2003; Weng, 2014
	Tourist satisfaction	Visitors' satisfaction with ecotourism experience or services should focus on five factors: accessibility, service quality, landscape and environment, organization and personnel, and price.	
	Participate in conservation	Evaluating tourist initiatives in ecotourism conservation activities.	
	Industry and conservation co-prosperity	The level of environmental conservation through ecotourism activities.	
	The integrity of package tours	To provide tourists with ecological tour planning and related information.	
	Tourism industry corporate social responsibility	The participation of enterprises in community development projects or public utilities, the relationship between enterprises and the community, and the proportion of community residents among employees.	

were constructed by level 2. Twenty-four indicators were constructed on level 3.

Each indicator used a pairwise comparison approach, values from 1 to 9 were used as the evaluation scale to find the relative importance of each one. If the two indicators had the same importance, the participants assigned

a value of 1 to this comparison, while a 9 represented the absolute importance of one criterion over the other (Saaty, 1994).

The first round expert questionnaire survey was conducted from April 12, 2016 to April 25, 2016 and the second round from April 27, 2016, to May 13, 2016. For the experts to understand the

**TABLE 2** | The average value of ecotourism service system indicators in the Penghu National Scenic Area.

Target (level 1)	Dimension (level 2)	Factors (level 3)	Average		
			Min	Middle	Max
Ecological tourists service system	Marine environmental resource	Biodiversity	7.58	8.83	9.08
		Resources in substitutability	6.75	7.08	8.25
		Resource rareness	7.00	7.58	8.33
		Ecological originality	7.42	8.33	8.42
		Ecological suitability	6.17	6.58	7.17
	Local community	Environmental protection	6.83	7.67	8.25
		The operation aspiration	6.67	8.42	8.75
		Community and resource co-prosperity	5.92	7.08	7.25
		Feedback fund to the community	7.17	7.58	7.83
		Growing revenue	6.67	7.25	7.75
		Community stability	6.67	7.25	7.42
		Developing the community	5.33	6.17	6.42
	Operating system	Island-to-island communication	6.58	7.08	7.33
		Traffic transportation	8.42	8.67	9.08
		Safety management	8.83	9.08	9.25
		Environmental quality	8.25	8.67	8.92
		Interpretation quality	7.17	7.58	8.17
		Service quality	8.00	8.42	8.67
		Tourist expectation	5.92	6.58	6.92
	Island tourist activity	Tourist satisfaction	7.92	8.42	8.58
Participate in conservation		7.25	7.58	8.17	
Industry and conservation co-prosperity		7.17	7.58	8.08	
The integrity of package tour		7.67	8.08	8.67	
Tourism industry corporate social responsibility		6.67	7.08	7.42	

contents of the expert questionnaires, the authors went to Penghu for both rounds.

## RESULTS AND DISCUSSION

### Indicator Selection

In the first stage of this article, an expert survey was conducted using the FDM to find the minimum, middle, and maximum values of the 24 indicators.

The experts ranked the indicators in order of importance as “safety management capability” (9.08), followed by “biodiversity” (8.83), “traffic and transportation” (8.67), “environmental quality” (8.67), “operation aspiration” (8.42), “service quality” (8.42), and “tourist satisfaction” (8.42).

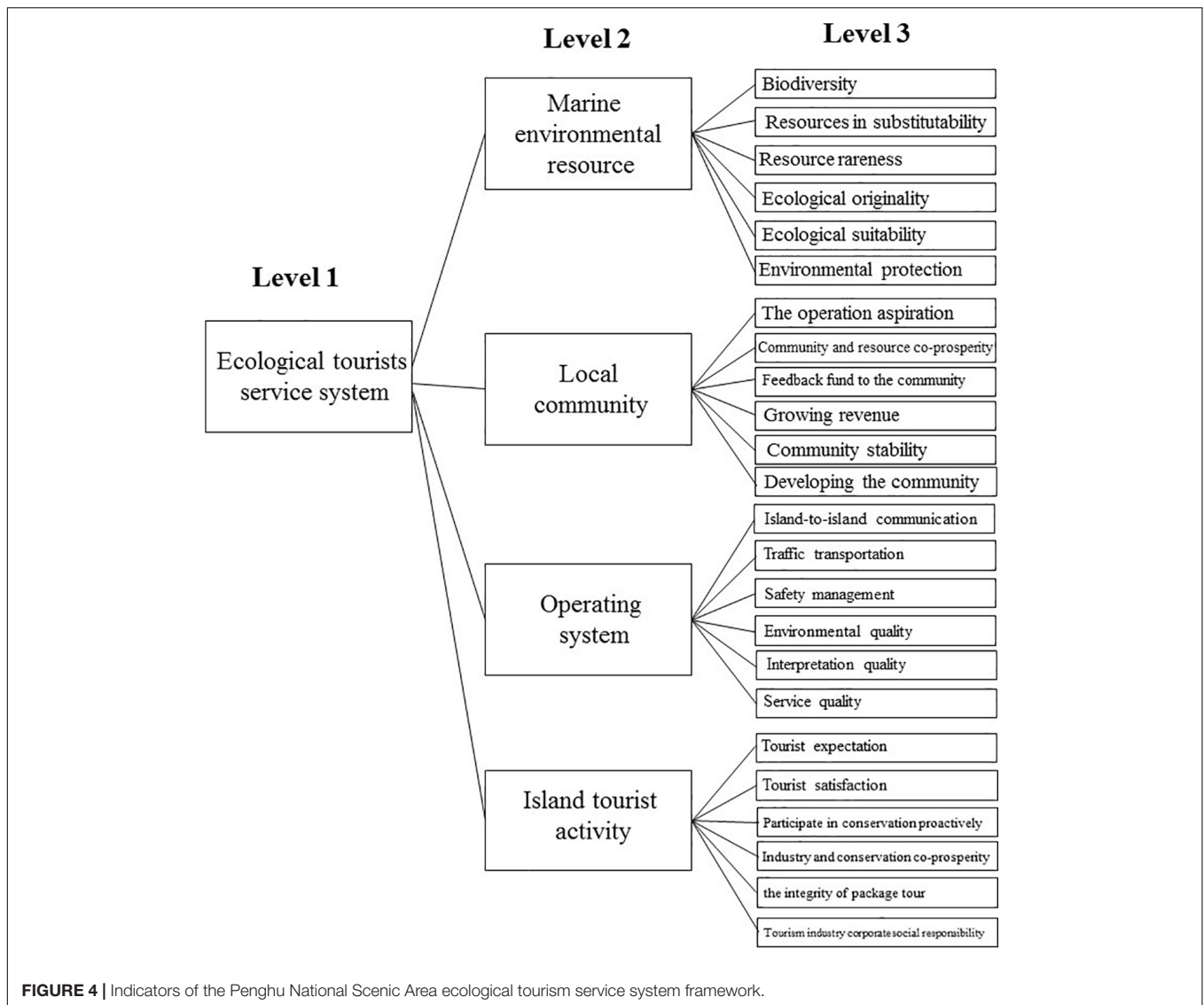
The results showed that the average value of the 24 indicators ranged from 5.00 to 9.00 in this study. Saaty (1980); Buckley (1985), and Kaganski et al. (2018) indicated that threshold values must be over 7.00 for the indicator to be considered. From the results shown in **Table 2**, safety management and biodiversity were found to be “absolutely important” indicators with scores of 9.

“Ecological suitability” (6.5), “developing the community” (5.0), and “tourist expectation” (6.5) were removed from the first round of the fuzzy Delphi survey because their value was below the threshold value. The Penghu National Scenic Area does not

regulate recreational carrying capacity. However, this concept is very important to maintain marine environmental resources. There are 93 local community associations in the Penghu National Scenic Area. Wang-An has an advanced community association, but the tourism business does not provide technical assistance to the community (Chao and Chao, 2017). For tourist expectation, tourist expectations come from past experience, external communication, word-of-mouth communication, and destination image (Rodríguez-del-Bosque et al., 2009; Jusoh et al., 2015). Thus, there is a strong causal relationship between expectation and satisfaction. In other words, satisfaction is the difference between expectation and reality. However, the Penghu National Scenic Area does not yet have a clear ecotourism standard, and tourists’ expectation is mainly mass tourism; they do not have an impression of Penghu ecotourism. The majority of tourists participated in water activities such as snorkeling, swimming, and surfing. The tourists do not have clear expectations of ecotourism in Penghu. Therefore, satisfaction is an indicator of ecotourism in Penghu.

### Results of Main Dimension

Fuzzy AHP has been used to determine the weights of each dimension concerning the goal and is presented in **Figure 4**. The results are shown in **Table 3**, where the most critical dimension is marine environmental resource (0.449) followed by operating



**TABLE 3 |** Analysis of the relative critical dimensions in the main dimension.

Ecological tourists' service system in the Penghu National Scenic Area	Weight	Ranking
Marine environmental resource dimension	0.449	1
Local community dimension	0.150	3
Operating system dimension	0.253	2
Island tourist activity dimension	0.148	4

C.R. = 0.011; C.I. = 0.010;  $\lambda_{max}$  = 4.031.

*CI = 0.010 < 0.1 means a consistent overall judgment; CR = 0.011 < 0.1 means the consistency of the display matrix is satisfactory.*

system (0.253), local community (0.150), and island tourist activity (0.148).

The experts believed that marine environmental resources are the primary indicator for constructing the

**TABLE 5 |** Key indicators of marine environmental resources.

Sub-criteria on marine environmental resources	Weight	Rank
Biodiversity	0.266	1
Resources in substitutability	0.152	5
Resources rareness	0.193	3
Ecological originality	0.181	4
Environmental protection	0.208	2

C.R. = 0.009; C.I. = 0.009;  $\lambda_{max}$  = 5.039.

*CI < 0.1 indicates a consistent overall judgment; CR < 0.1 means the consistency of the display matrix is satisfactory.*

service system of the Penghu National Scenic Area. Rich marine resources are key to developing ecotourism in the Penghu National Scenic Area. Marine resources can be designed as experiential activities for tourists, resulting in tourism activities.

**TABLE 4 |** Evaluating secondary factor points from triangular fuzzy functions.

Target (level 1)	Dimension (level 2)	Factors (level 3)	C1	C2	D1	D2	X
Ecological tourists service system	Marine environmental resource	Biodiversity	9	8	7	9	9
		Resources in substitutability	7	9	5	7	7
		Resource rareness	7	9	5	8	7.5
		Ecological originality	8	6	7	9	8.5
		Ecological suitability	6	8	4	7	6.5
	Local community	Environmental protection	7	10	5	8	7.5
		The operation aspiration	8	9	6	9	8.5
		Community and resource co-prosperity	6	9	5	8	7
		Feedback fund to the community	6	10	5	9	7.5
		Growing revenue	7	9	4	7	7
	Operating system	Community stability	7	9	6	8	7.5
		Developing the community	5	8	4	5	5
		Island-to-island communication	7	9	3	7	7
		Traffic transportation	8	9	6	9	8.5
		Safety management	9	9	7	9	9
	Island tourist activity	Environmental quality	8	9	7	9	8.5
		Interpretation quality	7	9	6	8	7.5
		Service quality	8	9	6	9	8.5
		Tourist expectation	6	9	4	7	6.5
		Tourist satisfaction	8	6	7	9	8.5
	Participate in conservation	6	9	5	9	7.5	
	Industry and conservation co-prosperity	7	9	5	8	7.5	
	The integrity of package tour	8	9	6	8	8	
	Tourism industry corporate social responsibility	7	8	3	7	7	

**TABLE 6 |** Key indicators of local community.

Sub-criteria on local community	Weight	Rank
The operation aspiration	0.318	1
Community and resource co-prosperity	0.287	2
Feedback fund to the community	0.155	3
Growing revenue	0.105	5
Community stability	0.135	4

C.R. = 0.017; C.I. = 0.015;  $\lambda_{max}$  = 5.068.

*CI < 0.1 indicates a consistent overall judgment; CR < 0.1 means the consistency of the display matrix is satisfactory.*

Second in rank is the “operation system” criterion, an important indicator in the construction of the ecological tourism service system. The ecotourism operating system needs to balance tourism activities, resources and the environment, and residents. It is important to plan the resources properly to maximize the benefits.

Ranking third is the “local community” criterion. The local community has the closest relationship with local natural resources and cultural resources, and is the core of ecotourism development. Community participation is decisive in the success or failure of ecotourism development, and can be more effective with community operation and participation.

Fourth in rank is the “island tourism activity” criterion, in which ecotourism is a nature-based tourism model that

enables visitors to cherish and care for local resources through tourism planning.

### Results of Factors

After removing ecological suitability, developing the community, and tourist expectation from the fuzzy Delphi survey, 21 indicators were kept for analysis. There are five, five, six, and five indicators respectively in the dimensions of marine environmental resource, local community, operating system, and island tourist activity (Table 4). The weight of these indicators was determined by Consistency Ratio (C.R.) and Consistency Index (C.I.) to ensure the reliability of the results.

#### Marine Environmental Resources

In this dimension, the result shows the weight of factors ranked as follows: biodiversity (0.266), environmental protection (0.208), resources rareness (0.193), ecological originality (0.181), and resources in substitutability (0.266). The C.R. and C.I. ratio values present 0.009 and 0.009, respectively, and the  $\lambda_{max}$  value is 5.039. This indicates a consistent judgment and that the consistency of the display matrix is satisfactory (Table 5).

#### Local Community

The result shows the weight of indicators ranked as follows: operation aspiration (0.318), community and resource co-prosperity (0.287), feedback to the community (0.155), community stability (0.181), and growing revenue (0.105). The C.R. and C.I. ratio values are 0.017 and 0.015, respectively, and the  $\lambda_{max}$  value is 5.068. This indicates a consistent

**TABLE 7** | Key indicators of operating system.

Sub-criteria on operating system	Weight	Rank
Island-to-island communication	0.060	6
Traffic transportation	0.192	3
Safety management	0.227	2
Environmental quality	0.254	1
Interpretation quality	0.117	5
Service quality	0.150	4

C.R. = 0.012; C.I. = 0.009;  $\lambda_{\max}$  = 6.061.

*CI < 0.1 indicates a consistent overall judgment; CR < 0.1 means the consistency of the display matrix is satisfactory.*

**TABLE 8** | Key indicators of island tourist activity.

Sub-criteria on island tourist activity	Weight	Rank
Tourist satisfaction	0.089	5
Participate in conservation proactively	0.226	2
Industry and conservation co-prosperity	0.356	1
Tourism comprehensive	0.183	3
Tourism industry corporate social responsibility	0.146	4

C.R. = 0.005; C.I. = 0.005;  $\lambda_{\max}$  = 5.022.

*CI < 0.1 means a consistent overall judgment; CR < 0.1 means the consistency of the display matrix is satisfactory.*

overall judgment and satisfactory consistency of the display matrix (**Table 6**).

### Operating System

The result shows the weight of indicators ranked as follows: environmental quality (0.254), safety management (0.227), traffic transportation (0.192), service quality (0.150), interpretation quality (0.117), and island-to-island communication (0.060). The C.R. and C.I. ratio values are 0.012 and 0.009, respectively, and the  $\lambda_{\max}$  value is 6.061. This indicates a consistent overall judgment and satisfactory consistency of the display matrix (**Table 7**).

### Island Tourist Activity

For the island tourist activity perspective, the result shows the weight of indicators ranked as follows: industry and conservation co-prosperity (0.356), participate in conservation proactively (0.226), tourism comprehensive (0.183), tourism industry corporate social responsibility (0.146), and tourist satisfaction (0.089). The C.R. and C.I. ratio values are 0.005 and 0.005, respectively, and the  $\lambda_{\max}$  value is 6.061, it indicates a consistent overall judgment and satisfactory consistency of the display matrix (**Table 8**).

### Results of Overall Indicators

In this study, the dimension and factors are combined to calculate the overall weights as results, in which the most essential factor is biodiversity (0.119), follow by environmental protection (0.093), resources rareness (0.087), ecological originality (0.081), resources in substitutability (0.068), environmental quality (0.064), safety management (0.057), industry and conservation co-prosperity (0.053), traffic transportation (0.049), and

operational aspiration (0.048). All C.R. and C.I. ratio values achieved the decision value, indicating a consistent judgment and satisfactory consistency of the display matrix (**Table 9**).

## Discussion

### Importance Factors for Ecological Tourists Service System

Most of the experts considered safety management and biodiversity as critical indicators. Hauber and Zandbergen (1996) argued that when tourists select a destination, their safety needs to be ensured. Secure safety management can encourage more tourist activities and enhance ethical tourism (Chang and Wu, 2014). Ng et al. (2017) applied FAHP on Tioman Island in Malaysia and concluded that the most crucial factor was biodiversity.

The weights of the indicators for the tourist service system in Penghu were determined using the AHP with references from 18 experts. The relative weights of the three levels of 4 dimensions and 21 indicators were calculated. This article combined the weights between the second and third levels. The results show that biodiversity (0.119) had the highest weight among environmental protection (0.093), resources rareness (0.087), and ecological originality (0.081); resources in substitutability (0.068) was assessed in terms of marine environmental resource. Wardani et al. (2017), examining ecotourism in nature-based tourism, identified the critical success factor on the East Java Island in Indonesia as the marine environmental resource. Yu et al. (2015) argued that protecting marine resources has a positive impact on tourism. Chao and Chao (2017) provided residents with the need to protect the local environment and design more ecotourism activities to gain more revenue.

The lowest weight indicators were tourist satisfaction (0.013), island-to-island communication (0.015), growing revenue to the community (0.016), stabilizing the community (0.020), and tourism industry CSR (0.022). Chao and Chao (2017) investigated the resident and visitor perceptions of the Wang-An Islands (green sea turtle), and pointed out the gap between visitors and residents; the resident could not provide tourist products or services to satisfy the visitors. For island-to-island communication, island resources can be shared with other islands, and each island can partner with other islands when setting multiple-day tours or designing long-term travel options (Tuan, 2016). To grow revenue and to stabilize the community, United Nations World Tourism Organization (2015) created the SDG criteria to measure the effect of sustainable tourism on the economic growth of the local community. Kontogeorgopoulos and Chulikavit (2010) pointed out that ecotourism can provide jobs and generate revenue for the community. Chao and Chao (2017) suggested that residents need to understand their environmental resources. Ng et al.'s (2017) research on Tioman Island in Malaysia argued that tourism CSR improves tourists' perception of environmental protection.

For the local community, the highest weight indicators were operational aspiration (0.048) and community and resource co-prosperity (0.043). Kutay (1991) illustrated that operational aspiration enhanced the community, and resource

**TABLE 9** | The different level weight ratios of the ecosystem service system in the Penghu National Scenic Area.

Target	Weight of dimension (a)	Weight of Factor (b)	Weight (a) × (b)		
Ecological tourists service system	Marine environmental resource (0.449)	Biodiversity (0.266)	0.119		
		Resources in substitutability (0.152)	0.068		
		Resources rareness (0.193)	0.087		
		Ecological originality (0.181)	0.081		
		Environmental protection (0.208)	0.093		
		CR = 0.009; CI = 0.009; $\lambda_{max}$ = 5.039			
	Local community (0.150)	Operation aspiration (0.318)	0.048		
		Community and resource co-prosperity (0.287)	0.043		
		Feedback fund to the community (0.155)	0.023		
		Growing revenue (0.105)	0.016		
		Community stability (0.135)	0.020		
		CR = 0.015; CI = 0.017; $\lambda_{max}$ = 5.068			
	Operating system (0.253)	Island-to-island communication (0.060)	0.015		
		Traffic transportation (0.192)	0.049		
		Safety management (0.227)	0.057		
		Environmental quality (0.254)	0.064		
		Interpretation quality (0.117)	0.030		
		Service quality (0.150)	0.038		
			CR = 0.009; CI = 0.012; $\lambda_{max}$ = 6.601		
		Island tourist activity (0.148)	Tourist satisfaction (0.089)	0.013	
Participate in conservation proactively (0.226)			0.034		
Industry and conservation co-prosperity (0.356)			0.053		
Tourism comprehensive (0.183)	0.027				
Tourism industry corporate social responsibility (0.146)	0.022				
	CR = 0.005; CI = 0.005; $\lambda_{max}$ = 5.022				

CI < 0.1 indicates a consistent overall judgment; CR < 0.1 means the consistency of the display matrix is satisfactory.

co-prosperity could encourage residents to protect and upgrade environmental quality, revitalize old structures, and conserve their local culture (United Nations World Tourism Organization, 2015). For the operating system, environmental quality (0.064) ranked first, above safety management (0.057), and traffic transportation (0.049). Harry (2017) pointed out that tourists prefer a high quality and clean environment. Chiu et al. (2014) investigated ecotourism and pointed out that good environmental quality leads to ecotourism; thus, it needs to maintain high environmental quality (Chen, 2015). Lin (2008) pointed out that excellent traffic transportation is a critical factor in ecotourism, and for island tourist activities, industry, and conservation co-prosperity (0.053). Chao and Chao (2017) identified that resident participation is a crucially important factor; upgrading the participation aspiration of residents can improve the economy.

### Managerial Implications

#### *Emphasis on the importance of biodiversity to improve the quality of the marine resource*

For the sustainable development of island ecotourism, biodiversity is essential (Hunt and Vargas, 2018). Bhuiyan et al. (2015) argued that the resource has a positive influence on community and tourism in Kenyir Island. Chang and Wu (2014) argued that biodiversity is an essential factor for coastal ecotourism, when they applied the FDM. To address

the conservation of marine resources, it is very important for people to maintain friendly ecotourism traveling and reduce the conflict of ecotourism. Therefore, tourists need to display actually protective environmental behavior, such as smaller-scale traveling and carrying toiletries by themselves, to deeply experience local environmental activities (Chao and Chao, 2017). At the same time, stakeholders and residents need to improve their local environmental protection awareness and knowledge, and then share it with the tourists.

#### *Promote the participation of stakeholders and local communities to increase ecotourism*

Many benefits are realized when the local community, stakeholders, and tourists interact in the course of ecotourism activity, interpretation, and sightseeing. Therefore, the community's willingness to participate has a considerable influence on ecotourism. The community can integrate tourism development with community development and environmental protection, protect the resources, and promote the economic development of the community at the same time (Bhuiyan et al., 2015; Hayes et al., 2015; Chao and Chao, 2017).

#### *Construct the safety management system to sustain ecotourism development*

Ecotourism is a relationship between the local community and tourists. To ensure the safety of tourists, Wang (2015)

constructed management indicators in Penghu Island that covered traffic, recreation, accommodation, sanitation, and shopping. Thus, the local community need to consider natural safety to prevent climate change; biological safety for protection against toxic plants and dangerous animals; avoidance of unplanned travel near steep slopes, narrow roads, and cliffs; and educating residents and tourists about safety.

#### ***Keep environmental conservation in the guideline of tourist activity***

The sustainable development of ecotourism relies on rich natural resources. Residents need to have an environmental concern and awareness to find a balance between tourists and the surroundings. Hayes et al. (2015) argued that the resources can be used to develop ecotourism, which can bring economic benefits for residents and for the environment (Chao and Chao, 2017). More residents are building ecological, physical, facility, and social capacity to benefit tourists (Shelby and Heberlein, 1984) and protect the environment.

#### ***Encourage local communities to promote ecotourism***

Ecotourism development attaches great importance to the participation of local communities in planning and management. Local communities are the key to protection, economic benefits, and social benefits (Kutay, 1991; Chao and Chao, 2017). The government should encourage and establish a business standard, protecting contracts and cooperation that can support sustainable ecotourism development in local communities, and also respect nature and the residents.

#### ***Improve tourist satisfaction***

The local residents preserve the island environment, develop ecological experience activities, and pay attention to service quality. Island tourists' satisfaction and revisit willingness comes from the factors: island natural beauty, local history and culture, hospitality, safety, facilities, and services, etc. (Truong and King, 2009). Moon and Han (2018) used Jeju Island to show that environmental resources and accessibility have a positive impact on tourists' experience and satisfaction.

### **Policy Implications**

#### ***The government needs to support the local resource inventory and provide guidelines for marine resource protection***

The government should be able to support the local resource inventory, divide ecotourism into core protected areas, and buffer recreational areas and intensive recreation areas. To reach the three-level environmental requirements, the environmental impact of visitor activities should be reduced, a high-quality tourism experience should be provided, and a damaged natural ecological environment should be protected and restored. The government should consider maintenance, restraint, binding, participation, and active policy support to implement environmental monitoring mechanisms. To enhance marine ecological protection, destruction of biodiversity should be avoided. Wardani

et al. (2017) argued that the government needs to guide stakeholders in managing their marine resources. Increasing marine biodiversity and establishing measures to protect marine resources can help the industry to maximize its economic, social, and environmental benefits in developing sustainable ecotourism.

#### ***The government constructs a normative plan for the ecotourism promotion service system***

The government should formulate a clear and specific management mechanism for ecotourism development, provide guidance for operators, and monitor progress in the environment, society, economy, and culture to maximize the benefits.

The government should prioritize environmental quality management practices to reduce marine waste. Provision should be made for accommodation and catering, water and power supply, telecommunications, and public toilets. Penghu ecotourism has rich natural resources but is more unsafe than other scenic spots; therefore, ecotourism for safety management is a key responsibility.

#### ***The government needs to improve the infrastructure in safety management and transportation***

The government should take the primary core resources of ecotourism as a starting point for creating a complete safety management system that includes integrated prevention, rescue, and after-care work. The transportation capacity of the Penghu National Scenic Area is limited, the busses run infrequently, and the information for maritime transportation is difficult to obtain. Many visitors must take private transportation to the island. This is not in line with international standards. The government should provide free-shipping classes to provide residents and tourists with a wide choice and make information on transportation services more easily available for tourists. In short, these factors provide the elements for successful ecotourism management. Yusof et al. (2014) applied the service quality models to ecotourism in Malaysia and argued for the need to refine the service system model.

## **CONCLUSION**

This study has several important theoretical implications. First, this study applying the fuzzy AHP method to establish the indicators for the tourist service system of the Penghu National Scenic Area based on the island ecotourism perspective. Second, we reviewed articles about island tourism, ecotourism, and tourist service systems, and tried to find dimensions such as marine environmental resource, local community, island tourist activity, and operating systems. The key factors of island ecotourism are marine environmental resources, notably biodiversity. Protecting marine environmental resources could

develop island ecotourism. Third, we identified the model to develop island ecotourism in the early steps of the decisional process guide. In this case, the Penghu National Scenic Area has three ecotourism systems and many resources to attract tourists. This ecotourism indicator framework can be applied to other islands or protected areas, especially in popular tourist destinations, such as Bali Island, Jeju Island, and Tioman Island.

This study still has some limitations, which need to be considered in future research. This study was undertaken in the Penghu National Scenic Area. It is recommended to generate other studies on other islands. In the study, only 18 experts were consulted; the inclusion of more experts would produce significant results.

This study used fuzzy AHP to establish island ecological indicators in the Penghu National Scenic Area. In future research studies, fuzzy-based MCDM methods such as ANP, DEA, ELECTRE, TOPSIS, and VIKOR can be applied to similar problems. The results could be compared to those of this study to determine an island's ecological indicators.

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## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

## ETHICS STATEMENT

Ethical review and approval was not required for this study with human participants, in accordance with the local legislation and institutional requirements.

## AUTHOR CONTRIBUTIONS

CH contributed to the data analysis and drafting of the manuscript. CK contributed to significant revisions of the manuscript. CT contributed to the concept construction design of the manuscript.

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## APPENDIX

**TABLE A1** | Fuzzy Delphi method members' background for the first round.

Categories	Affiliation	Position	Job tenure	Principle*
Industry	Tongliang Community Development Association in Baisha Township	Executive director	20	(2)
	Erkan Community Development Association in Xiyu Township	Chairman	30	(2)
	Penghu Qimei Ocean Ecology Care Association	Chairman	20	(1), (3)
	HuaHsin Travel service company	General manager	25	(1)
Government	Department of Leisure, Penghu National Scenic Area administration	Supervisor	17	(4)
	Department of Management, Penghu National Scenic Area Administration	Senior coordinator	12	(4)
	Department of the Northern Sea, Penghu National Scenic Area Administration	Chairman	15	(5)
	Tourism Promotion Section, Penghu County Government	Senior coordinator	10	(6)
Expert	Department of Agribusiness Management, National Pingtung University of Science and Technology	Professor	30	(8)
	Department of Forestry, National Pingtung University of Science and Technology	Associated professor	11	(8)
	College of Tourism and Leisure, National Penghu University of Science and Technology	Dean	20	(7)
	Department of Leisure and Sport Management, Cheng Shiu University	Assistant professor	10	(9)

*\*(1) Local tourism operators; (2) representatives of local associations; (3) ecotourism operators; (4) director of the Tourism Bureau; (5) fishery supervisor; (6) county government authorities; (7) island tourism experts; (8) ecotourism experts; (9) tourism experts.*

**TABLE A2** | Fuzzy Delphi method members' background for the second round.

Categories	Affiliation	Position	Job tenure	Principle*
Industry	Tongliang Community Development Association in Baisha Township	Executive director	20	(2)
	Erkan Community Development Association in Xiyu Township	Chairman	30	(2)
	Penghu Qimei Ocean Ecology Care Association	Chairman	20	(1), (3)
	HuaHsin Travel service company	General manager	25	(1)
	Shili Community Development Association in Penghu City	Chairman	15	(2)
	Penghu Ecotourism Association	Execute manager	16	(1), (3)
Government	Department of Management, Penghu National Scenic Area Administration	Senior coordinator	12	(4)
	Department of the Northern Sea, Penghu National Scenic Area Administration	Chairman	15	(5)
	Tourism Promotion Section, Penghu County Government	Senior coordinator	10	(6)
	Technical Section, Taiwan Tourism Bureau	Section director	21	(4)
	Fishery Research Institute in Penghu	Associate research fellow	19	(5)
	Department of the Wan-An, Penghu National Scenic Area administration	Chairman	15	(5)
Expert	Department of Agribusiness Management, National Pingtung University of Science and Technology	Professor	30	(8)
	Department of Forestry, National Pingtung University of Science and Technology	Associated professor	11	(8)
	College of Tourism and Leisure, National Penghu University of Science and Technology	Dean	20	(7)
	Department of Leisure and Sport Management, Chen Shiu University	Assistant professor	10	(9)
	Department of Leisure Management, Mingxin University of Science and Technology	Assistant professor	15	(7)
	Taiwan Leisure Agriculture Association	Director	12	(9)

*\*(1) Local tourism operators; (2) representatives of local associations; (3) ecotourism operators; (4) director of the Tourism Bureau; (5) fishery supervisor; (6) county government authorities; (7) island tourism experts; (8) ecotourism experts; (9) tourism experts.*