# Rating and Ranking Criteria for Selected Islands using Fuzzy Analytic Hierarchy Process (FAHP)

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***Abstract*—**Destination choice is one of decision making problems which should carefully be investigated in order to choose the best alternative among popular alternatives. The structure in modeling decision making may influencing the decision made and different decision making models impose different objectives with the result may not be variant. Therefore island evaluation has become one of important components in the selections. Multi-criteria decision making (MCDM) is a possible evaluation scale for many characters or quantities of decision makers' evaluation. It could be determined by advantage or ranking. This study presents fuzzy AHP as a proposed method for dealing with decision making in ten (10) social attributes. Fuzzy analytic hierarchy process (FAHP) is employed to calculate the weights of these criteria and sub-criteria, so as to build the fuzzy multi-criteria model of island evaluation. FAHP performed better than domain experts in tourism when the size of criteria and sub-criteria set increase. A detailed numerical example, illustrating the application of our approach to criteria evaluation is given.

***Keywords*—**Fuzzy Analytic Hierarchy Process (FAHP), Island Tourism, Multi-Criteria Decision Making (MCDM), Social Attributes.

## I. Introduction

NOWADAYS, tourism is one of the major service industries in the world. The World Tourism Organization (WTO) ranked Malaysia as the 9th in the list of top 10 countries most popular tourism destination in 2009. Malaysia is a rich country of assets and attractions for each tourist. It is a country which has international level for hospitality services, modern tourism infrastructure and convenient transportation.

Geographically, Malaysia consists of thirteen states and three federal territories and has a total landmass of 329,847 square kilometers (127,350 sq. mi). It is separated by the South China Sea into two regions, Peninsular Malaysia and Malaysian Borneo(also known as West and East Malaysia respectively). There are 14 states in Malaysia include Terengganu. Terengganu has 244km long stretches of sandy coastline. It is located in north-eastern Peninsular Malaysia, and is bordered in the northwest by Kelantan, the southwest by Pahang, and the east by the South China Sea.

In Malaysia, the coral reef ecosystem is reported to support aquatic organism numbering more than 50 kinds of coral and more than 200 species of fish. Each time a marine bio-diversity survey is conducted in the Malaysian tropical sea, the species list increases. There are several outlying islands in Terengganu, including *Pulau Perhentian*, *Pulau Rhu Hentian*, *Pulau Lang Tengah*, *Pulau Redang*, *Pulau Tenggol* and *Pulau Gemia*.

Multiple Criteria Decision Making (MCDM) was developed by Zimmerman in 1985[1]. MCDM is the optimal choice with different type depended on decision makers' preference, sorted of Multiple Objective Decision Making and Multiple Attribute Decision Making (MADM). Hwang and Yoon [2] provided that MCDM is a possible evaluation scale for many characters or quantities of decision makers' evaluation. It could be determined by advantage or ranking. The purpose of this study is to evaluate social attributes of islands by using Fuzzy Multi-Criteria Decision Making (MCDM). An investigation into travel behavior has to do for government planners to get the answer about where to locate new facilities, what type of facilities, what kind of travel to promote including demographic issue and tourist choice behavior [3]. Tien-Chin Wang and S.-C. Hsu [4] agreed that the problems of social economics and environmental change are more complicated and uncertain in the real world. Decision could be made by unique criterion, but need to consider relative factors as well. Therefore, multi-criteria decision making could satisfy the need.

Destination choice is one of many more decision making problems which should carefully be investigated towards choosing the best alternative among popular alternatives we have. Ordinary, selection and evaluation of island as tourism destination choice considering various criteria is a multiple

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criteria decision-making (MCDM) process. But in the past, may precision-based methods of MCDM for evaluating/selecting alternatives have been developed. These methods have been widely used in various fields such as location selection, material selection, information project selection, management decisions, strategy selection, and problems relating to decision-making [5-8]. The structure in modeling decision making problem may influencing the decision made and different decision making models impose different objectives with the result may not be variant. The paper by [9-12] demonstrating decision making model such as AHP, TOPSIS in tourism planning.Such the destination choice problem is modeling the tourism destination regarding the best choice chooses by tourist and we observe that tourists differ in goals and characters whereby these will govern the result at least for the individual tourist.

The practical applications reported in the literature [8, 10, 11, 13, 14]have shown advantages in handling qualitative criteria and obtained quite reliable results. Thus, this study applied fuzzy set theory [15] in order to select the best island in Terengganu. This study presents fuzzy AHP as a proposed method for dealing with decision making in social attributes. Evaluation destination is a wide ranging problem and complex. This problem requires method that can handle qualitative criteria [16] that are difficult to describe in crisp values[5, 17].

The rest of this paper is organized as follows. Section 1 introduced tourism islands in Malaysia, practical applications and proposed method. Section 2 provides discussion on the establishment of a hierarchical structure for the AHP, and a brief introduction to AHP, FEA and FAHP methods. Section 3 provides discussion on the preliminary knowledge. In Section 4, in order to demonstrate the applicability of the framework, we then examine an empirical case as an illustration to demonstrate the synthesis decision using integration of FAHP and FMCDM approach for dimension evaluation. In Section 5analysis and result of the findings are conducted. Finally concluding remarks are presented in the last section.

## II. METHOD

Evaluation destination recommendation is a wide ranging problem and complex. This problem requires method that can handle qualitative criteria that are difficult to describe in crisp values. Analytical Hierarchy Process (AHP) is one of the beneficial methods of MCDM introduced by Saaty (1980) [18].This method plays an important role in selecting alternatives [19, 20]. AHP has become one of the most widely used methods for the practical solution of MCDM problems [21]. AHP uses considerate and informed knowledge without the need of specific data [13]. The main weakness of AHP is that it deals with domain expert judgment as a crisp number between 1and 9 and their Eigen values. This situation doesn't handle the uncertainty correlating to these judgments. In order to overwhelm that incompetence, Fuzzy Environment Approach (FEA) is used within AHP calculations to determine the best alternative [8], [6]. The integration between Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Environment Approach (FEA) is noble in order to serve tourist the best recommendation islands and leads to more flexibility in judgment and decision making. Fuzzy AHP (FAHP) redirects to human thinking as it uses inaccurate information and vagueness to generate decision in addition to inheritance of the advantages of AHP, ease of handling qualitative and quantitative data, use of hierarchical structure, pair wise comparison, reduce inconsistency, and generates priority vectors [19].

### *A. Analytic Hierarchy Process(AHP)*

Analytic hierarchy process (AHP) is developed by Saaty[22]. It has been applied to many recommendations decision area [7, 23-26]. This powerful method can solve any complex problem by composed decision making problems into several sub problems using AHP in terms of hierarchical levels among goal, attributes, sub attributes and alternatives [27] (Fig. 1). By reducing complex decisions to a series of simple pair-wise comparisons and rankings, then synthesizing the results, AHP method not only facilitates arriving at the best decision, but also provides a clear rationale for the choices made. AHP affords a technique for structuring problems so that it can be given a quasi-quantitative structure. This method uses pair wise comparisons that let decision makers get more precise information. Spires conclude that judges are not required to explicitly define a measurement scale for each attribute by using pair-wise comparison [28].

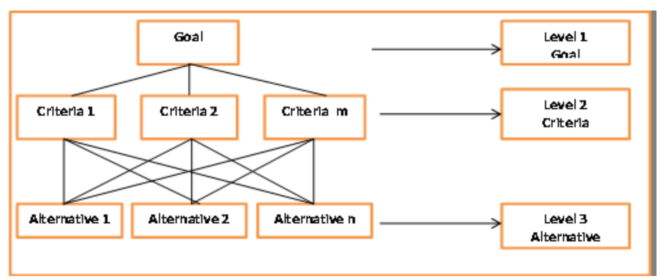


Fig. 1: The structure of analytic hierarchy process (AHP)

The AHP divides the decision problem into the following main steps [29, 30] :

1) Problem structuring.

The AHP decision problem is structured hierarchically at different levels, each level consisting of a finite number of decision elements. The top level of the hierarchy represents the goal; one or more intermediate levels embody the decision criteria and sub-criteria while the lowest level is composed of all potential alternatives.

2) Calculation of local priorities.

The relative importance of the decision elements (weights of criteria and scores of alternatives) is assessed indirectly from comparison judgments' during the second step of the decision process. The domain expert is required to provide his/her preferences by comparing all criteria, sub-criteria and alternatives with respect to upper level decision elements. The values of the weights and scores are elicited from these comparisons and represented in a decision table. The last step of the AHP aggregates all local priorities from the decision table by a simple weighted sum.

3) Calculation of global priorities.

The global priorities thus obtained are used for final ranking of the alternatives and selection of the best one.Best Non-fuzzy Performance value (BNP) is used as crisp values for final ranking of alternatives.

### B. *Fuzzy Environment Approach(FEA)*

Fuzzy decision making is a powerful method to solve complex decision making problems in a fuzzy environment and this method can deal with the problem of ranking and selection. In real world, linguistic environment is used by human beings to make decisions [31-34]. Classical decision making method works only with exact and ordinary data without qualitative data. For example, when evaluating a car's speed linguistic terms like "very slow", "slow", "fast", "very fast" can be used [35]; evaluating hotel's price, linguistic terms like "cheap", "moderate", "expensive" are usually be used [36]. Fuzzy can be used for vague and qualitative assessment of human beings [37, 38]. The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope well with any vagueness problems.

### C. *Fuzzy Analytic Hierarchy Process (FAHP)*

FAHP is an extension of AHP. The assessment of different criteria requires using of fuzzy number. While, AHP based on the use of crisp numbers. FAHP overcomes that defect in AHP. Since fuzziness is a common characteristic of decision making problems, the FAHP method was developed to address this problem [30]. Fuzzy set theory is a mathematical theory designed to model the fuzziness of real world situations[39].

This section described a new fuzzy systematic approach, Fuzzy Analytic Hierarchy Process (FAHP), for evaluation of criteria by integrating fuzzy approach and Analytic Hierarchy Process. In this study, the conceptual model of the proposed approach is applied [40]. Despite the richness of travel decision making literature, only a very limited number have contributed to integrating decision models with travel recommender systems. The majority of existing models are based on traditional studies of consumer behavior which are not focused on web technology or travel interactive decision aids.

The algorithm for the proposed approach has been developed in the following three phases: (1) rating phase, (2) aggregation phase and (3) selection phase. Decision makers express their opinion or performance rating of alternatives by questionnaires in the rating phase. These ratings are generally in fuzzy data form. The fuzzy data can be linguistic variables. This phase aims to convert fuzzy data into triangular fuzzy numbers. In the aggregation phase, weight for criteria which is based on geometric mean technique is employed. Wen-Hsiang Wu et. al [41] stated that the number of experts should be considered when decision makers are selecting the aggregation method; if the number of experts is large, a geometric mean is inappropriate, because it cannot be calculated; and thus the arithmetic mean is a better method in this situation. In the selection phase, the fuzzy weight of individual attributes and the total fuzzy scores of individual alternatives are defuzzified in the defuzzification step. These alternatives are then ranked by crisp values of Best Non-fuzzy Performance value (BNP). This study concentrates on rating phase for evaluation of criteria.

## III. Preliminary Knowledge

From the FAHP results Fuzzy numbers area subset from the real numbers set, representing the uncertain values or the enlargement of the idea of the poise interval. All fuzzy numbers are related to degrees of membership which state how true it is to say if something belongs or not to a firm set. Triangular fuzzy number (TFN)is a fuzzy number represented with three points as follows (Fig. 2):

$$\tilde{A} = (L, M, U) \quad (1)$$

Among the various shapes of fuzzy number, triangular fuzzy number (TFN) is the most popular one among the various shapes of fuzzy numbers (Trapezoidal fuzzy number, Gaussian fuzzy number and many more). The TFN can be denoted by $\tilde{A} = (L, M, U)$ where M is the modal value, L stand for the lower bound of the fuzzy number $\tilde{A}$nd U stand for the upper bound. There are operational laws of two TFNs $\tilde{A}_1 = (L_1 M_1, U_1)$ and $\tilde{A}_2 = (L_2 M_2, U_2)$ as shown [13] :

Addition of a fuzzy number $\oplus$

$$\tilde{A}_1 \oplus \tilde{A}_2 = (L_1, M_1, U_1) \oplus (L_2, M_2, U_2) = (L_1 + U_2, M_1 + M_2, U_1 + L_2) \quad (2)$$

Subtraction of a fuzzy number $\ominus$

$$\tilde{A}_1 \ominus \tilde{A}_2 = (L_1, M_1, U_1) \ominus (L_2, M_2, U_2) = (L_1 - U_2, M_1 - M_2, U_1 - L_2) \quad (3)$$

Multiplication of a fuzzy number $\otimes$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (L_1, M_1, U_1) \otimes (L_2, M_2, U_2) = (L_1 L_2, M_1 M_2, U_1 U_2)$$
$$\text{for } L_i > 0, M_i > 0, U_i > 0. \quad (4)$$

Division of a fuzzy number $\varnothing$

$$\tilde{A}_1 \varnothing \tilde{A}_2 = (L_1, M_1, U_1) \varnothing (L_2, M_2, U_2) = (L_1/U_2, M_1/M_2, U_1/L_2)$$
$$\text{for } L_i > 0, M_i > 0, U_i > 0. \quad (5)$$

Reciprocal (inverse) of a fuzzy number

$$\tilde{A}_1^{-1} = (L_1, M_1, U_1)^{-1} = (1/U_1, 1/M_1, 1/L_1)$$
$$\text{for } L_i > 0, M_i > 0, U_i > 0. \quad (6)$$

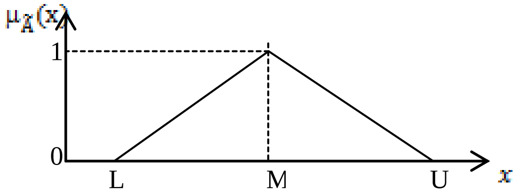


Fig. 2 Triangular fuzzy number structure

### A. *Linguistic Variable*

This method uses pair wise comparisons that let decision makers get more precise information. Fuzzy decision making is a powerful method to solve complex decision making problems in a fuzzy environment and this method can deal with the problem of ranking and selection. In real world, linguistic environment is used by human beings to make decisions [31]. Classical decision making method works only with exact and ordinary data without qualitative data. Fuzzy can be used for vague and qualitative assessment of human beings [37]. This paper used linguistic variable to express reasonably situation that difficult to define. Table 1 shows membership function of linguistic scales.

TABLE 1.MEMBERSHIP FUNCTION OF LINGUISTIC SCALES.

| Fuzzy number | linguistic scales | TFN | Inverse TFN |
|---|---|---|---|
| $\tilde{1}$ | Equally important (Eq) | (1,1,3) | (1/3,1,1) |
| $\tilde{3}$ | Weakly important (Wk) | (1,3,5) | (1/5,1/3,1) |
| $\tilde{5}$ | Essentially important (Es) | (3,5,7) | (1/7,1/5,1/3) |
| $\tilde{7}$ | Very strongly important (Vs) | (5,7,9) | (1/9,1/7,1/5) |
| $\tilde{9}$ | Absolutely important (Ab) | (7,9,9) | (1/9,1/9,1/7) |

## IV. EVALUATION OF DIMENSION FOR TOURISM DESTINATION RECOMMENDATION OF ISLANDS IN TERENGGANU

A numerical study is illustrated and real data is used for selecting the best island according to decision maker preference. Decision maker can help tourists to evaluate islands based on social attributes like Attraction, Environment, Accommodation, Transportation, Residents' attitudes, Restaurant, Other Facilities, Activity, Entertainment and Souvenir in order to serve tourist the best recommendation based on their preferences. Decision makers express their opinion or performance rating of criteria's and sub-criteria's by questionnaires in the rating phase. In this research, decision makers are also known as tourism domain experts. This study used domain experts in tourism in Terengganu to evaluate ten (10) social attributes to exercise the process of recommendation islands. Domain experts can specify preferences in the form of natural language or numerical value about the importance of each performance attribute [42]. We introduced ten dimensions by our own after doing study on previous literature. Fig. 3 shows ten (10) dimensions of island which has been evaluated in Terengganu. Attraction means the fascination of the islands such as unspoiled nature, unspoiled forest, traditional fishermen village, waterfall, beautiful scenery, nice beaches and colorful fish. Environment describes how the surroundings of islands, accommodation are known as budget chalet, luxury resort, middle class resort, swimming pool and etc. Transportation outlines the efficiency of vehicle on the islands, restaurant means the configurations of eating place on the islands, other facilities means other accommodation can be offered to tourist on the islands, activity means outdoor activity that can be done on the islands such as swimming, snorkeling, fishing, canoeing, jungle trekking and etc. Entertainment defines the showbiz for instance cultural shows and colorful nightlife. Resident attitudes refer to attitude of surroundings' island people, souvenir describes about the originality, variety of choices, the quality and the reasonable price of souvenir.

Weights were obtained by using FAHP method [40]. The following example demonstrates the computational procedure of the weight dimensions for domain experts in tourism[43]. This study used FAHP method for determining the final ranking criteria of islands in Terengganu. In this paper, evaluation of criteria will be completed by three domain experts.

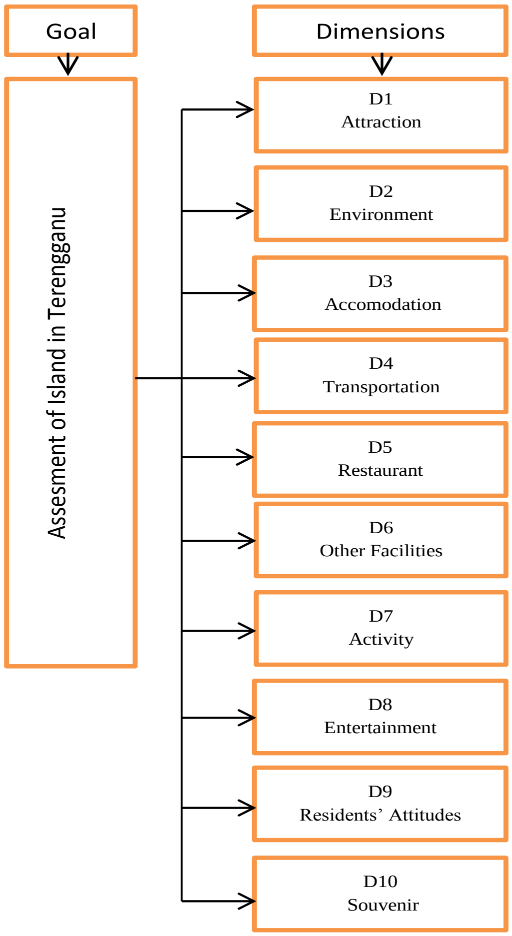


Fig. 3 Dimension for islands in Terengganu

### A. *Criteria Evaluation*

According to the formulated structure for evaluation of social attributes, the weights of the dimension hierarchy can be analyzed. The simulation process was followed by a series of interview with domain experts in tourism about the importance of the dimension and criteria of social attributes, then the pair wise comparison matrices has been construct as follows (Fig. 4, Fig. 5,Fig. 6):

$$\begin{array}{cc} & \begin{array}{cccccccccc} D1 & D2 & D3 & D4 & D5 & D6 & D7 & D8 & D9 & D10 \end{array} \\ \begin{array}{c} D1 \\ D2 \\ D3 \\ D4 \\ D5 \\ D6 \\ D7 \\ D8 \\ D9 \\ D10 \end{array} & \left[\begin{array}{cccccccccc} 1 & Ab & Ab & Ab & Ab & Ab & Ab & Ab & Ab & Ab \\ & 1 & Ab & Ab & Ab & Es & Es & Es & Ab & Ab \\ & & 1 & Ab & Ab & Es & Es & Es & Ab & Ab \\ & & & 1 & Ab & Ab & Es & Es & Ab & Ab \\ & & & & 1 & Es & Es & Ab & Ab & Ab \\ & & & & & 1 & Es & Es & Ab & Ab \\ & & & & & & 1 & Es & Ab & Ab \\ & & & & & & & 1 & Ab & Ab \\ & & & & & & & & 1 & Ab \\ & & & & & & & & & 1 \end{array}\right] \end{array}$$

Fig.4 Pairwise comparison matrices for the first domain expert

$$\begin{array}{cc} & \begin{array}{cccccccccc} D1 & D2 & D3 & D4 & D5 & D6 & D7 & D8 & D9 & D10 \end{array} \\ \begin{array}{c} D1 \\ D2 \\ D3 \\ D4 \\ D5 \\ D6 \\ D7 \\ D8 \\ D9 \\ D10 \end{array} & \left[\begin{array}{cccccccccc} 1 & Ab & Vs & Ab & Vs & Vs & Ab & Vs & Ab & Ab \\ & 1 & Ab & Ab & Eq & Vs & Es & Es & Eq & Ab \\ & & 1 & Ab & Ab & Eq & Wk & Es & Eq & Ab \\ & & & 1 & Wk & Wk & Wk & Eq & Wk & Eq \\ & & & & 1 & Eq & Eq & Eq & Wk & Ab \\ & & & & & 1 & Eq & Wk & Wk & Ab \\ & & & & & & 1 & Ab & Eq & Ab \\ & & & & & & & 1 & Wk & Eq \\ & & & & & & & & 1 & Wk \\ & & & & & & & & & 1 \end{array}\right] \end{array}$$

Fig. 5 Pairwise comparison matrices for the second domain expert

$$\begin{array}{cc} & \begin{array}{cccccccccc} D1 & D2 & D3 & D4 & D5 & D6 & D7 & D8 & D9 & D10 \end{array} \\ \begin{array}{c} D1 \\ D2 \\ D3 \\ D4 \\ D5 \\ D6 \\ D7 \\ D8 \\ D9 \\ D10 \end{array} & \left[\begin{array}{cccccccccc} 1 & LEs & Ab & Ab & Vs & Ab & LAb & Vs & Ab & Ab \\ & 1 & Ab & Ab & Ab & Es & Es & Es & Es & Ab \\ & & 1 & Ab & Ab & Es & Es & Es & Es & Ab \\ & & & 1 & Es & Es & Es & Es & Es & Ab \\ & & & & 1 & Es & Es & Ab & Es & Ab \\ & & & & & 1 & Es & Es & Es & Ab \\ & & & & & & 1 & LEs & Es & Ab \\ & & & & & & & 1 & LWk & Eq \\ & & & & & & & & 1 & Ab \\ & & & & & & & & & 1 \end{array}\right] \end{array}$$

Fig. 6 Pair wise comparison matrices for the third domain expert

Applying the fuzzy numbers defined in Table 1, it transfers the linguistic scales to the corresponding fuzzy numbers. However, for limitation of article space, we divide the synthetic pair wise comparison matrices of the three representatives into two parts. Geometric mean technique is used to define the fuzzy geometric mean and fuzzy weight of each criterion by Buckley [19](Fig. 7a and fig. 7b).

After forming fuzzy pair wise comparison matrix, weights of all criteria and sub-criteria are determined by FAHP. Geometric mean method is applied to compute the elements of synthetic pair wise comparison matrix (Fig. 7a and Fig. 7b). From Table 1, Synthesis values respects to main goal are calculated like in Eq. (7):

Fig. 7a Synthetic pairwise comparison matrices

| | D1 | D2 | D3 | D4 | D5 |
|---|---|---|---|---|---|
| D1 | 1 | (1.914,2.530,2.999) | (6.257,8.277,9.000) | (7.000,9.000,9.000) | (5.593,7.612,9.000) |
| D2 | (0.333,0.395,0.523) | 1 | (7.000,9.000,9.000) | (7.000,9.000,9.000) | (3.659,4.327,6.240) |
| D3 | (0.111,0.121,0.160) | (0.111,0.111,0.143) | 1 | (7.000,9.000,9.000) | (7.000,9.000,9.000) |
| D4 | (0.111,0.111,0.143) | (0.111,0.111,0.143) | (0.111,0.111,0.143) | 1 | (2.759,5.130,6.804) |
| D5 | (0.111,0.131,0.179) | (0.160,0.231,0.273) | (0.111,0.111,0.143) | (0.147,0.195,0.362) | 1 |
| D6 | (0.111,0.121,0.160) | (0.131,0.179,0.281) | (0.190,0.342,0.480) | (0.147,0.195,0.362) | (0.190,0.342,0.480) |
| D7 | (0.442,0.480,0.569) | (0.143,0.200,0.333) | (0.160,0.237,0.480) | (0.160,0.237,0.480) | (0.190,0.342,0.480) |
| D8 | (0.111,0.131,0.179) | (0.143,0.200,0.333) | (0.143,0.200,0.333) | (0.190,0.342,0.480) | (0.160,0.231,0.273) |
| D9 | (0.111,0.111,0.143) | (0.174,0.281,0.362) | (0.174,0.281,0.362) | (0.147,0.195,0.362) | (0.147,0.195,0.362) |
| D10 | (0.111,0.111,0.143) | (0.111,0.111,0.143) | (0.111,0.111,0.143) | (0.160,0.231,0.273) | (0.111,0.111,0.143) |

| | D6 | D7 | D8 | D9 | D10 |
|---|---|---|---|---|---|
| D1 | (6.257,8.277,9.000) | (1.759,2.079,2.263) | (5.593,7.612,9.000) | (7.000,9.000,9.000) | (7.000,9.000,9.000) |
| D2 | (3.557,5.593,7.612) | (3.000,5.000,7.000) | (3.000,5.000,7.00) | (2.759,3.557,5.739) | (7.000,9.000,9.000) |
| D3 | (2.080,2.924,5.278) | (2.080,4.217,6.257) | (3.000,5.000,7.000) | (2.759,3.557,5.739) | (7.000,9.000,9.000) |
| D4 | (2.759,5.130,6.804) | (2.080,4.217,6.257) | (2.080,2.924,5.278) | (2.759,5.130,6.804) | (3.659,4.327,6.240) |
| D5 | (2.080,2.924,5.278) | (2.080,2.924,5.278) | (3.659,4.327,6.240) | (2.759,5.130,6.804) | (7.000,9.000,9.000) |
| D6 | 1 | (2.080,2.924,5.278) | (2.080,4.217,6.257) | (2.759,5.130,6.804) | (7.000,9.000,9.000) |
| D7 | (0.190,0.342,0.480) | 1 | (3.979,6.082,7.612) | (2.759,3.557,5.739) | (7.000,9.000,9.000) |
| D8 | (0.160,0.237,0.480) | (0.131,0.164,0.251) | 1 | (1.119,2.079,3.557) | (1.913,2.080,4.327) |
| D9 | (0.147,0.195,0.362) | (0.174,0.281,0.362) | (0.281,0.480,0.894) | 1 | (3.659,6.240,7.399) |
| D10 | (0.111,0.111,0.143) | (0.111,0.111,0.143) | (0.160,0.231,0.273) | (0.195,0.333,0.523) | 1 |

Fig. 7b Synthetic pairwise comparison matrices

$$\tilde{a}_{ij} = (\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \tilde{a}_{ij}^3)^{1/3} \text{ for } \tilde{a}_{12},$$
$$\tilde{a}_{12} = \mathrm{Ab} \otimes \mathrm{Ab} \otimes \mathrm{LEs} \quad (7)$$

$$\tilde{a}_{12} = \left((7,9,9)\otimes(7,9,9)\otimes\left(\frac{1}{7},\frac{1}{5},\frac{1}{3}\right)\right)^{\frac{1}{3}}$$
= 1.914, 2.530, 2.999

It can be obtained the other matrix elements by the same computational procedures; as a result the synthetic pairwise comparison matrices of the three representatives will be constructed as follows:

According to FAHP method, firstly synthesis values must be calculated. Eq. (8) is used to gain the fuzzy weights of dimensions for domain experts in tourism as shown above:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \cdots \tilde{a}_{in})^{1/n}, \quad (8)$$

$$\tilde{r}_1 = (\tilde{a}_{11}\otimes\tilde{a}_{12}\otimes\tilde{a}_{13}\otimes\tilde{a}_{14}\otimes\tilde{a}_{15}\otimes\tilde{a}_{16}\otimes\tilde{a}_{17}\otimes\tilde{a}_{18}\otimes\tilde{a}_{19}\otimes\tilde{a}_{110})^{1/10}$$

$$\tilde{r}_1 = (1 \times 1.914 \times \ldots. \times 7.000)^{1/10}, (1 \times 2.530 \times \ldots. \times 9.000)^{1/10}, (1 \times 2.999 \times \ldots. \times 9.000)^{1/10},$$
$$\tilde{r}_1 = 4.121, 5.227, 5.638$$

Likewise, we can obtain the remaining , that is,

$$\tilde{r}_2 = (2.862, 3.795, 4.685)$$
$$\tilde{r}_3 = (1.652, 2.153, 2.719)$$
$$\tilde{r}_4 = (0.924, 1.257, 1.690)$$
$$\tilde{r}_5 = (0.785, 1.011, 1.390)$$
$$\tilde{r}_6 = (0.604, 0.881, 1.225)$$
$$\tilde{r}_7 = (0.582, 0.811, 1.148)$$
$$\tilde{r}_8 = (0.281, 0.384, 0.587)$$
$$\tilde{r}_9 = (0.268, 0.375, 0.541)$$
$$\tilde{r}_{10} = (0.157, 0.179, 0.225)$$

Then priority weights of each dimension can be calculated by using Eq.(9):

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \cdots \oplus \tilde{r}_n)^{-1}, \quad (9)$$

$$\tilde{w}_1 = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \otimes \tilde{r}_6 \otimes \tilde{r}_7 \otimes \tilde{r}_8 \otimes \tilde{r}_9 \otimes \tilde{r}_{10})^{-1}$$
$$= (4.121, 5.227, 5.638) \otimes (1/(5.638 + 4.685 + \cdots + 0.225), (1/(5.227 + 3.795 + \cdots + 0.179), (1/(4.121 + 2.862 + \cdots + 0.157)$$

$\tilde{w}_1 = (0.208, 0.325, 0.461)$

Likewise, $\tilde{w}_2 = 0.144, 0.236, 0.383$,
$\tilde{w}_3 = 0.083, 0.134, 0.222$,
$\tilde{w}_4 = 0.047, 0.078, 0.138$, $\tilde{w}_5 = (0.040, 0.063, 0.114)$,
$\tilde{w}_6 = (0.030, 0.055, 0.100)$, $\tilde{w}_7 = (0.029, 0.050, 0.094)$,
$\tilde{w}_8 = (0.014, 0.024, 0.048)$, $\tilde{w}_9 = (0.014, 0.023, 0.044)$,
$\tilde{w}_{10} = (0.008, 0.011, 0.019)$

COA method is applied to compute the BNP value of the fuzzy weights of each dimension. To take the BNP value for domain experts as an example, the calculation process is as follows:

$$\mathrm{BNP}_{W_i} = ((U_{wi} - L_{wi}) + (M_{wi} - L_{wi}))/3 + L_{wi} \quad (10)$$
$$\mathrm{BNP}_{W_1} = ((U_{w1} - L_{w1}) + (M_{w1} - L_{w1}))/3 + L_{w1}$$
$$\mathrm{BNP}_{W_1} = \frac{(0.461 - 0.208) + (0.325 - 0.208) + 0.208}{3}$$

$BNR_{W_1} = 0.331$

Similarly, the weights for the remaining dimensions as follows:

$BNR_{W_2} = 0.254$
$BNR_{W_3} = 0.146$
$BNR_{W_4} = 0.088$
$BNR_{W_5} = 0.072$
$BNR_{W_6} = 0.062$
$BNR_{W_7} = 0.058$
$BNR_{W_8} = 0.029$
$BNR_{W_9} = 0.027$
$BNR_{W_{10}} = 0.013$

## V. Analysis and Results

The criteria considered when determining the suitable location: attraction (0.331), environment (0.254), environment was followed in importance by performance to accommodation (0.146), transportation (0.08), restaurant (0.072), other facilities (0.062), activity (0.058), entertainment (0.029) and residents' attitudes (0.027)whereas the least important is souvenir (0.013) (Fig. 8).Table 2 shows weights of dimensions and criteria for domain experts. These results indicate overall performance of dimension using social attributes for island evaluation.

TABLE 2 WEIGHTS OF DIMENSIONS AND CRITERIA FOR DOMAIN EXPERTS

| Dimension and criteria | Local weights | | | Overall weight | | | BNP |
|---|---|---|---|---|---|---|---|
| ATTRACTION | (0.208, | 0.325, | 0.461) | | | | 0.331 |
| Unspoiled Nature | (0.118, | 0.271, | 0.695) | (0.024, | 0.088, | 0.320) | 0.144 |
| Beautiful Scenery | (0.082, | 0.212, | 0.508) | (0.017, | 0.069, | 0.234) | 0.107 |
| Marvelous Coral Reef | (0.060, | 0.153, | 0.370) | (0.012, | 0.050, | 0.171) | 0.078 |
| Nice Beaches | (0.039, | 0.090, | 0.216) | (0.008, | 0.029, | 0.099) | 0.046 |
| Colourful Fish | (0.041, | 0.098, | 0.200) | (0.009, | 0.032, | 0.092) | 0.044 |
| Unspoiled Forest | (0.025, | 0.072, | 0.193) | (0.005, | 0.023, | 0.089) | 0.039 |
| Traditional Fishermen Village | (0.021, | 0.052, | 0.169) | (0.004, | 0.017, | 0.078) | 0.033 |
| Waterfall | (0.018, | 0.051, | 0.127) | (0.004, | 0.016, | 0.058) | 0.026 |
| ENVIRONMENT | (0.144, | 0.236, | 0.383) | | | | 0.254 |
| Security | (0.245, | 0.446, | 0.945) | (0.035, | 0.105, | 0.362) | 0.475 |
| Safety | (0.150, | 0.290, | 0.545) | (0.022, | 0.068, | 0.209) | 0.286 |
| Clean and Tidy | (0.080, | 0.166, | 0.297) | (0.012, | 0.039, | 0.114) | 0.158 |
| Non-polluted | (0.041, | 0.098, | 0.150) | (0.006, | 0.023, | 0.057) | 0.085 |
| ACCOMODATION | (0.083, | 0.134, | 0.222) | | | | 0.146 |
| TRANSPORTATION | (0.047, | 0.078, | 0.138) | | | | 0.088 |
| RESTAURANT | (0.040, | 0.063, | 0.114) | | | | 0.072 |
| OTHER FACILITIES | (0.030, | 0.055, | 0.100) | | | | 0.062 |
| ACTIVITY | (0.029, | 0.050, | 0.094) | | | | 0.058 |
| ENTERTAINMENT | (0.014, | 0.024, | 0.048) | | | | 0.029 |
| RESIDENT ATTITUDES | (0.014, | 0.023, | 0.044) | | | | 0.027 |
| SOUVENIR | (0.008, | 0.011, | 0.019) | | | | 0.013 |

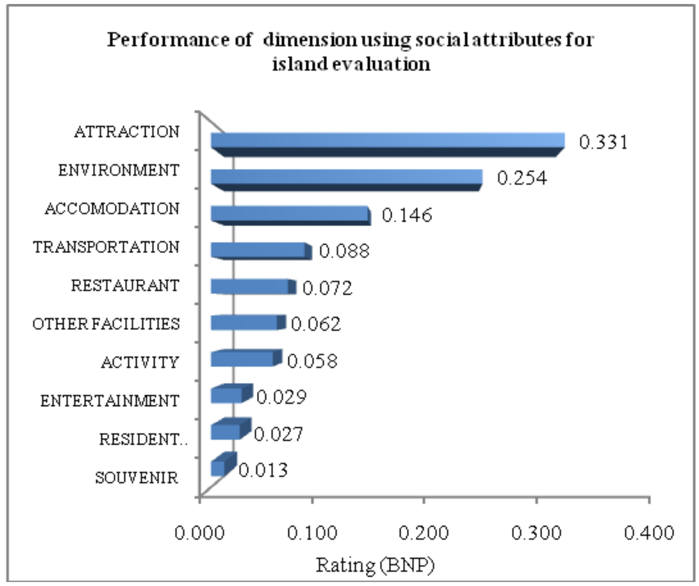


Fig. 8 Performance of dimension using social attributes for island evaluation

Attraction is the most important criteria for selection island evaluation. This research focused the performance on sub-dimension of dimension attraction. Based on FAHP results, we found the important sub-dimensions on attraction are unspoiled nature (0.144), beautiful scenery (0.107), marvelous coral reef (0.078), nice beaches (0.046), colorful fish (0.044), unspoiled forest (0.039), traditional fishermen village (0.033), and waterfall (0.026) whereas the least important is waterfall (0.013) (Fig. 9). These results indicate overall performance of sub-dimension of attraction.

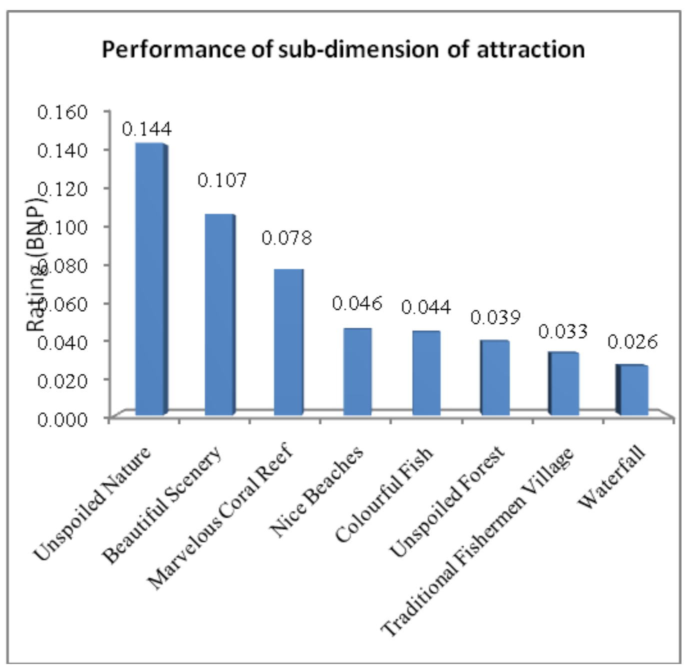


Fig.9 Performance of sub-dimension of attraction for island evaluation

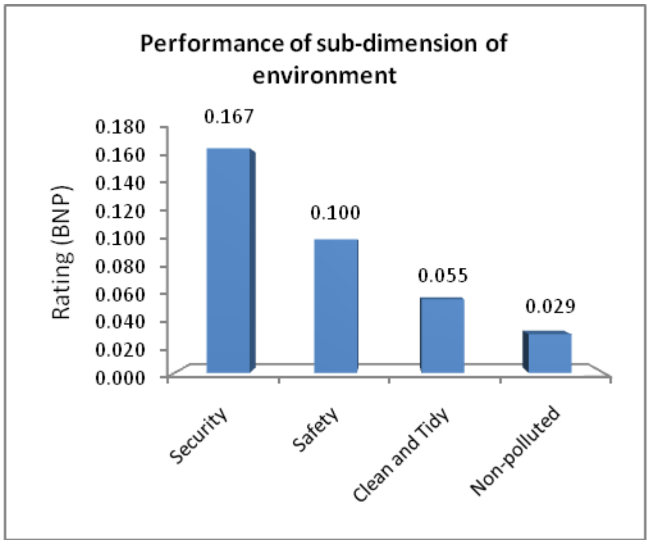


Fig. 10 Performance of sub-dimension of environment for island evaluation

Environment is the second important criteria for selection island evaluation. This research focused the performance on sub-dimension of dimension environment. Based on FAHP results, we found the important sub-dimensions on environment are security (0.167), safety (0.100), clean and tidy (0.055), non-polluted (0.029) (Fig. 10). These results indicate overall performance of sub-dimension of environment.

## VI. Conclusion

This paper proposed integration between fuzzy MCDM approaches represented by the fuzzy AHP to select the best location for a recommendation tourism destination. A real world case study from Island in Terengganu was selected. According to the results of case simulation, the ranking order of weights of dimension shows that tourists are very concerned with the attraction of islands. The first three important criteria are attraction 0.331, environment 0.254 and accommodation 0.146. In the process of obtaining weights of dimensions by FAHP, we can see the different views of respondents. The purpose of this study is to develop a scientific framework for the evaluation of criteria for selected islands. Furthermore, the ranking order of weights sub-dimension of attraction shows that tourists are concerned with the unspoiled nature of islands. The first three important sub-dimensions of attraction are unspoiled nature 0.144, beautiful scenery 0.107 and marvelous coral reef 0.078 while the first three important sub-dimensions of environment are security 0.167, safety 0.100 and clean and tidy 0.055. In this research, we can conclude that FAHP could be applied among domain experts in tourism. Using the FMCDM can decide the relative weights of criteria. The FMCDM to construct a new plan model for island recommendation effects which may be worth doing further researches. This method can be used to the prioritization of criteria and sub-criteria for tourism islands in Terengganu, Malaysia. Future research regarding tourism decision making may attempt performance of all sub-dimensions for 10 social attributes.

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