

## Article

# Performance Indicator Framework for Evaluation of Sustainable Tourism in the Taiwan Coastal Zone

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**Abstract:** Surrounded by the ocean, Taiwan has been increasingly developing coastal tourism projects. Concerns that negative impacts might be brought about by prosperous tourism have resulted in a recent focus on sustainable tourism. Sustainable tourism involves policies that acknowledge the interdependences among the environment, the community, and the economy. The goal of sustainable tourism is to enhance and protect the environment while satisfying basic human requirements, as well as those of the contemporary and future tourism industries to improve quality of life. On the other hand, unsustainable coastal tourism might undermine the natural environment and society, resulting in air, water, and soil pollution, wildlife habitat disruption, and changes of local community cultural characteristics. Therefore, performance evaluation of coastal tourism, using an indicator framework to facilitate sustainable development and enhance the effectiveness of coastal resources exploitation, is critical. Through a literature review and expert surveys using the methods of the fuzzy Delphi method (FDM) and the fuzzy analytic hierarchy process (FAHP), this study builds a performance indicator framework and identifies the key factors affecting the sustainable development of coastal tourism in Taiwan. The results can serve as a reference for the public sector to be used for the sustainable planning and development of coastal tourism.

**Keywords:** sustainable coastal tourism; performance indicator framework; fuzzy Delphi method; fuzzy analytic hierarchy process

## 1. Introduction

The tourism industry in Taiwan is growing at a fast pace. The Taiwanese government continuously encourages the development of the tourism sector to boost economic revenues. Since Taiwan is an island, the development of coastal tourism is crucial for the tourism industry as a whole. Coastal areas contribute greatly to sustain people's lives and lifestyles, such as by providing food, materials, shelter, and recreational amenities. In 1992, the United Nations proposed Agenda 21, which described the marine environment as part of the life-support system of Earth. However, if the coastal environment is a very valuable asset for human development, it is also very vulnerable [1]. Inappropriate planning can damage natural resources and negatively affect coastal communities. To ensure sustainability, it is of utmost importance to develop tools that seek the implementation of careful tourism planning.

Sustainable tourism planning for coastal areas aims at monitoring changes in the coastal zone and adjusting strategies so that a balance can be found between economic, environmental, and societal aspects. There is no recipe for reaching this balance but rather a conceptual framework from which planning procedures and appropriate management methods can be derived to sustainably develop

the coastal area, preserve natural resources and culture, while incorporating tourism activities and facilities that satisfy tourists' experiences [2].

Taiwan, which encompasses a group of islands, is situated between longitudes  $120^{\circ}$  and  $122^{\circ}$  E and between latitudes  $22^{\circ}$  and  $25^{\circ}$  N. The main island is surrounded by the Pacific Ocean to its east and the Taiwan Strait to its west. Being 377 km long along the north–south direction and 142 km wide along the east–west direction, the main island has approximately 1200 km of coastline. Adding the Penghu archipelago leads to a total coastline of approximately 1520 km. Most of these coasts have sandy beaches, which support very diverse recreational activities and encourage tourism development. Facing the increasing pressure of coastal tourism on local communities and the environment, action should be taken now.

The present study aims to develop a performance indicator framework for the evaluation of coastal tourism sustainability. The framework is intended to provide a holistic view focused on balancing environmental conservation, economic development and socio-cultural harmony, by building a set of indicators. Using such an approach allows for the evaluation of current tourism development plans and the formulation of strategies that seek sustainability. The results are expected to serve as a reference for public sectors and stakeholders.

## 2. Methodologies

### 2.1. Fuzzy Delphi Method (FDM)

Fuzzy set theory was proposed by professor Zadeh of the University of California, Berkeley, in 1965 [3]. Since traditional scientific methods ignore fuzziness and uncertainty existing in human life, Zadeh developed fuzzy set theory to address what human language cannot precisely describe or measure.

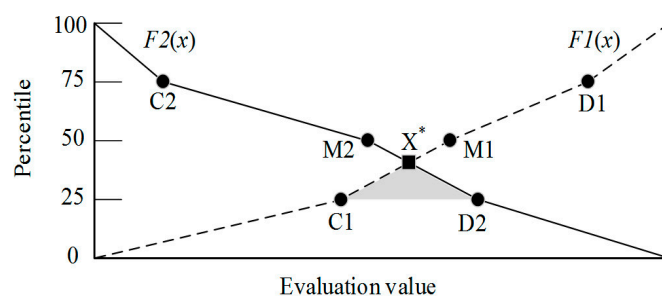
The Delphi method is an expert knowledge acquisition approach and a group decision-making method that aims at obtaining a consensus from an expert group regarding a specific issue. The Delphi method not only enables the collection of wide and numerous evaluation standards, but also maintains the quality of individual expert judgment [4]. However, since opinions are often expressed with adjectives such as “good” or “bad”, some level ambiguity is likely to result from the Delphi process. In order to lower the resulting uncertainty, the fuzzy Delphi method was proposed [5]. We chose to use the max-min fuzzy Delphi method proposed by Ishikawa et al. [6], for which the operation steps are listed as follows:

*Step 1:* Establish two cumulative frequency distribution functions for the value with the highest degree of agreement  $F1(x)$  and the value with the lowest degree of agreement  $F2(x)$ .

*Step 2:* Calculate the first quartile, median, and third quartile of  $F1(x)$  and  $F2(x)$ , which are represented by  $(C1, M1, D1)$  and  $(C2, M2, D2)$ , respectively.

*Step 3:* Connect  $(C1, M1, D1)$  and  $(C2, M2, D2)$  to obtain the target value  $X^*$  at the intersection.

The overlapped part  $(C1, X^*, D2)$  of the first quartile, median, and the third quartile of  $F1(x)$  and  $F2(x)$  shown in Figure 1 is known as the gray area.



**Figure 1.** Max–min FDM membership function and target value  $X^*$ .

After calculating the prediction value  $x_i$  of the evaluation factor  $A_i$  by using the FDM, we defined the threshold value  $S$  to screen for evaluation factors that satisfy the research requirements as follows:

- (1) If  $x_i$  is greater than or equal to  $S$ ,  $A_i$  is accepted as an evaluation factor; or
- (2) If  $x_i$  is lower than  $S$ ,  $A_i$  is rejected as an evaluation factor.

Threshold settings are dependent on distinct needs. By using the max–min FDM, the study was able to screen the preliminary performance indicators based on the experts' consensus for the subsequent weighting calculation.

## 2.2. Fuzzy Analytic Hierarchy Process (FAHP)

The purpose of the FAHP is to solve semantic fuzziness and uncertain judgment problems when experts are deciding relative importance in a conventional analytic hierarchy process (AHP). Incorporating the concept of fuzziness can formulate conceptual semantics mathematically. Since the logic of people's thinking is typically fuzzy, judgment is often made even if the condition and data are unclear. However, computers must operate based on numbers, which do not conform to the fuzzy thinking logic of human beings. Through the use of membership functions, the subjective judgment of people can be numeralized to facilitate more flexible processes in response to decision-making. Fuzzy sets can be used to express the sets containing things of a specific nature without a clear boundary or border. The goal of employing fuzzy sets is to address uncertainty and fuzziness in reality [7].

We used the concept of triangular fuzzy number, as shown in Figure 2, to replace the pairwise comparison of AHP proposed by Saaty [8]. Geometric means were then applied to calculate fuzzy weighting. This approach effectively solves the potential fuzzy problems during a criterion decision-making process [9]. For the FAHP, interval values were applied to replace exact values in the conventional AHP; thus, experts could evaluate problems from a user-friendly scale and provide reasonable comparison values during the decision-making process.

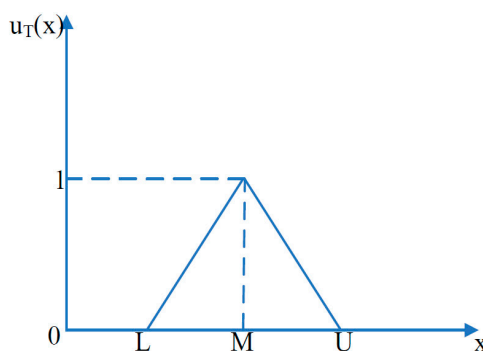


Figure 2. Triangular fuzzy number.

The detailed implementation procedure of the fuzzy pairwise comparison matrix was performed as follows. Triangular fuzzy numbers were extracted through the transformations described in Table 1 to convert the experts' opinions. After compiling and calculating the fuzzy numbers for each indicator's weight, the fuzzy weights were defuzzified to yield crisp weights, which were then normalized to yield a set of comparable weights for the indicators. Finally, a hierarchy of indicators was formulated. The public sector can apply the indicator framework to determine the priority of alternative coastal tourism development plans based on the performance scores. Additionally, the indicator framework articulates the importance of each indicator which influences the sustainable development of coastal tourism.

**Table 1.** Fuzzy evaluation scale.

| Semantic Lexicon                                 | Triangular Fuzzy Number |
|--|-------------------------|
| Equally important                                | $\tilde{1} = (1,1,1)$   |
| Between equally important and somewhat important | $\tilde{2} = (1,2,3)$   |
| Somewhat important                               | $\tilde{3} = (2,3,4)$   |
| Between somewhat important and important         | $\tilde{4} = (3,4,5)$   |
| Important  | $\tilde{5} = (4,5,6)$   |
| Between important and very important             | $\tilde{6} = (5,6,7)$   |
| Very important                                   | $\tilde{7} = (6,7,8)$   |
| Between very important and Extremely important   | $\tilde{8} = (7,8,9)$   |
| Extremely important                              | $\tilde{9} = (8,9,10)$  |

The detailed steps and calculation methods are listed as follows:

### 2.2.1. Determination of the Fuzzy Pairwise Comparison Matrix

If a conventional judgment matrix  $A = [a_{ij}]$  is a positive reciprocal, all numbers in the matrix become fuzzy numbers, instead of single values. The matrix then becomes the fuzzy positive reciprocal  $\tilde{A} = [\tilde{a}_{ij}]$ .

### 2.2.2. Calculation of Fuzzy Weightings

In accordance with Buckley [10], fuzzy weighting values were calculated using the geometric mean:

$$\tilde{z}_i = [\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \cdots \otimes \tilde{a}_{in}]^{1/n} \quad (1)$$

$$\tilde{w}_i = \tilde{z}_i \otimes (\tilde{z}_1 \oplus \tilde{z}_2 \oplus \cdots \oplus \tilde{z}_n)^{-1} \quad (2)$$

Among which

$\tilde{a}_{ij}$ :column  $i$  row  $j$  of matrix,  $i, j = 1, 2, \dots, n$ ;

$\tilde{z}_i$ :column vector mean value of fuzzy number,  $i = 1, 2, \dots, n$ ;

$\tilde{w}_i$ :weight of  $i$ -th indicator.

$\otimes$ : multiplication of fuzzy numbers  $\tilde{A} \otimes \tilde{B} = (a_1, b_1, c_1) \otimes (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2)$

$\oplus$ : addition of fuzzy numbers  $\tilde{A} \oplus \tilde{B} = (a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$

### 2.2.3. Defuzzification

The center of gravity method was applied to defuzzify weighting values as follows:

$$DF_i = (a + b + c) / 3 \text{ with } \tilde{w}_i = [a, b, c] \quad (3)$$

### 2.2.4. Normalization

The weighting value of each indicator  $i$  was normalized as follows:

$$NW_i = DF_i / \sum DF_i \quad (4)$$

### 2.2.5. Building the Global Weight of Each Indicator

After the preceding steps, weighting values of all dimensions and indicators were determined. To further identify the global weight of the  $j$ -th indicator in the bottom level under the  $i$ -th dimension, the calculation was conducted based on the hierarchical structure, as follows:

$$NW_j = NW_i \times NW_{ij} \quad (5)$$

### 3. Research Flow and Preliminary Indicator Framework

#### 3.1. Research Flow

The research flow is shown on Figure 3. After reviewing the literature on sustainable coastal tourism, we built a preliminary (stage 1) indicator set to cover the diverse aspects that were deemed important to include in the framework.

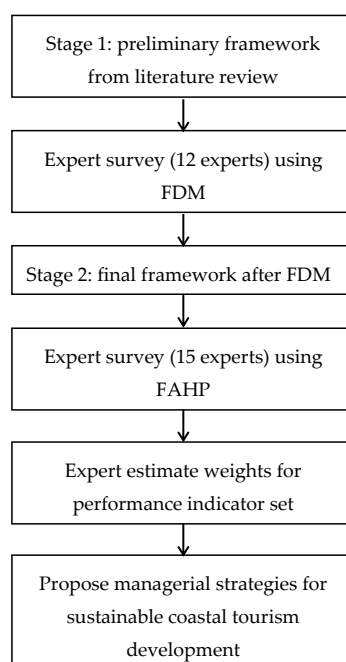


Figure 3. Study flowchart.

FDM was then applied to consolidate the initial framework with experts' opinions. Twelve experts from the academic, public, and private sectors were recruited during this phase. Details concerning the profiles of FDM experts are given in Table 2.

Table 2. FDM expert profiles.

| Service Domain | Organization   | Title                        | Expertise   |
|----------------|--|------------------------------|---|
| Public Sector  | District Office in a coastal city                              | District Chief               | Sustainable development planning in coastal area                          |
|                | District Office in a coastal city                              | District Chief               | Tourism industry development planning, and sustainability assessment      |
|                | District Office in a coastal city                              | Chief Secretary              | Sustainable coastal tourism development planning                          |
|                | National Scenic Area   | Director                     | Tourism industry development and management                               |
| Private Sector | Association to promote tourism/Coastal tourism related company | President/Chairman           | Coastal tourism industry development and management                       |
|                | Coastal tourism related company                                | Representative               | Coastal tourism industry development and management                       |
|                | Coastal Recreation Area  | Chief Executive Officer(CEO) | Regional sustainability planning  |
|                | Sailboat committee in a coastal city                           | Chairperson                  | Recreational industry development and management                          |
| Academic       | Department of Leisure and Recreation Management                | Associate Professor          | Recreational resources Planning and sustainable tourism development       |
|                | Department of Marine Leisure Management                        | Assistant Professor          | Oceanography and sustainability assessment                                |
|                | Department of Eco-science and Eco-technology                   | Associate Professor          | Environmental management and oceanography                                 |
|                | Department of Eco-science and Eco-technology                   | Professor                    | Planning and management of marine environment and sustainable development |

FDM induced modifications in the indicators set which led to the establishment of a (stage 2) final framework.

Another group of fifteen experts was consulted and FAHP was applied with them to calculate the weights for the indicators of the final framework. Details concerning the profiles of FAHP experts are given in Table 3.

**Table 3.** FAHP expert profiles.

| Service Domain | Organization  | Title                 | Expertise                                       |
|----------------|---|-----------------------|---|
| Public Sector  | Bureau of Urban Development in a coastal city                                   | Commissioner          | Regional sustainability planning                |
|                | Bureau of Urban Development in a coastal city                                   | Deputy Chief Engineer | Regional sustainability planning and management |
|                | Division Office in coastal city, Ministry of Economic Affairs                   | Director              | Regional economic development and planning      |
|                | Bureau of Land Administration in the coastal city                               | Commissioner          | Coastal geology                                 |
|                | Port Authority in the coastal city  | Senior Director       | Coastal tourism development and management      |
| Private Sector | Aquaculture Development Association in a coastal city                           | Chairman              | Marine resource planning                        |
|                | Industrial Development and Investment Promotion Committee in a the coastal city | Secretary-general     | Sustainable tourism development and planning    |
|                | Coastal tourism related company   | Representative        | Tourism industry development and management     |
|                | Port operation company in the coastal city                                      | Manager               | Coastal tourism development and planning        |
|                | Hotel in coastal zone   | Chairman              | Tourism industry development and management     |
| Academic       | Environmental Resources Research and Management Center                          | Researcher            | Environmental resource planning                 |
|                | Environmental Resources Research and Management Center                          | Researcher            | Oceanography and marine ecological conservation |
|                | Sustainable Environment Research Laboratory                                     | Researcher            | Sustainable development planning and management |
|                | Department of Architecture  | Associate Professor   | Regional sustainability planning                |
|                | Department of Architecture  | Associate Professor   | Regional sustainability planning                |

### 3.2. Preliminary Indicator Framework

The (stage 1) preliminary performance evaluation framework was organized into a framework covering six dimensions and twenty-nine indicators. According to the literature review, the sustainable coastal tourism needs to consider diverse criteria which were categorized into (a) environment and ecology, (b) economy and development, (c) society and culture, (d) tourism and recreational value creation, (e) management and policy, and (f) climatic conditions. Table 4 presents the contents of these dimensions and associated literature references. For each dimension, several indicators for performance assessment were selected. For example, the indicator “ecological planning”, “pollution prevention”, “environmental maintenance”, “ecological restoration system”, “environmental monitoring system”, and “landscape diversity” are related to the dimension “environment and ecology”.

**Table 4.** Dimension and contents of the preliminary (stage 1) indicator framework.

| Dimensions              | Dimension Contents   | References   |
|-------------------------|--|--------------|
| Environment and Ecology | <ul style="list-style-type: none"> <li>- Maintenance of the integrity of the ecological system;</li> <li>- Treatment and prevention of wastes and pollution caused by tourism;</li> <li>- Reduction of the damage and interference caused by the tourist activities;</li> <li>- Active remediation and restriction of access to damaged areas;</li> <li>- Performance of academic research and creation of an environmental monitoring system;</li> <li>- Planning and diversification of coastal and land use.</li> </ul>   | [11–17]      |
| Economy and Development | <ul style="list-style-type: none"> <li>- Increase of employment opportunities for local residents;</li> <li>- Financial subsidization and compensation for local residents;</li> <li>- Charging of the users and establishment of a development association and proper use of the funds;</li> <li>- Overall planning of local tourism industries.</li> </ul>   | [11–15]      |
| Society and Culture     | <ul style="list-style-type: none"> <li>- Upgrade of local medical and transportation systems and living quality;</li> <li>- Promotion and education of tangible wildlife conservation concepts;</li> <li>- Protection of local culture and industries;</li> <li>- Enhancement of social identification through tourism and environmental protection for local residents;</li> <li>- Training and development of local tourism personnel.</li> </ul>  | [11–15]      |
| Tourism value creation  | <ul style="list-style-type: none"> <li>- Cleanness and quality of tourism facilities;</li> <li>- Attitude of the tour guide toward service, quality, and training mechanisms;</li> <li>- Overall service quality of a restaurant, vender, and server;</li> <li>- Customer satisfaction with related activities;</li> <li>- Added value and quality of potential industries.</li> </ul>   | [12,18–20]   |
| Management and Policy   | <ul style="list-style-type: none"> <li>- Sound regulation stipulations and prohibition policies;</li> <li>- Reinforcement of executive abilities, and ban, and control policies;</li> <li>- Assistance from local coaches and guides with offering more tourism and recreation information;</li> <li>- Management efficiency for tourism and recreational activities and integration and planning of long-term management tasks;</li> <li>- Establishment of a dedicated management department;</li> <li>- Increase of the management subsidy and budget;</li> <li>- Local residents and owner involvement with stipulating related policies on management and remediation.</li> </ul> | [1,14–17,21] |
| Climatic conditions     | <ul style="list-style-type: none"> <li>- Hot and wet summer monsoon</li> <li>- styphoons</li> </ul>  | [22–24]      |

#### 4. Results and Discussion

The responses of the FDM questionnaire from twelve experts were used to finalize the stage 1 indicator framework. Following is an illustrative example of FDM process using the dimension of environment and ecology.

- (1) Initially, we built the cumulative frequency distributions of two functions,  $F1(x)$  representing the highest value in an interval of agreement, and  $F2(x)$  the lowest value in an interval of agreement, based on the FDM questionnaires. For illustration purposes, results related to the dimension of environment and ecology are shown in Table 5.
- (2) The first quartile, median, and third quartile of  $F1(x)$  and  $F2(x)$  were calculated and expressed as  $(C1, M1, D1)$  and  $(C2, M2, D2)$ . According to the max–min cumulative frequency of  $F1(x)$  and  $F2(x)$  shown in Table 3, the first quartile, median, and third quartile of  $F1(x)$  and  $F2(x)$  were  $F1(C1, M1, D1) = (7.5, 8.5, 9.25)$ , respectively, and  $F2(C2, M2, D2) = (5.5, 7.5, 8.25)$ , respectively.
- (3) The intersecting points of  $(C1, M1, D1)$  and  $(C2, M2, D2)$  represent the target importance value  $X^*$ . The arithmetic means of  $C1$  and  $D2$  is the intersecting point  $X^*$  of  $F1(x)$  and  $F2(x)$  [25]. The  $X^*$  for the dimension of environment and ecology was  $(C1 + D2)/2 = (7.5 + 8.25)/2 = 7.88$ , which summarized the importance of this dimension based on the experts' opinions. By following the aforementioned steps, the importance values of each dimension and indicator were calculated, as shown in Table 4.



**Table 5.** Max–min cumulative frequency of the “environment and ecology” dimension.

| Evaluation value                       | 5  | 5.5 | 6 | 6.5 | 7 | 7.5 | 8 | 8.5 | 9 | 9.5 | 10 |
|--|----|-----|---|-----|---|-----|---|-----|---|-----|----|
| Highest value frequency                | 0  | 1   | 1 | 1   | 0 | 0   | 0 | 5   | 1 | 2   | 1  |
| F1: Cumulative highest value frequency | 0  | 1   | 2 | 3   | 3 | 3   | 3 | 8   | 9 | 11  | 12 |
| Lowest value frequency                 | 2  | 2   | 0 | 0   | 0 | 4   | 1 | 2   | 0 | 1   | 0  |
| F2: Cumulative lowest value frequency  | 12 | 10  | 8 | 8   | 8 | 8   | 4 | 3   | 1 | 1   | 0  |

We set the threshold to eliminate less important indicators to a value of 7; dimensions and indicators with an  $X^*$  value larger or equal to 7 passed the screening process and were adopted in the final evaluation framework for the next stage of FAHP weighting calculation [25–27]. The indicator “economic subsidy” under the dimension of “economy and development”, “budget execution” under “management and policy”, and “typhoons” under “climatic conditions” failed to pass the screening threshold (these are grayed out in Table 6). After examining the experts’ responses, we found that three governmental experts and one industry expert gave low importance to “economic subsidy”. Two academic experts and one governmental expert gave low importance to “budget execution”. Two governmental experts and one academic expert gave low importance to “typhoons”. These three indicators were, thus, removed from the indicator framework. The remaining twenty-six indicators still accounted for 89.66% of the preliminary evaluation items. It is noteworthy that results are dependent on the composition of the group of experts. Therefore, it is important to ensure that a variety of sectors, backgrounds, and interests are represented within the group. If possible, more than one expert in each field should be invited to participate in the process.

**Table 6.** Importance value of each level of indicator through FDM (indicators with  $X^* < 7$  are grayed).

| Dimensions              | Indicators                                 | C1   | C2   | D1   | D2   | $X^*$ |
|-------------------------|--|------|------|------|------|-------|
| Environment and Ecology |  | 7.5  | 5.5  | 9.25 | 8.25 | 7.88  |
|                         | - Ecological planning                      | 8    | 7    | 9.5  | 8.5  | 8.25  |
|                         | - Pollution prevention                     | 8    | 7.25 | 9.5  | 8.5  | 8.25  |
|                         | - Environmental maintenance                | 7.5  | 7    | 9.5  | 8.5  | 8     |
|                         | - Ecological restoration system            | 7.5  | 6.5  | 9    | 8    | 7.75  |
|                         | - Environmental monitoring system          | 7.25 | 6    | 8.5  | 7.5  | 7.38  |
|                         | - Landscape diversity                      | 7    | 6    | 9    | 8    | 7.5   |
| Economy and Development |  | 7.5  | 6    | 8.5  | 7    | 7.25  |
|                         | - Local job opportunities                  | 8.5  | 7.5  | 9.5  | 8.5  | 8.5   |
|                         | - Economic subsidy                         | 6.5  | 5.5  | 8    | 7    | 6.75  |
|                         | - Developmental association operations     | 7    | 6    | 8.5  | 7.5  | 7.25  |
|                         | - Recreational industry planning           | 8.5  | 7.5  | 9.5  | 8.5  | 8.5   |
| Society and Culture     |  | 7.5  | 6.5  | 8.5  | 7.5  | 7.5   |
|                         | - Quality of infrastructures               | 7.5  | 6.5  | 8.5  | 7.5  | 7.5   |
|                         | - Promotion of conservational concepts     | 8    | 7    | 9.5  | 8    | 8     |
|                         | - Protection of local culture              | 7.5  | 6.5  | 9    | 8.25 | 7.88  |
|                         | - Cultural identity                        | 8    | 7.5  | 9.5  | 8.5  | 8.25  |
|                         | - Training of tourism personnel            | 8    | 7    | 9.5  | 8.5  | 8.25  |
| Tourism value creation  |  | 6.5  | 5.5  | 9.5  | 8.5  | 7.5   |
|                         | - Quality of tourism facilities            | 7.75 | 7    | 9.5  | 8    | 7.88  |
|                         | - Tour guide service                       | 7.5  | 6.5  | 9    | 8    | 7.75  |
|                         | - Service quality                          | 8    | 7    | 9.25 | 8    | 8     |
|                         | - Customer experience value                | 7.5  | 6.5  | 9.5  | 8.5  | 8     |
|                         | - Quality of creative activity             | 7.5  | 6.5  | 9    | 8    | 7.75  |
| Management and Policy   |  | 7.5  | 6.5  | 9.5  | 8.5  | 8     |
|                         | - Comprehensive formulation of regulations | 7.25 | 6    | 10   | 9    | 8.13  |
|                         | - Control measures                         | 7.5  | 6.75 | 9.5  | 7.75 | 7.63  |
|                         | - Professional management personnel        | 7.5  | 6.5  | 9    | 8    | 7.75  |
|                         | - Management task planning                 | 7.5  | 6.5  | 9.5  | 8.5  | 8     |
|                         | - Dedicated administration unit            | 7.75 | 6.75 | 9.25 | 8.5  | 8.13  |
|                         | - Budget allocation                        | 6.5  | 5.75 | 8.25 | 7.25 | 6.88  |
|                         | - Local participation policy               | 7    | 6    | 9.5  | 8.5  | 7.75  |
| Climatic conditions     |  | 7.5  | 4.5  | 8.5  | 6.5  | 7     |
|                         | - Seasonal factor                          | 6.25 | 5.25 | 9    | 8    | 7.13  |
|                         | - Typhoons                                 | 6.25 | 5.25 | 8.25 | 7    | 6.63  |

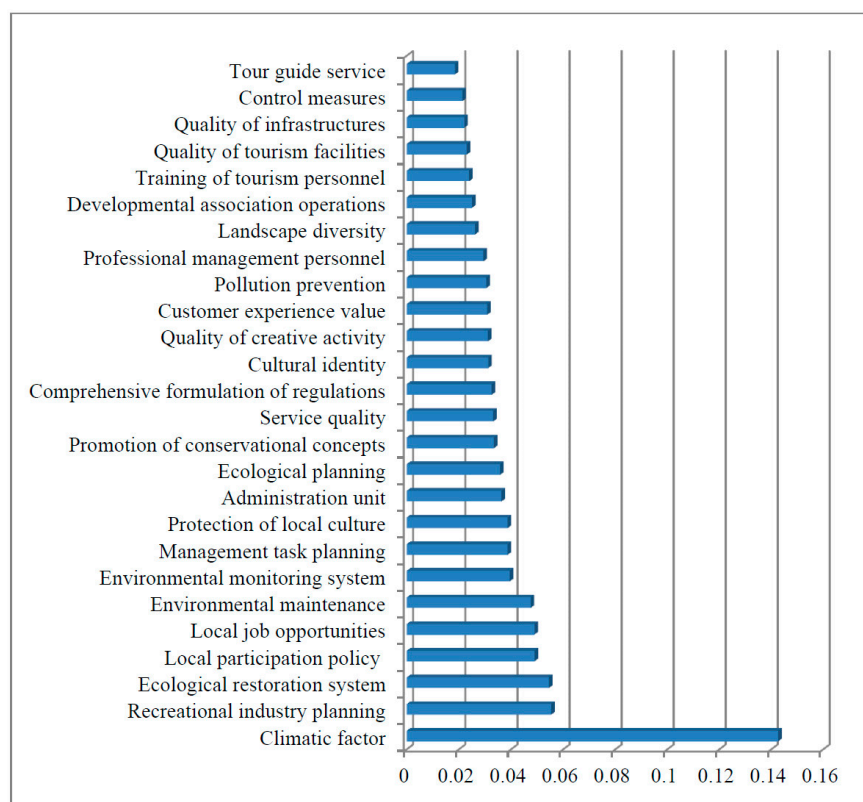


After the FDM screening process was completed, the final performance indicator framework was constituted by six main dimensions and twenty-six indicators. FAHP was then applied by assigning a pairwise comparison questionnaire to the other group of experts. Experts' responses were analyzed through fuzzification and defuzzification processes using the software Power Choice (Ixon Technology, Taipei, Taiwan) for the calculation of weighting values. Power Choice is a hybrid software system accommodating various multi-criteria decision-making methods, including FAHP. Weights at the dimensional level are shown in Table 7.

**Table 7.** Dimensional level weights and ranks by FAHP.

| Dimension   | Weight   | Rank |
|---|----------|------|
| Environment and Ecology                                       | 0.234107 | 1    |
| Economy and Development                                       | 0.129325 | 6    |
| Society and Culture   | 0.149469 | 3    |
| Tourism value creation  | 0.136835 | 5    |
| Management and Policy   | 0.207553 | 2    |
| Climatic conditions   | 0.142710 | 4    |
| $\Lambda_{\max} = 6.09076$ , C.I. = 0.018152, C.R. = 0.014639 |          |      |

Power Choice returned low ( $<0.1$ ) values for both the consistency index and consistency ratio, suggesting that the structure of the FAHP framework is acceptable as is. The experts recognized that “environment and ecology” and “management and policy” were the most important two dimensions influencing the sustainable development of coastal tourism in Taiwan. This result is similar to the finding of the other group of experts who previously participated in the FDM. Eventually the weighting values of all indicators were derived from the FAHP questionnaire using fuzzification and defuzzification processes. The weights and ranks of the indicators are shown in Table 8, while the sorted histogram is displayed as Figure 4.



**Figure 4.** Sorted weight histogram of all indicators.

**Table 8.** Weights and ranks of the performance evaluation indicators.

| Indicator                                | Dimension               | Weight   | Rank |
|--|-------------------------|----------|------|
| Climatic factor                          | Climatic conditions     | 0.142710 | 1    |
| Recreational industry planning           | Economy and Development | 0.055409 | 2    |
| Ecological restoration system            | Environment and Ecology | 0.054538 | 3    |
| Local participation policy               | Management and Policy   | 0.048988 | 4    |
| Local job opportunities                  | Economy and Development | 0.048940 | 5    |
| Environmental maintenance                | Environment and Ecology | 0.047473 | 6    |
| Environmental monitoring system          | Environment and Ecology | 0.039519 | 7    |
| Management task planning                 | Management and Policy   | 0.038739 | 8    |
| Protection of local culture              | Society and Culture     | 0.038733 | 9    |
| Administration unit                      | Management and Policy   | 0.036389 | 10   |
| Ecological planning                      | Environment and Ecology | 0.035839 | 11   |
| Promotion of conservational concepts     | Society and Culture     | 0.033506 | 12   |
| Service quality                          | Tourism value creation  | 0.033185 | 13   |
| Comprehensive formulation of regulations | Management and Policy   | 0.032596 | 14   |
| Cultural identity                        | Society and Culture     | 0.031247 | 15   |
| Quality of creative activity             | Tourism value creation  | 0.031143 | 16   |
| Customer experience value                | Tourism value creation  | 0.030911 | 17   |
| Pollution prevention                     | Environment and Ecology | 0.030590 | 18   |
| Professional management personnel        | Management and Policy   | 0.029457 | 19   |
| Landscape diversity                      | Environment and Ecology | 0.026147 | 20   |
| Developmental association operations     | Economy and Development | 0.024976 | 21   |
| Training of tourism personnel            | Society and Culture     | 0.023950 | 22   |
| Quality of tourism facilities            | Tourism value creation  | 0.023096 | 23   |
| Quality of infrastructures               | Society and Culture     | 0.022034 | 24   |
| Control measures                         | Management and Policy   | 0.021384 | 25   |
| Tour guide service                       | Tourism value creation  | 0.018501 | 26   |

The climatic factor, which is under the dimension of “climatic condition”, has the highest weight among all indicators, although the corresponding aspect is ranked fourth out of six dimensions. This situation is reasonable since there is only one indicator under this dimension, and the weight in the criterion level is the same as in the dimensional level. The other indicators have to share the weights with the group of indicators belonging to the same dimension. Tourism is a particularly climate-sensitive economic sector, considering that climate change affects a number of key factors pertinent to the tourism industry [28]. Climate plays an important role in tourism, especially on destination choice and the timing of travel [29–31]. Additionally, Taiwan faces changeable weather conditions due to its unique geographic location, which makes the indicator of climatic factor extremely important when considering the sustainable development of coastal tourism.

The indicators of “recreational industry planning” and “local job opportunities”, both belonging to the “economy and development” dimension, are ranked second and fifth. The results indicate that an appropriate planning for local recreational activities associated with coastal tourism may increase local resident employment chances. Public sectors thus need to develop a sustainable coastal tourism plan based on natural scenery, cultural heritage, and other recreational activities which could enhance local economy. Without careful planning and local economic development, coastal tourism may be a flash in the pan. For many communities, countries and regions around the world, coastal tourism constitutes the main economic sector and source of employment [32]. For example in Calvià, a coastal town in the island of Majorca (Spain), 95% of the jobs in 2002 were related to tourism [33].

“Ecological restoration system” is ranked third by the experts, showing a strong need to improve the current situation in Taiwan. Due to inappropriate coastal and watershed development, many coastal zones face the problem of coastal erosion. To mitigate coastline retreat, extensive coastal protection works have been implemented by building concrete breakwaters or placing armor blocks, causing the side-effect of degraded ecosystems. It is, therefore, important to recover the damaged ecosystem, such as wetlands, estuaries, sand dunes, and landscapes, which have high values for sustainable coastal tourism. Especially, coastal wetland ecosystems have been suffering from serious degradation, alteration or loss due to intense anthropogenic activities (i.e., pollution and drainage) [34–36] and, thus,

coastal wetlands are listed amongst the most heavily damaged of natural ecosystems worldwide [37]. Habitat management is particularly important to the coastal zones of Taiwan to protect natural habitats from the threat of erosion [38].

“Local participation policy” is ranked fourth in the evaluation framework. The experts highly supported the idea that this indicator should be of paramount importance for the public sector since local stakeholder involvement is for a necessary condition for sustainable development. However, many political decisions related to the coastal tourism sector in Taiwan still adopt the top-down approach without much consideration for local people opinions. To involve local stakeholders for policy-making should seek to build a consensus toward the modalities of sustainable coastal tourism development. The lack of or ineffective stakeholder participation is a major obstacle to sustainable tourism [39]. In particular, local participation and support is a very critical factor for sustainable tourism in Taiwan [40,41].

Sustainable tourism, as based on the principles of sustainable development, takes “full account of its current and future economic, social and environmental impacts” [33] and addresses the needs of stakeholders [39]. The first fifteen indicators within the performance evaluation framework of sustainable coastal tourism account for 71.78% of the total weight. These indicators cover all six dimensions articulated in the hierarchy structure. Therefore public sectors and local stakeholders may pay more attention to the fulfillment of these fifteen indicators given limited resources. At least 70% of ideal performance for sustainable coastal tourism in Taiwan can thus be attained.

## 5. Conclusions

Recently, more visitors have been attracted to the coastal areas in Taiwan for tourism activities. This emerging coastal tourism pressure has made the study of sustainable coastal tourism imperious, so that the impact on the environment can be reduced, while coastal zone development is still promoted. This study adopted a comprehensive approach to establish a performance indicator framework for the evaluation of coastal zone sustainable tourism. Through an extensive literature review, an initial evaluation hierarchy structure was built covering six dimensions and twenty-nine indicators. FDM was then applied by the expert surveys to identify the most important dimensions and indicators. Three indicators were eliminated and the final performance evaluation framework was set forth for consecutive FAHP analyses. Based on the second round of expert surveys using FAHP, the weights associated with all dimensions and indicators were identified. The resulting performance indicator framework can be used as a general guideline to show the most important issues regarding sustainable development of coastal tourism in Taiwan, according to our group of experts. Furthermore, the evaluation framework has laid a useful foundation for future case analyses. The central government agent, in charge of coastal tourism, may adopt this framework to assess the overall performance of each subordinate agent. A local public sector may also apply this evaluation framework to review strengths and weaknesses of current coastal tourism development, so that better managerial plans can be conceived toward sustainable coastal tourism.

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## Abbreviations

The following abbreviations are used in this manuscript:

|      |                                  |
|------|----------------------------------|
| AHP  | Analytics Hierarchy Process      |
| FAHP | Fuzzy Analytic Hierarchy Process |
| FDM  | Fuzzy Delphi Method              |

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