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Implementation of Fuzzy AHP in Prioritizing Hotel Selection for Various Activities

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Abstract

The hotel sector plays a pivotal role in tourism, serving as a crucial venue for businesspeople, tourists, and other guests, significantly boosting regional and national economies. Facing increasing competition due to the rise in attractive tourist destinations and business travel for specific agendas such as meetings and seminars, the hotel industry must optimize its selection process. This study aims to aid in hotel selection based on weighted criteria for various activities by implementing the Fuzzy Analytical Hierarchy Process (Fuzzy AHP). AHP, widely used for multi-criteria decision-making, and Fuzzy Logic, chosen for its effectiveness in handling uncertainty and ambiguity, form the methodological foundation. The study utilized criteria such as price, quality, security, and location, with alternatives including traveling, meetings, and seminars. Data from 30 anonymous respondents were processed using Microsoft Excel for Fuzzy AHP computations. Results indicated that for meetings, hotel selection prioritizes quality and security, while for seminars, price and location are more important. In traveling, the emphasis is evenly distributed but generally low across all criteria, with the location being the least significant. This research underscores the potential of Fuzzy AHP in improving decision-making accuracy in hotel selection based on varying activity preferences.

Keywords: AHP, Fuzzy, Fuzzy AHP, Hotel, Tourism Industry.

1. Introduction

The term "hotel" originates from the Latin word "hospitium", meaning guest room [19]. Over time, the term hospitium evolved in meaning, and to differentiate between a guest house and a mansion house, large houses were called “hostel”. The letter "s" in the word hostel was eventually dropped or omitted, leading to the transformation of the term “hostel” into “hotel” [1]. A hotel is a significant sector of tourism, serving businesspeople, tourists, and other guests. According to the Regulation of the Minister of Tourism and Creative Economy of the Republic of Indonesia Number PM.53/HM.001/MPEK/2013 on Hotel Business Standards, a hotel is a business providing accommodation in the form of rooms within a building that may include food and beverage services, entertainment activities, and/or other facilities daily for profit. The hotel industry also boosts the economy of a region or country, as it creates numerous job opportunities [2]. Hotels continually adapt to changing trends and market demands, including hotel technology, personalized services, and local food and beverage options. Business competition in this industry is becoming increasingly intense due to the growing number of attractive tourist destinations and business trips with specific agendas such as meetings and seminars, making hotels a compelling choice. The rise in the number of new hotels entering the market has substantially intensified competition within the hospitality industry [20]. In response to this challenge, an effective decision support method is required. The Analytic Hierarchy Process (AHP) stands out as one of the most commonly employed techniques for making multi-criteria decisions [10]. The AHP method is a systematic approach used to model complex and unstructured problems by representing them as pairwise comparisons built into a hierarchical structure [4]. By using a hierarchy, a complex problem can be broken down into groups, which are then organized hierarchically, making the problem more structured and systematic [5]. The Analytic Hierarchy Process (AHP) is a decision-support method developed by Thomas L. Saaty in 1993 [15]. AHP has been utilized across various domains including business, government, military, and industry [12]. Additionally, AHP has been applied in diverse areas such as economics, politics, and engineering [13]. Its reliability is well-established due to its strong mathematical foundation, making it suitable for the evaluation and selection of alternatives [11]. The accuracy of this process can be enhanced by incorporating Fuzzy logic, which converts imprecise data into precise and accurate information [14]. The application of Fuzzy logic has shown a significant impact across various fields and is widely adopted by researchers [18]. Fuzzy logic enables decision-making in uncertain and ambiguous situations, addressing unexpected problems or those with incomplete information [3]. Combining Fuzzy logic with AHP, referred to as Fuzzy AHP (F-AHP), can effectively aid in hotel selection based on weighted criteria for various activities. This study employs several general criteria, including price, quality,

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security, and location, to determine the weight values, with alternatives used for activities such as traveling, meetings, and seminars. Based on these considerations, this study aims to implement the Fuzzy AHP method in selecting hotel options for various activities.

2. Research Method

2.1 Data Collection and Analysis Methods

The data analysis method used in this study is the Fuzzy Analytical Hierarchy Process (Fuzzy AHP). Calculations for the Fuzzy AHP were performed using Microsoft Excel. The model output of this research is the comparison of the weight values of the criteria with the predetermined alternatives. Data collection was conducted by distributing questionnaires, which were completed anonymously and randomly by 30 respondents. These data were then processed and calculations were performed to determine the weight values of each criterion using Fuzzy AHP.

2.2 AHP (Analytical Hierarchy Proses)

Before conducting Fuzzy AHP computations, the hierarchical arrangement of the issue is initially addressed utilizing the AHP technique, guaranteeing that the consistency ratio (CR) is ≤ 0.1 concerning the comparison matrix. The procedures involved in AHP for computing the consistency ratio and ensuring matrix consistency are delineated as follows [6]:

a. Weighting the questions provided to respondents based on their level of importance.

Table 1. Level of Importance

No.	Level of Importance	
1	1	Equally important
2	3	Fairly Important (1 level more important than the other criteria)
3	7	More Important (2 levels more important than the other criteria)
4	5	Very Important (3 levels more important than the other criteria)
5	9	Important (4 levels more important than the other criteria)

b. Performing consistency ratio calculations

(The matrix of average weight calculations) x (the vector of weights for each row)

c. Performing consistency vector calculations

$$\frac{\textit{The Consistency Ratio}}{\textit{Partial Weight of Each Row}}$$

d. Calculating the average entry

$$\lambda max = \frac{\sum_{1=1}^{n} Vector\ Consistency}{n}$$

e. Calculating *consistency index*

$$CI = \frac{\lambda max - n}{n - 1}$$

f. Determining the index ratio value

Table 2. Index Ratio Value

n	IR
1	0.00
2	0.00
3	0.52
4	0.89
5	1.12
6	1.25

7	1.35
8	1.40
9	1.45
10	1.49

g. Calculating the consistency ratio value

$$CR = \frac{CI}{IR}$$

2.3 Fuzzy AHP (Fuzzy Analytical Hierarchy Process)

Fuzzy AHP is a derivative analytical approach stemming from AHP [16]. It employs a fuzzy ratio termed as Triangular Fuzzy Number (TFN) during the process of fuzzification [17]. TFN comprises three membership functions: the lower value (l), the middle value (m), and the upper value (u). The concept of TFN within fuzzy set theory is designed to facilitate measurements in scenarios involving subjective human evaluations using linguistic descriptors [7]. The scale values associated with TFN are presented in the subsequent table.

Table 3. Triangular Fuzzy Number Scale

AHP	Linguistic Set	TFN	Reciprocal
1	*Just Equal* (Comparison of the same elements)	(1,1,1)	(1,1,1)
2	*Intermediate* (Mid)	(1/2,1,3/2)	(2/3,1,2)
3	*Moderately Important* (One element is quite important than the others)	(1,3/2,2)	(1/2,2/3,1)
4	*Intermediate* (Mid)	(3/2,2,5/2)	(2/5,1/2,2/3)
5	*Strongly Important* (One element is more important than the others)	(2,5/2,3)	(1/3,2/5,1/2)
6	*Intermediate* (Mid)	(5/2,3,7/2)	(2/7,1/3,2/5)
7	*Very Strong* (One element is significantly more important than the others)	(3,7/2,4)	(1/4,2/7,1/3)
8	*Intermediate* (Mid)	(7/2,4,9/2)	(2/9,1/4,2/7)
9	*Extremely Strong* (One element is more important than the others)	(4,9/2,9/2)	(2/9,2/9,1/4)

The membership function of Triangular Fuzzy Number (TFN) is illustrated in Figure 1 [8]:

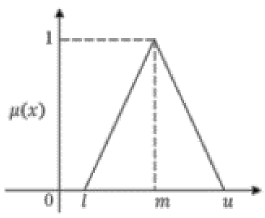

Figure 1. *The Triangular Fuzzy Number (TFN) Membership Function*

The stages in Fuzzy AHP are as follows [9]:

Stage 1: AHP structure is established. Decision makers identify decision objectives and criteria that are relevant to these objectives. Additionally, expert ratings on comparison matrices are modeled using fuzzy numbers through linguistic variables.

Stage 2: For each criterion, the canonical representation of fuzzy numbers is used with multiplication operations to obtain comparison matrices.

Stage 3: Determination of the average weights of these criteria.

Stage 4: Determination of the final weights of each criterion by normalizing the average weights of these criteria.

3. Results And Discussion

The AHP hierarchical structure serves as the initial phase in employing the Fuzzy AHP model. The hierarchical structure in this study is illustrated in Figure 2.

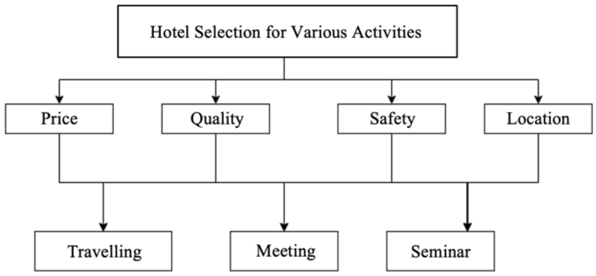

Figure 2. *Hierarchical Structure*

The AHP comparison matrix of criteria is constructed from questionnaire distribution results, followed by pairwise comparison of its values. The paired comparison outcomes of each criterion can indicate final weights to determine priorities.

Table 4. Results of Criteria Comparison Matrix & Priority Values

Criteria	Price	Quality	Safety	Location	Priority
Price	0.26	0.28	0.24	0.25	0.26
Quality	0.25	0.27	0.29	0.28	0.27
Safety	0.28	0.24	0.26	0.26	0.26
Location	0.21	0.20	0.21	0.21	0.21

From the comparison table above, pairwise comparison fuzzification can be conducted on the criteria, and the results can be observed in Table 5.

Table 5. Fuzzification Results of Criteria Comparison

Criteria	Price			Quality			Safety			Location		
	L1	M1	U1	L2	M2	U2	L3	M3	U3	L4	M4	U4
Price	1.00	1.00	1.00	0.80	0.96	1.08	0.78	0.95	1.02	0.92	1.11	1.32
Quality	0.85	1.04	1.11	1.00	1.00	1.00	0.88	1.07	1.19	1.02	1.24	1.37
Safety	0.89	1.07	1.17	0.77	0.93	1.01	1.00	1.00	1.00	1.10	1.29	1.25
Location	0.77	0.93	1.08	0.67	0.81	0.91	0.66	0.77	0.81	1.00	1.00	1.00

The results of the fuzzification process are utilized to normalize the average weights of criteria, as shown in Table 6.

Table 6. Results of Criteria Weight Normalization

Normalization of Weight Values	
Price	0.17264178
Quality	0.17264178
Safety	0.17264178
Location	0.48207465

The criteria weights have been determined; the next step is to ascertain the weights of the alternatives: Traveling, Meetings, and Seminars. The subsequent procedures involve a similar approach as previously employed, comparing alternative comparisons based on the scale values derived from respondent feedback. The Comparison Matrix depicts the outcomes, as shown in Table 7-10.

Table 7. The Outcome of the Alternative Comparison Matrix on 'Price'

PRICE	TRAVELLING	SEMINAR	MEETING	PRIORITY
TRAVELLING	0.32	0.43	0.27	0.34
SEMINAR	0.17	0.22	0.28	0.22
MEETING	0.52	0.35	0.44	0.44

Table 8. The Outcome of the Alternative Comparison Matrix on 'Quality'

QUALITY	TRAVELLING	SEMINAR	MEETING	PRIORITY
TRAVELLING	0.26	0.21	0.38	0.28
SEMINAR	0.57	0.47	0.36	0.47
MEETING	0.17	0.32	0.25	0.25

Table 9. The Outcome of the Alternative Comparison Matrix on 'Safety'

SAFETY	TRAVELLING	SEMINAR	MEETING	PRIORITY
TRAVELLING	0.32	0.43	0.27	0.34
SEMINAR	0.17	0.22	0.28	0.22
MEETING	0.52	0.35	0.44	0.44

Table 10. The Outcome of the Alternative Comparison Matrix on 'Priority'

LOCATION	TRAVELLING	SEMINAR	MEETING	PRIORITY
TRAVELLING	0.50	0.44	0.56	0.50
SEMINAR	0.26	0.23	0.18	0.22
MEETING	0.23	0.33	0.26	0.28

From the comparison table of alternatives above, a re-fuzzification was conducted yielding results as depicted in Tables 11 to 14.

Table 11. Results of Alternative 'Price' Fuzzification

PRICE	TRAVELLING			SEMINAR			MEETING		
	L1	M1	U1	L2	M2	U2	L3	M3	U3
TRAVELLING	1.00	1.00	1.00	1.26	1.52	1.82	0.66	0.78	0.93
SEMINAR	0.55	0.66	0.60	1.00	1.00	1.00	0.69	0.81	0.97
MEETING	1.08	1.29	1.14	1.04	1.23	1.44	1.00	1.00	1.00

Table 12. Results of Alternative 'Quality' Fuzzification

QUALITY	TRAVELLING			SEMINAR			MEETING		
	L1	M1	U1	L2	M2	U2	L3	M3	U3
TRAVELLING	1.00	1.00	1.00	0.48	0.56	0.50	1.00	1.21	1.09
SEMINAR	1.52	1.78	2.08	1.00	1.00	1.00	0.91	1.14	1.05
MEETING	0.69	0.82	1.00	0.55	0.63	0.55	1.00	1.00	1.00

Table 13. Results of Alternative 'Safety' Fuzzification

SAFETY	TRAVELLING			SEMINAR			MEETING		
	L1	M1	U1	L2	M2	U2	L3	M3	U3
TRAVELLING	1.00	1.00	1.00	0.48	0.56	0.50	1.00	1.21	1.09
SEMINAR	1.52	1.78	2.08	1.00	1.00	1.00	0.91	1.14	1.05
MEETING	0.69	0.82	1.00	0.72	0.87	0.83	1.00	1.00	1.00

Table 14. Results of Alternative 'Location' Fuzzification

LOCATION	TRAVELLING			SEMINAR			MEETING		
	L1	M1	U1	L2	M2	U2	L3	M3	U3
TRAVELLING	1.00	1.00	1.00	1.26	1.52	1.82	1.44	1.70	2.00
SEMINAR	0.55	0.66	0.60	1.00	1.00	1.00	0.69	0.87	1.14
MEETING	0.50	0.59	0.39	0.87	1.14	1.44	1.00	1,00	1.00

The results of the fuzzification process reveal the normalized weights of each alternative criterion value, as presented in Tables 15 to 18.

Table 15. Results of Normalized Weight Vector of Alternative Vectors (Price)

NORMALIZATION OF VECTOR WEIGHTS (d(An)) - PRICE	
TRAVELLING	0.2195614
SEMINAR	0.560877199
MEETING	0.2195614

Table 16. Results of Normalized Weight Vector of Alternative Vectors (Quality)

NORMALIZATION OF VECTOR WEIGHTS (d(An)) - QUALITY	
TRAVELLING	0.2195614

SEMINAR	0
MEETING	0.751029345

Table 17. Results of Normalized Weight Vector of Alternative Vectors (Safety)

NORMALIZATION OF VECTOR WEIGHTS (d(An)) - SAFETY	
TRAVELLING	0.2195614
SEMINAR	0
MEETING	0.751771084

Table 18. Results of Normalized Weight Vector of Alternative Vectors (Location)

NORMALIZATION OF VECTOR WEIGHTS (d(An)) - LOCATION	
TRAVELLING	0
SEMINAR	0.556723299
MEETING	0.2195614

Based on the calculations above, a comparison of the criteria weights can be made with the alternatives outlined in Table 19.

Table 19. Comparison of Weighted Values between Criteria - Alternatives

ACTIVITY	Price	Quality	Safety	Location
	0.17264178	0.17264178	0.17264178	0.48207465
TRAVELING	0.21956140	0.21956140	0.21956140	0.00000000
SEMINAR	0.56087720	0.00000000	0.00000000	0.55672330
MEETING	0.21956140	0.75102934	0.75177108	0.21956140

4. Conclusion

The utilization of the Fuzzy AHP method can be implemented to measure hotel selection preferences based on planned activities. From the aforementioned descriptions, it can be concluded that the primary priority in selecting hotels for conducting meetings lies in aspects of quality and security, with price and location carrying relatively lower importance weights. Conversely, for seminars, hotel selection prioritizes price and location while disregarding considerations of quality and security. During travel activities, emphasis is more evenly distributed but with low weights across all criteria, particularly where location holds minimal value. Further research in this area necessitates additional data to enhance accuracy and precision.

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