Evaluation of Criteria for Selected Islands using Fuzzy Analytic Hierarchy Process (FAHP)

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Abstract: - Tourism is one of the most become an extremely popular, global activity. In 2009, there were over 23.6 million international tourist arrivals to Malaysia. As a service industry, tourism has numerous tangible and intangible elements. Major tangible elements include transportation, accommodation, and other components of a hospitality industry. Major intangible elements relate to the purpose or motivation for becoming a tourist, such as rest, relaxation, the opportunity to meet new people and experience other cultures, or simply to do something different and have an adventure. The terms tourism and travel are sometimes used interchangeably. In this context travel has a similar definition to tourism, but implies a more purposeful journey. The terms tourism and tourist are sometimes used pejoratively to imply a shallow interest in the cultures or islands visited by tourists. This paper presents fuzzy MCDM approach for social attributes of islands evaluation. In order to accomplish the best criteria of social attributes performance, Fuzzy Analytic Hierarchy Process (FAHP) is used for weight and alternative evaluation. Fuzzy environment is used for dealing with the problem rating and ranking of social attributes. There are different criteria in characterizing real world for evaluating islands. This paper described the implementation of FAHP that influences ten specific social attributes of islands. The simulation process shows the results that find the two most important aspects for tourist in order to choose the destination of islands.

Key-Words: - Fuzzy Analytic Hierarchy Process (FAHP), Island Tourism, Multi-Criteria Decision Making (MCDM).

1 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.

There are several outlying islands in Terengganu, Malaysia including Pulau Perhentian, Pulau Rhu Hentian, Pulau Lang Tengah, Pulau Redang, Pulau Tenggol and Pulau Gemia. 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 behaviour [1].

Destination choice is a part of decision making problems which should carefully be investigated towards choosing the best alternative among popular alternatives we have. 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 [2-5] demonstrating decision making model such as AHP, TOPSIS in
tourism planning. The integration between FAHP and FMCDM is significant in order to serve tourist the best recommendation islands.

Further, this paper is organized as follows. Section 1 introduced tourism islands in Malaysia, practical applications and proposed method. Section 2 discusses about method. Section 3 discusses the preliminary knowledge. Section 4 is elaborate analysis and result of the findings. The last section concludes the overall research.

2 Method
Evaluation destination recommendation is a wide ranging problem and complex. This study presents fuzzy AHP as a proposed method for dealing with decision making in social attributes by applying fuzzy approach. This problem requires method that can handle qualitative criteria that are difficult to describe in crisp values [6].

2.1 Analytic Hierarchy Process
Analytic hierarchy process (AHP) is developed by Saaty[7]. It has been applied to many recommendations decision area [8-12]. This 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. 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 [13].

![Fig. 1: The structure of analytic hierarchy process (AHP)](image)

2.2 Fuzzy Environment Approach
Fuzzy decision making is a 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 [14-17]. The practical applications reported in the literature [3, 4, 18-20] have shown advantages in handling qualitative criteria and obtained quite reliable results. Thus, this study applied fuzzy set theory [21] in order to select the best island in Terengganu. 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 [22, 23]. The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope well with any vagueness problems.

2.3 Fuzzy Analytic Hierarchy Process (FAHP)
FAHP is used for evaluation of criteria by integrating fuzzy approach and AHP. In this study, the conceptual model of the proposed approach is applied [24]. 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 behaviour 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. This study concentrates on rating phase for evaluation of criteria.

3 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. 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. Decision quality significantly depends upon the
decision-makers level of expertise which is domain experts [25]. We introduced ten after doing study on previous literature [26-29] to meet worthy criteria. Fig. 2 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 colourful 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, snorkelling, fishing, canoeing, jungle trekking and etc. Entertainment defines the showbiz for instance cultural shows and colourful 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.

3.1 Criteria Evaluation
Weights were obtained by using FAHP method [24]. The following example demonstrates the computational procedure of the weight dimensions for domain experts in tourism. This study used FAHP method for determining the final ranking criteria of islands in Terengganu. Fuzzy numbers defined in Table 1 is applied to transfer the linguistic scales to the corresponding fuzzy numbers. However, for limitation of article space, this research divides the synthetic pairwise comparison matrices of the three representatives into two parts.

<table>
<thead>
<tr>
<th>Fuzzy number</th>
<th>linguistic scales</th>
<th>TFN</th>
<th>Inverse TFN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equally important (Eq)</td>
<td>(1,1,3)</td>
<td>(1/3,1,1)</td>
</tr>
<tr>
<td>3</td>
<td>Weakly important (Wk)</td>
<td>(1,3,5)</td>
<td>(1/5,1/3,1)</td>
</tr>
<tr>
<td>5</td>
<td>Essentially important (Es)</td>
<td>(3,5,7)</td>
<td>(1/7,1/5,1/3)</td>
</tr>
<tr>
<td>7</td>
<td>Very strongly important (Vs)</td>
<td>(5,7,9)</td>
<td>(1/9,1/7,1/5)</td>
</tr>
<tr>
<td>9</td>
<td>Absolutely important (Ab)</td>
<td>(7,9,9)</td>
<td>(1/9,1/9,1/7)</td>
</tr>
</tbody>
</table>

After forming fuzzy pairwise comparison matrix, weights of all criteria and sub-criteria are determined by FAHP. Geometric mean technique is used to define the fuzzy geometric mean and fuzzy weight of each criterion by Buckley [30] as follows: From Table 1, Synthesis values respects to main goal are calculated like in Eq. (7):

$$\bar{a}_{ij} = (\bar{a}_{ij} \odot \bar{a}_{ij} \odot \bar{a}_{ij})^{1/2}$$ for $\bar{a}_{12}$,

$$\bar{a}_{12} = Ab \odot Ab \odot LEs$$

$$\bar{a}_{12} = (7,9,9) \odot (7,9,9) \odot \left(\frac{1}{7}, \frac{1}{5}, \frac{1}{3}\right)$$

$$= 1.914, 2.530, 2.999$$
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:

\[ \tilde{w}_i = \frac{1}{n} \left( \tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{in} \right)^{1/n}, \]  

Likewise, we can obtain the remaining \( \tilde{r}_i \); that is, \( \tilde{r}_1 = (4.121, 5.227, 5.638) \), \( \tilde{r}_2 = (2.862, 3.795, 4.685) \), \( \tilde{r}_3 = (1.652, 2.153, 2.719) \), \( \tilde{r}_4 = (0.924, 1.257, 1.690) \), \( \tilde{r}_5 = (0.785, 1.011, 1.390) \), and \( \tilde{r}_6 = (0.604, 0.881, 1.225) \)

\[ \tilde{w}_7 = (0.582, 0.811, 1.148) \]
\[ \tilde{w}_8 = (0.281, 0.384, 0.587) \]

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

\[ \tilde{w}_i = \tilde{r}_i \otimes (\mid \tilde{r}_1 \otimes \ldots \otimes \tilde{r}_n \mid )^{-1}. \]

Likewise, we can obtain the remaining \( \tilde{w}_i \); that is, \( \tilde{w}_2 = (0.208, 0.325, 0.461) \), \( \tilde{w}_3 = (0.083, 0.134, 0.222) \), \( \tilde{w}_4 = (0.047, 0.078, 0.138) \), \( \tilde{w}_5 = (0.030, 0.055, 0.100) \), \( \tilde{w}_7 = (0.029, 0.050, 0.094) \), \( \tilde{w}_9 = (0.014, 0.024, 0.048) \), \( \tilde{w}_{10} = (0.008, 0.011, 0.019) \)
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:

\[
\text{BNR}_{W_1} = \frac{((U_{w_1} - L_{w_1}) + (M_{w_1} - L_{w_1})/3 + L_{w_1}}{(0.461 - 0.208) + (0.325 - 0.208) + 0.208}
\]

\[
\text{BNR}_{W_1} = 0.331
\]

Similarly, the weights for the remaining dimensions as follows:

\[
\text{BNR}_{W_2} = 0.254 \quad \text{BNR}_{W_3} = 0.146
\]

\[
\text{BNR}_{W_4} = 0.088 \quad \text{BNR}_{W_5} = 0.072
\]

\[
\text{BNR}_{W_6} = 0.062 \quad \text{BNR}_{W_7} = 0.058
\]

\[
\text{BNR}_{W_8} = 0.029 \quad \text{BNR}_{W_9} = 0.027 \quad \text{BNR}_{W_{10}} = 0.013
\]

4 Analysis and Results

The finding of research shows that there are two most important aspects for tourism destination, attraction (0.331) and environment (0.254) whereas the least important is souvenir (0.013). 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) (Fig. 3). These results indicate overall performance of dimension using social attributes for island evaluation.

5 Conclusion

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. Future research regarding tourism decision making may attempt performance of sub-dimensions of attraction.

References:


