A PERSONALIZED TRAVEL RECOMMENDER SYSTEM USING FUZZY ANALYTIC HIERARCHY PROCESS

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ABSTRACT

Information and communication technologies have a deep implication for the industry. This combination is being used extensively in an excessive variety of functions and numerous applications. On the other hand, tourism has become an extremely dynamic system. The globalization enabled by technology development and budget travel cost has greatly increased competition. Decision support system (DSS) can play an important role to organizations and people who managing tourism destinations. The main intention of this research is to apply Decision Support System (DSS) in tourism. It aims to establish a personalized travel recommender system that is interactive and can be easily shared and integrated in order to verify the concept of providing tourism decision support system interactively. Specifically, the study aims to achieve the following objectives; (1) To evaluate and measure criteria and alternatives performance; (2) To analyze the ranking of criteria and alternatives; (3) To recommend tourist in terms of islands, accommodation, activities and etc. based on budget. Evaluation module enables experts in tourism to evaluate criteria and alternatives of small islands to indicate islands' performance. Analysis module will provide reports for performance of criteria and alternatives based on Best Non-fuzzy Performance. A risk analysis model for travel recommender system development using a fuzzy set approach is proposed and incorporated into the Fuzzy Decision Support System (FDSS).This study presents fuzzy-AHP as a proposed method to apply with decision making in social attributes by applying fuzzy approach. A web-based prototype Decision Support System (DSS) is designed and developed in order to prove the objectives.

Keywords: Decision Support System, Travel Recommender System, Fuzzy Analytic Hierarchy Process

1.0 INTRODUCTION

Over the past new decades, numerous studies have been carried out on customer choice behavior, particularly on the destination choice model. However, only a few have attempted to integrate the use of web technology with traditional approaches to consumer choice behavior (Nasir, Simsek, Cornelsen, Ragothaman, & Dag, 2021) (Dewi & Putra, 2021). With tourism expanding globally, the use of the internet in tourism becomes inevitable. This study presents an approach to the design of a destination choice model using a fuzzy multi-criteria decision support system that can be used by tourists to make choices on travel destinations.

This study presents fuzzy AHP as a proposed method for dealing with decision making in evaluating social attributes. Evaluation destination is a wide ranging problem and complex. This problem requires method that can handle qualitative criteria (Noor Maizura Mohamad Noor, Ily Amalina Ahmad Sabri, Noraida Haji Ali, & Ismail, 2010) that are difficult to describe in crisp values. Analytic Hierarchy Process (AHP) can solve any complex problems by composing decision making problems into several sub problems using AHP in terms of hierarchical levels among goal, attributes, sub attributes and alternatives (1977). This study focuses on island as a travel destination. Location is an important factor leading to the island selection since it will determine the convenience of service to tourists and how many are attracted. The importance of island selection is inevitable. There are six small islands in Terengganu and tourist may have some characteristics considered while selecting the island. Within the island selection process, the evaluation process needs to be evaluated by tourism experts to give the best recommendation for tourist.

This research incorporates two major theoretic frameworks, tourism decision support systems and web services, and applies them to evaluate islands to recommend the best island for tourist. The tourism decision support system uses computer to analyze performance of islands based on ten social attributes such as attraction, accommodation, transportation, activity, entertainment, resident attitudes, environment, other facilities and souvenir in order to enhance analysis accuracy. This system also been developed for handling recommendation to tourist. Tourism decision support systems have been in existence for a few decades. During the early days, the focus was on developing better tourism data acquisition technology. Then it is attempted to integrate database management systems and artificial intelligence for more effective use and interpretation of available data to assist decision making in tourism.

The objective of this study is to build a tourism decision support. It aims to establish a tourism decision support system that is interactive and can be easily shared and integrated in order to verify the concept of providing tourism decision support system interactively.

2.0 LITERATURE REVIEW

Evaluation destination recommendation is a wide ranging problem and complex. This study presents fuzzy-AHP as a proposed method to apply 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 (Noor Maizura Mohamad Noor et al., 2010).

2.1 Fuzzy Approach

Knowledge Fuzzy decision making is a powerful method to solve complex decision making problems in a fuzzy environment. This method can be applied with the problem of ranking and selection. In real world, linguistic environment is used by human beings to make decisions (Zadeh, 1975; Zadeh, 1983, 1987, 1997). 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 (Zadeh, 1976); evaluating hotel's price, linguistic terms like "cheap", "moderate", "expensive" are usually be used (Ngai & Wat, 2003). Fuzzy can be used for vague and qualitative assessment of human beings (Abdullah et al., 2009; Lv et al., 2021; Torfi et al., 2010; Wang et al., 2021). The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope well with any vagueness problems.

Fuzzy numbers are a 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 (Figure 1):

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

Triangular fuzzy number (TFN) is a fuzzy number represented with three points $\tilde{A}$=(L,M,U) (Figure.1). Inverse TFN means reciprocal of a fuzzy number.

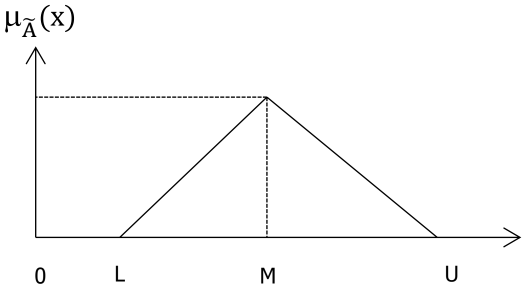


Figure 1: Triangular Fuzzy Number (TFN)

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 $\tilde{A}$ and 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 (Hsieh, Lu, & Tzeng, 2004). Equation 2 is addition of a fuzzy number $\oplus$, Equation 3 is subtraction of a fuzzy number O, Equation 4 is multiplication of a fuzzy number $\otimes$, Equation 5 is division of a fuzzy number $\varnothing$ and Equation 6 is reciprocal (inverse) of a fuzzy number.

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

$$= (L_1 + U_2, M_1 + M_2, U_1 + L_2) \tag{2}$$

$$\tilde{A}_1 \overline{\text{O}}\ \tilde{A}_2 = (L_1, M_1, U_1) \overline{\text{O}}\ (L_2, M_2, U_2)$$

$$= (L_1 - U_2, M_1 - M_2, U_1 - L_2) \tag{3}$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (L_1, M_1, U_1) \otimes (L_2, M_2, U_2) = (L_1 L_2, M_1 M_2, U_1 U_2)$$

$$\text{for } L_i > 0, M_i > 0, U_i > 0. \quad (4)$$

$$\tilde{A}_1 \emptyset \tilde{A}_2 = (L_1, M_1, U_1) \varnothing (L_2, M_2, U_2)$$

$$= (L_1/U_2, M_1/M_2, U_1/L_2)$$

$$\text{for } L\_i > 0, M\_i > 0, U\_i > 0. \quad (5)$$

$$\tilde{A}_1^{-1} = (L_1, M_1, U_1)^{-1} = (1/U_1, 1/M_1, 1/L_1)$$

$$\text{for } L_i > 0, M_i > 0, U_i > 0. \quad (6)$$

2.2 Analytic Hierarchy Process (AHP)

Analytic hierarchy process (AHP) is developed by Saaty (Saaty, 1977). It has been applied to many recommendations decision area (Amiri, 2010; Chen et al., 2009; S.-Y. Chou & Chang, 2008; T.-Y. Chou, Hsu, & Chen, 2008; Güngör, SerhadlIoglu, & Kesen, 2009; Omair et al., 2021). 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 (Lee & Cheng, 2008). 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 (Spires, 1991). Figure 2 shows the structure of Analytic Hierarchy Process (AHP).

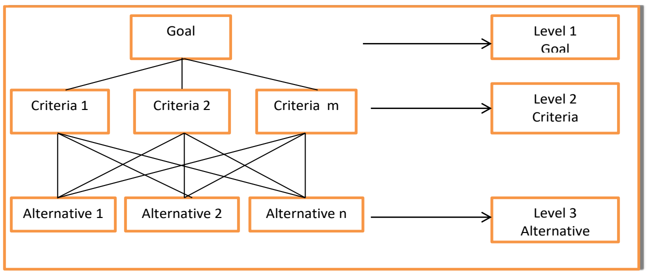


Figure 2: The Structure of Analytic Hierarchy Process (AHP)

2.3 Fuzzy-Analytic Hierarchy Process (Fuzzy-AHP)

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 (Sabri, Noor, Ali, & Ismail, 2011). Despite the richness of travel decision making literature, only a very limited number have contributed to integrating decision models with travel recommender systems. Most of existing models are based on traditional studies of consumer behavior which is 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, weights of criteria which are based on geometric mean technique are employed. Wen-Hsiang Wu et. Al (Wen-Hsiang Wu, Chang-tzu Chiang, & Lin, 2008) 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).

3.0 DISCUSSION

The main operational inference engine of the system is decision making in evaluation. Figure 3 shows data input screen for criteria evaluation in Terengganu. Through this interface, tourism experts can evaluate criteria according to their experience.

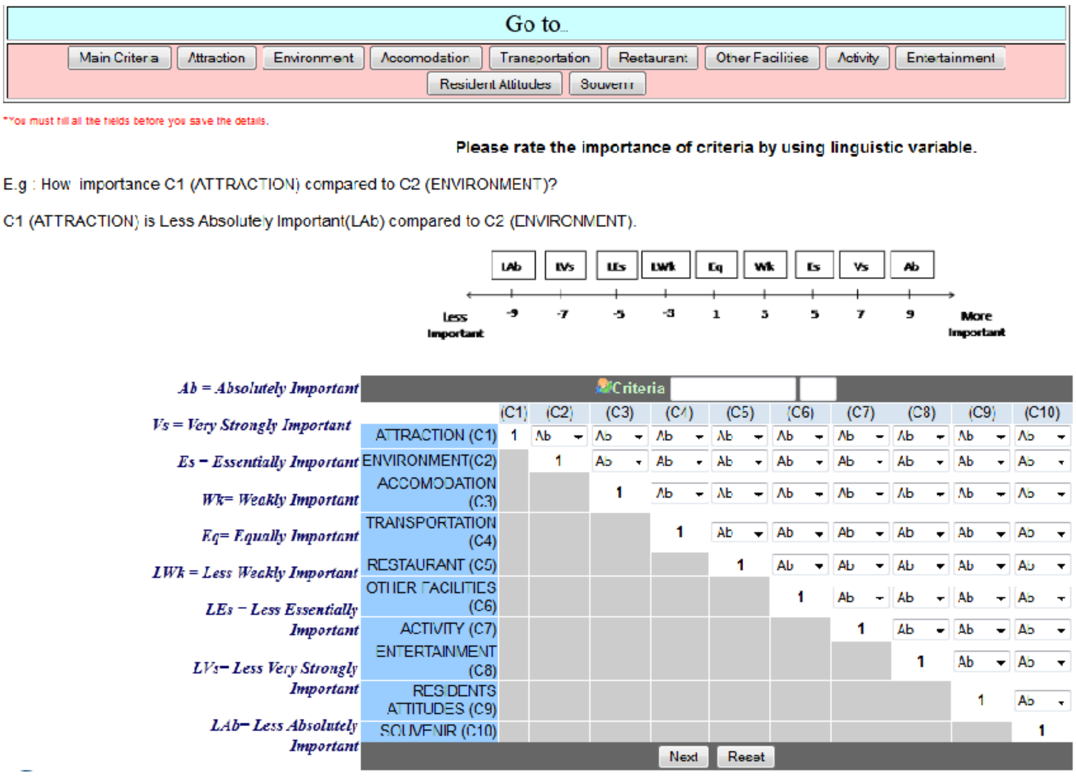


Figure 3: Data Input Screen for Evaluation of Islands in Terengganu

After ten (10) criteria and six (6) alternatives have been evaluated, this system will generate fuzzy analysis for all criteria and alternatives. Figure 4 shows the analysis of evaluation islands in Terengganu.

.:Island Tourism Advisory System (iTAS) :.

Attraction

	ra1	ra2	ra3			Rating (BNP)
Pulau Perhentian	5.492	25.007	96.093		Pulau Perhentian	35.692
Pulau Lang tengah	4.215	19.063	82.540		Pulau Lang tengah	30.323
Pulau Redang	5.803	26.147	98.430		Pulau Redang	36.679
Pulau Tenggol	5.318	24.052	91.717		Pulau Tenggol	34.118
Pulau Gemia	3.990	18.003	81.143		Pulau Gemia	29.708
Pulau Kapas	3.255	15.273	75.423		Pulau Kapas	27.311

Tourism Advisory System

ATTRACTION

	Redang1			Perhentian2			Lang Tengah4			Tenggol5			Gemia6			Kapas7		
Unspoiled Nature	58.333	68.333	83.333	46.667	56.667	76.667	46.667	56.667	76.667	68.333	81.667	90.000	58.333	68.333	83.333	35.000	45.000	70.000
Beautiful Scenery	80.000	93.333	96.667	80.000	93.333	96.667	46.667	56.667	76.667	68.333	81.667	90.000	58.333	68.333	83.333	35.000	45.000	70.000
Marvelous Coral Reef	80.000	93.333	96.667	80.000	93.333	96.667	70.000	80.000	90.000	80.000	93.333	96.667	35.000	45.000	70.000	46.667	56.667	76.667
Nice Beaches	85.000	100.000	100.000	85.000	100.000	100.000	63.333	75.000	86.667	80.000	93.333	96.667	58.333	68.333	83.333	58.333	68.333	83.333
Colourful Fish	85.000	100.000	100.000	85.000	100.000	100.000	75.000	86.667	93.333	68.333	81.667	90.000	46.667	56.667	76.667	58.333	68.333	83.333
Waterfall	0.000	0.000	20.000	0.000	0.000	20.000	0.000	0.000	20.000	0.000	0.000	20.000	0.000	0.000	20.000	0.000	0.000	20.000
Traditional Fishermen Village	70.000	80.000	90.000	70.000	80.000	90.000	0.000	0.000	20.000	0.000	0.000	20.000	0.000	0.000	20.000	0.000	0.000	20.000
Unspoiled Forest	75.000	86.667	93.333	70.000	80.000	90.000	58.333	68.333	83.333	58.333	68.333	83.333	58.333	68.333	83.333	58.333	68.333	83.333

Attraction!

	R			W			Ow			BNP
Unspoiled Nature	1.789	2.58	4.256	0.119	0.271	0.697	0.025	0.088	0.321	0.145
Beautiful Scenery	1.262	2.037	3.111	0.084	0.214	0.509	0.017	0.07	0.235	0.107
Marvelous Coral Reef	0.878	1.473	2.164	0.058	0.155	0.354	0.012	0.05	0.163	0.075
Nice Beaches	0.594	0.85	1.302	0.04	0.089	0.213	0.008	0.029	0.098	0.045
Colourful Fish	0.624	0.921	1.209	0.042	0.097	0.198	0.009	0.032	0.091	0.044
Waterfall	0.382	0.685	1.18	0.025	0.072	0.193	0.005	0.023	0.089	0.039
Traditional Fishermen Village	0.311	0.497	1.032	0.021	0.052	0.169	0.004	0.017	0.078	0.033
Unspoiled Forest	0.268	0.482	0.776	0.018	0.051	0.127	0.004	0.017	0.059	0.027

Figure 4: Analysis of Evaluation Islands in Terengganu (Attraction)

There are ten (10) analysis for each criterion that has been evaluated. Calculation results of 10 analyses will contribute to performance islands in Terengganu as shown in Figure 5. Figure 6 shows ranking of islands in Terengganu. These alternatives are ranked by crisp values of Best Non-fuzzy Performance value (BNP).

Figure 5: Performance Islands in Terengganu

.:Island Tourism Advisory System (iTAS) :.

Ranking Islands		
RANKING	ISLANDS	RATING (BNP)
1	Pulau Redang	103.989
2	Pulau Perhentian	99.7911
3	Pulau Lang Tengah	94.2611
4	Pulau Tenggol	91.8189
5	Pulau Gemia	88.8622
6	Pulau Kapas	87.6622

Figure 6: Ranking of Islands in Terengganu

Recommendation is a main part of this tourism decision support system after evaluation of islands. Tourists can choose their interest either to choose their own islands or trust this system to recommend the best islands. Figure 7 shows the flow for tourist to choose their interest.

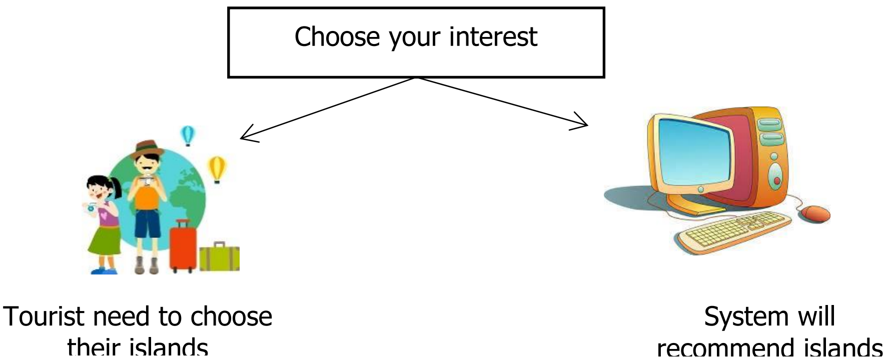


Figure 7: The Flow for Tourist Choose their Interest

If tourist select "Choose Your Island", data input screen for recommendation package based on tourists' budget will be appear as shown in Figure 8. Tourists asked to select the estimated budget required, then select the island of destination and package of interest. Besides of that, the tourist also needs to select the room type either single, twin, triple, quad or family and season. Figure 9 shows the results of recommendation.

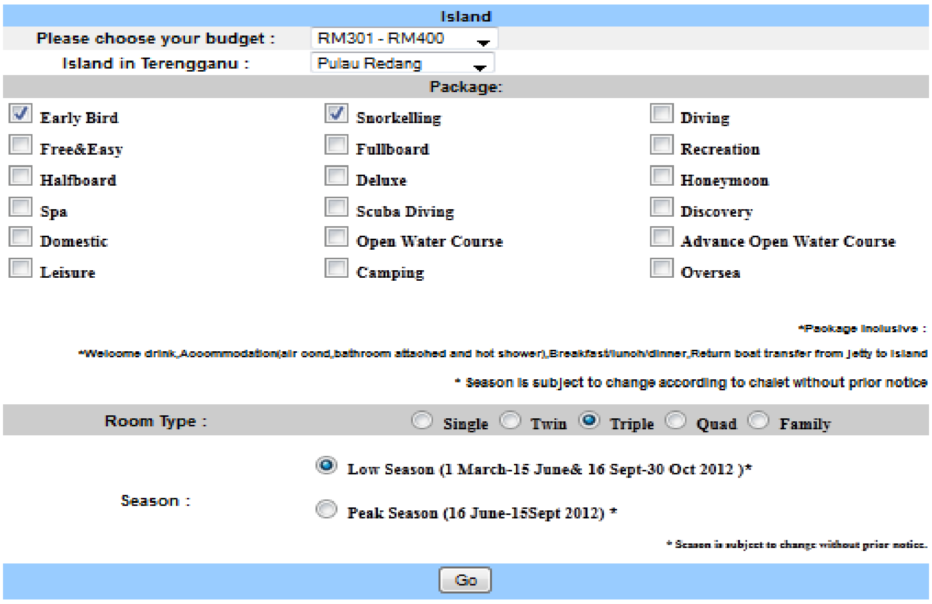
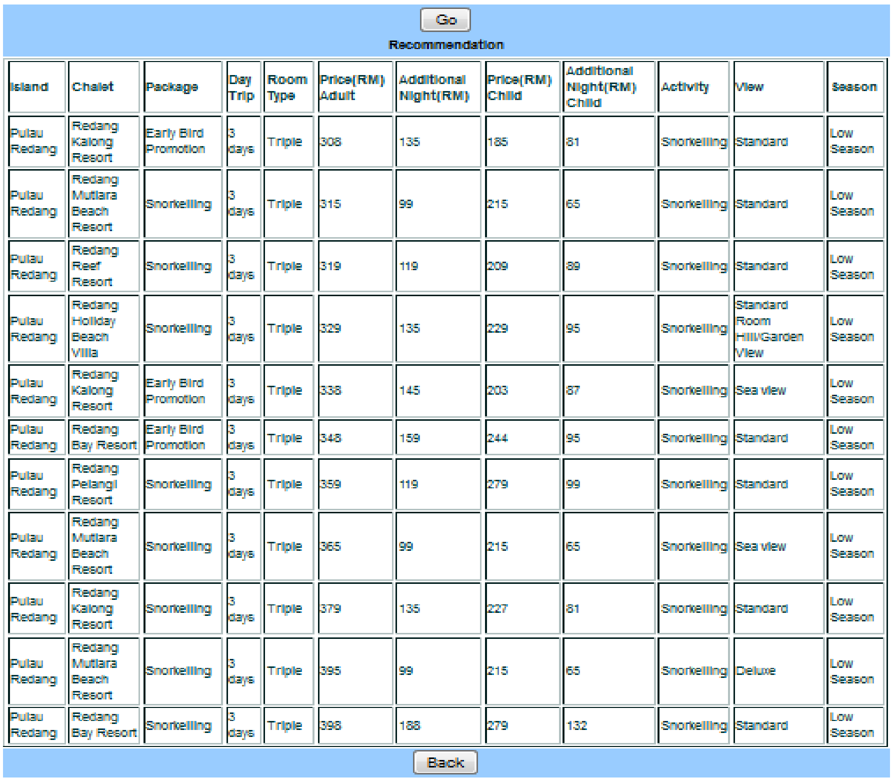


Figure 8: Data Input Screen for Recommendation Package based on Tourists' Budget



Go

Recommendation

Island	Chalet	Package	Day Trip	Room Type	Price(RM) Adult	Additional Night(RM)	Price(RM) Child	Additional Night(RM) Child	Activity	View	Season
Pulau Redang	Redang Kalong Resort	Early Bird Promotion	3 days	Triple	308	135	185	81	Snorkelling	Standard	Low Season
Pulau Redang	Redang Mutiara Beach Resort	Snorkelling	3 days	Triple	315	99	215	65	Snorkelling	Standard	Low Season
Pulau Redang	Redang Reef Resort	Snorkelling	3 days	Triple	319	119	209	89	Snorkelling	Standard	Low Season
Pulau Redang	Redang Holiday Beach Villa	Snorkelling	3 days	Triple	329	135	229	95	Snorkelling	Standard Room Hill/Garden View	Low Season
Pulau Redang	Redang Kalong Resort	Early Bird Promotion	3 days	Triple	338	145	203	87	Snorkelling	Sea view	Low Season
Pulau Redang	Redang Bay Resort	Early Bird Promotion	3 days	Triple	348	159	244	95	Snorkelling	Standard	Low Season
Pulau Redang	Redang Pelangi Resort	Snorkelling	3 days	Triple	359	119	279	99	Snorkelling	Standard	Low Season
Pulau Redang	Redang Mutiara Beach Resort	Snorkelling	3 days	Triple	365	99	215	65	Snorkelling	Sea view	Low Season
Pulau Redang	Redang Kalong Resort	Snorkelling	3 days	Triple	379	135	227	81	Snorkelling	Standard	Low Season
Pulau Redang	Redang Mutiara Beach Resort	Snorkelling	3 days	Triple	395	99	215	65	Snorkelling	Deluxe	Low Season
Pulau Redang	Redang Bay Resort	Snorkelling	3 days	Triple	398	188	279	132	Snorkelling	Standard	Low Season

Back

Figure 9: Results for Recommendation Package based on Tourists' Budget

This study hypothesizes that when entering an interaction with the system, novice users tend to engage in exploratory actions. Based on the evaluation of user satisfaction of the iTAS, this study proposes the following hypotheses with regard to the use of iTAS (Table 1).

Indicator	Hypotheses
H1	The iTAS web-system is helpful to the experts and tourist
H2	The users feel in control over the iTAS
H3	The iTAS is easy to learn for the first time users
H4	The users perceived the iTAS as easy to use
H5	The users perceived the iTAS as useful

Table 1: Hypotheses

3.1 Software Usability Measurement Inventory (SUMI)

The usability testing is a way to test whether the tourism products are user friendly to experts and tourists. In this study, the respondents of usability evaluation are tourists and experts in Terengganu. The techniques used to evaluate the iTAS are interviews and questionnaires. Interview is used to get understanding of user's satisfaction towards the system. Whereas questionnaire technique is used to measure user's satisfaction of the system.

3.1.1 Interview

The interviews were guided by using questionnaires. The researcher then has the flexibility to move beyond the confines of the established questions to seek further insight into an area of interest. Interviews were conducted with experts in tourism in person lasted approximately 1 hour.

3.1.2 Questionnaire

A questionnaire was used in order to obtain tourism experts' and tourists' views in measurement. Based on questionnaires, respondents were asked to response about usability of iTAS. This usability testing used Software Usability Measurement Inventory (SUMI) questionnaire. SUMI questionnaire is used to measure the usability of a system.

The results from the SUMI evaluations are presented in Table 2 and Table 3 in terms of the mean, upper and lower confidence intervals. These intervals are derived from the global usability scale and each of the five usability sub-scales which are efficiency, affect, helpful, controllability and learnability. The upper and lower confidence intervals represent the limits within which the theoretical true score falls 95% of the time for these respondents. Table 2 and Table 3 show that, on the global scale, the SUMI evaluation indicates that the usability of the iTAS is within the lower and upper confidence intervals. The results showed consistent in terms of usability sub-scales.

Scale	Lower confidence interval	Mean	Upper confidence interval
Global n = 10	2.78	3.30	3.81
Helpfullness	3.41	3.91	4.41
Controllability	2.96	3.47	3.97
Learnability	2.18	2.73	3.28
Efficiency	2.32	2.90	3.48
Affect	2.99	3.45	3.90

Table 2: The Results from SUMI Questionnaires (Experts)

Scale	Lower confidence interval	Mean	Upper confidence interval
Global n = 60	2.94	3.17	3.39
Helpfullness	3.70	3.89	4.08
Controllability	3.00	3.33	3.66
Learnability	2.37	2.60	2.82
Efficiency	2.42	2.62	2.83
Affect	3.19	3.39	3.58

Table 3: The Results from SUMI Questionnaires (Tourists)

This study uses Fuzzy-AHP as basis and generate outcome via the method that integrates priority of criteria and alternatives. It also can generate recommendation islands and package that suits with tourist budget. Integration with web service technology can reduce the development cost of the entire tourism decision support system, improve the speed and effective evaluation of alternatives and greatly improve the flexibility of system development.

The usability methodology presented in this paper for evaluating five sub-scales of user satisfaction of the users of iTAS is acceptable. The findings of the study gave feedback response for the developer and designers of the iTAS to know how users response when interacting with the system and how useful the system to them.

4.0 CONCLUSION

The findings in this research show that this study is consistent with the hypotheses made. All hypotheses made based on the five aspects of user satisfaction are consistent and therefore accepted to be true. The iTAS is found to be helpful. The users feel in control over the iTAS. The iTAS is easy to learn for the novice users. On a global scale of experts, aspects of helpfulness and controllability have the highest mean scores compared to other aspects. This shows that the experts find that the iTAS as helpful and they are in control over the iTAS. However, designers need to make improvements in the user interface with better function and informative function to improve efficiency and learnability. On the other hands, aspects of helpfulness and affect have the highest mean scores compared to other aspects for tourists. Tourists find that the iTAS as helpful and easy to use but some modifications has to be focused on learnability and efficiency parts same goes to the experts due to lowest mean compared to the other aspects.

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