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Fuzzy AHP model in influencing the decision to visit a coffee shop

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ABSTRACT--*The results have been well proven by using the classical AHP method, but failing to produce better results in many cases of application. The results obtained in showing coffee quality products are very desirable for visitors to visit a coffee shop, where strategic location and facilities are a priority for visiting coffee shops. The availability of Wi-Fi and good service is not a consideration for visitors to visit a coffee shop. However, the price receipt is a priority for visitors to visit the coffee shop. Cheaper price is not an indication that a coffee shop will be a priority for visitors to visit the coffee shop. Satisfaction of coffee taste attracts visitors to visit the coffee shop.*

Keywords*-- model, influencing, decision, visit coffee shop*

I. INTRODUCTION

The coffee shop is used as a gathering place and completing work as well as a place for discussion both with colleagues or family. Many of the students use the coffee shop as an alternative place to complete assignments or exchange ideas between students. Not infrequently also civil servants and professionals use the coffee shop as an alternative place to entertain business partners in informal meetings.

The most widespread business is business related to food, drinks, and wifi facilities provided. Many businesses in the field of food or culinary that present all forms of facilities in it. As with the widespread coffee shop business in Lhokseumawe City, many coffee shops that provide a variety of unique flavors and various facilities in it make consumers interested in trying.

This makes consumers have many considerations for buying coffee in a coffee shop. Some of the considerations include the quality of the coffee served, the variety of coffee variants, the atmosphere of the coffee shop, and other supporting facilities [1]. The number of variants of coffee in a coffee shop is very important in choosing a coffee shop, the atmosphere of a coffee shop is a consideration to choose a coffee shop as a place to enjoy coffee. Consumer behavior can change due to external influences, such as culture, social and others [2]. AHP (Analytic Hierarchy Process) is a method of analysis in decision making based on quantity, coefficient, weight and coefficient of the index calculated based on the rank [3]. Decision making with the AHP method uses subjective criteria, in solving the problem, fuzzy set techniques are developed in AHP [4].

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The most basic problem often faced in the decision making process is the difficulty of defining feelings, thoughts and decisions quickly and precisely. Feelings, thoughts and decisions are expressed in a range of numerical values rather than using integers, which are reliable [5].

This calculation, it has been proven that good results have been achieved using the classical AHP method, but failed to produce good results in many application cases.

In this study, we applied the fuzzy AHP method in determining the influence of the buyer's decision to visit a coffee shop in Lhokseumawe City. There are [4] main criteria, namely product, price, distribution, and service. In the product criteria there are sub criteria namely satisfying taste, interesting form, quality. Price has sub criteria, namely affordable prices, according to quality and cheap. Distribution has sub criteria namely strategic location, attractive place, clean and complete facilities. Process has sub criteria, namely price receipt, service and WiFi.

II. LITERATURE REVIEW

2.1 Analytical Hierarchy Process

Fuzzy Analytical Hierarchy Process (FAHP) is a combination of AHP method and fuzzy concept approach. Fuzzy AHP covers the weaknesses found in AHP, namely problems that have a subjective nature. Uncertainty in numbers is represented by scale. Determination of the degree of Fuzzy AHP membership by using the triangle membership function (Triangular Fuzzy Number/TFN) [4].

Chang defined the value of AHP intensity into fuzzy triangles, namely dividing each fuzzy set by two, except for the number one intensity. Fuzzy Triangular Numbers (TFN) are fuzzy set theory in measurements related to subjective judgments of human using language or linguistics. The use of fuzzy AHP is better because fuzzy valuation uses top and good values that are not used in AHP. Pairwise comparisons are described by the ratio scale that is related to the fuzzy scale, with fuzzy triangular numbers symbolized, defined in 3 series (l, m, u) with membership functions $\mu_{A\,(x)}$[4], which is defined using equation (1).

$$\mu_{A(x)} = \begin{cases} \frac{x-1}{m-1}, & 1 \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \\ 0\ , & otherwise. \end{cases} \qquad (1)$$

Where x is the average value of A and l, m, u is the true value. By setting two TFN A and B with three values A = (l_1, m_1, u_1) and B = (l_2, m_2, u_2). Triangular Fuzzy Number mathematical rules as follows:

1. Addition ⊕

$$A\,(+)\,B = \left(l_1, m_1, u_1\right)\,(\div)\,\left(l_2, m_2, u_2\right)$$

$$= \left(l_1 + l_2, m_1 + m_2, u_1 + u_2\right) \qquad (2)$$

2. Multiplication ⊗

$$A\,(x)\,B = (l_1,\ m_1, u_1)\,(x)\,(l_2, m_2, u_2) \qquad (3)$$

$$A\,.\,B = (l_1.l_2,.m_2, u_1.u_2)$$

3. Exponent

$$\left(l_1, m_1, u_1\right)^{-1} = \left(\frac{1}{l_1}, \frac{1}{m_1}, \frac{1}{u_1}\right) \quad (4)$$

2.2 Fuzzy Synthetic Extent

Fuzzy synthetic extent value is used to obtain a goal, with extent analysis value [4], each object set can be carried out extent analysis on each object to get a goal. With the following values:

$$M_{gi}^{1},\ M_{gi}^{2}, \dots,\ M_{gi}^{m},\ i = 1,2,..,\ n \quad (5)$$

Where all $M_{gi}^{j}, i = 1,2,..,m$ is fuzzy triangular number, which is defined as follows:

(6)

Value of, $\sum_{j=1}^{m} M_{gi}^{J}$ can be determined by performing M fuzzy addition operation on the M extent analysis matrix.

$$\sum_{J»1}^{m} M_{gi}^{j} = \bigotimes \left[\sum_{I»1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad (7)$$

and

$$\sum_{j=1}^{m} M_{gi}^{J} = \left(\sum_{J»1}^{m} L_I,\ \sum_{J»1}^{m} m_i,\ \sum_{j=1}^{m} u_i\right)$$

$$\left[\sum_{i=1}^{m} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = (l_i, m_i, u_i)^{-1} = \left(\frac{1}{u_i}, \frac{1}{m_i}, \frac{1}{l_i}\right) \quad (8)$$

To get the value of the weight vector on each criterion, it is necessary to consider the principle of comparison for fuzzy numbers. There are two possible questions [4], namely:

1. What is the smallest fuzzy value or the largest value in the set of fuzzy numbers
2. Which is the smallest and largest number value among several numbers of fuzzy values

To get the weight value of each criterion, two Fuzzy Triangular numbers $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ with possibility level $M_1 \geq M_2$ [4,6] can be defined as follows:

$$V(M_1 \geq M_2) = \sup_{x \geq y} \left[min\left(\mu_{M1}(x), \mu_{M2}(y)\right)\right] \quad (9)$$

With sup represents supremum, $V(M_1 \geq M_2) = 1$, because $M_1\ dan\ M_2$ is a convex fuzzy defined by Fuzzy Triangular numbers$M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$, can be obtained by equation:

$$V(M_1 \geq M_2) = 1;\ if\ m_1 \geq m_2$$

$$V(M_1 \geq M_2) = hgt(M_1 \cap M_2) = \mu_{M1}(x_d) \quad (10)$$

With 'if' is 'if only if' represents d is the slice coordinate of the highest point between μ_{M1} and μ_{M2}, to get the result of d coordinate. The term hgt () is the highest fuzzy value in M having a slice between M_1 and M_2, $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ coordinate slices are obtained from equation (10). And convex fuzzy numbers are obtained from equation (11).

$$V(M_1 \geq M_2) = hgt(M_1 \cap M_2) = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} = d \quad (11)$$

Ratio between M_1 and M_2, needs both values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$. The value of d is the coordinates of the highest intersection between μ_{M1} and μ_{M2} [7], ratio between M_1 and M_2 needs both values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$. It is possible that value of convex fuzzy is greater than k number of convex fuzzy $M_i\ (i = 1,2,3..,k)$.

The convex fuzzy number value of M is greater than k number of fuzzy number M_i (i = 1, 2, 3,…, n) obtained in doing mathematical operations namely max and min [6] can be defined as follows:

$$V(M \geq M_1, M_2, .., M_k) = V[(M \geq M_1) \, dan \, (M \geq M_2) \, dan \, (M \geq M_k)]$$
$$= V(M \geq M_i), \text{ i=1, 2, 3 …, k}$$
$$d'(A_i) = \min V(S_i \geq S_k) \quad (12)$$

Assume that $d'(A_i) = \min V(S_i \geq S_k)$, k=1,2,3,4,5, …n, k ≠ I, and n is the end of the given number. Vector weight is obtained from

$$w' = \left(d'(A_1), d'(A_2), .., d'(A_m)\right) \quad (13)$$

A_i (i= 1,2,3, .. ,n) is an alternative to the decisions obtained, $d'(A_i)$ shows the relationship to decision choices in the vector denoted by the equation below.

$$w = \left(d(A_1), d(A_2), .., d(A_n)\right)^T \quad (14)$$

Eigen vector (w) is not fuzzy [3], which obtained from mathematical equation:

$$x_I = \frac{1}{n} \sum_{j=1}^{n} a_{ij} \quad (15)$$

$$w_I = \frac{x_i}{\sum_{i=1}^{n} x_I} \quad (16)$$

III. RESEARCH METHODOLOGY

The locations of coffee shop located in Lhokseumawe City were QBO Coffee, ND Coffee, Premium Coffee and ABUWA Coffee. Data collection was performed by distributing questionnaires to respondents according to predetermined criteria. There are several variables as criteria as the choice of the writer in influencing the behavior of visitors to visit the coffee shop.

In table 1, the decision makers identified criteria selection as a consideration by giving weight. The main criteria for choice are product, price, distribution and process.

Table 1: Pairwise comparison between criteria

	Product			Price			Distribution			Process		
Product	1	1	1	1/2	1	3/2	2/3	1	2	1/2	1	3/
Price	2/3	1	2	1	1	1	1/2	2/3	1	1/2	1	3/
Distribution	1/2	1	3/2	1	3/2	2	1	1	1	1/2	1	2
Process	2/3	1	2	2/3	1	2	2/3	1	2	1	1	1

In table 2, interviews are limited to several respondents to give an assessment of the criteria that have been determined. Satisfied is the opinion of respondents when visiting a coffee shop with good coffee flavor. Interesting means that the coffee is pleasing to the eye so interested in trying coffee. Quality means the taste of coffee with the best product from coffee. For example, civet coffee with the best quality but has a sour taste on the tongue.

Table 2: Pairwise comparison between criteria product

	Satisfied			Interested			Qualified		
Satisfied	1	1	1	1	3/2	1	3/2	2	5/2
Interested	1/2	2/3	1	1	1	1	1/2	1	3/2
Qualified	2/5	1/2	2/3	2/3	1	2	1	1	1

Coffee shop location near where visitors live, prices are comparable to the quality of coffee in the coffee shop, and prices are cheaper than other coffee shops.

Table 3: Pairwise comparison between criteria price

	Affordable			Suitable			Cheap		
Affordable	1	1	1	1/2	1	3/2	1/2	1	3/2
Suitable	2/3	1	2	1	1	1	1/2	1	3/2
Cheap	2/3	1	2	2/3	1	2	1	1	1

Distribution has a sub-criteria, namely the location of the coffee shop is very strategic for visitors. Then the coffee shop is interesting, either located on the edge of the beach or visited by young people, both girls and boys. Clean means that cleanliness in the coffee shop is very good and beautiful to the eye. Facilities mean a coffee shop provides good parking, small rooms are available. Near places of worship and the availability of entertainment. If one of the criteria becomes a choice for visitors, which criteria are higher in value that visitors will choose.

Table 4: Pairwise comparison between criteria distribution

	Strategic			Interested			Facility		
Strategic	1	1	1	1/2	1	3/2	1/2	1	3/2
Interested	2/3	1	2	1	1	1	1/2	1	3/2
Facility	2/3	1	2	2/3	1	2	1	1	1

A receipt will be given, after visitors make a payment at the coffee shop. The service provided is good, if visitors visit the coffee shop, and WIFI is available. However, visitors are given the choice of the best and higher value criteria, if the receipt is not given when visitors make payments or slow service to visitors but Wi-Fi is available well.

Table 5: Pairwise comparison between criteria price

	Receipt			Service			WIFI		
Receipt	1	1	1	3/2	2	5/2	1	3/2	2
Service	2/5	1/2	2/3	1	1	1	1	3/2	2
WIFI	1/2	2/3	1	1/2	2/3	1	1	1	1

IV. DATA ANALYSIS AND IMPLICATIONS

Data collected was performed from a limited survey, calculated using geometric mean to measure the comparison of pairs between predetermined criteria. Each respondent has a difference of opinion between

predetermined criteria. The geometric mean was used in converting different judgments into one number for each criterion and sub-criteria. Comparison of criteria and sub criteria was performed on each element with pair-wise comparison using fuzzy AHP.

Step-1: fuzzy synthetic extent

$$S_i = \sum_{J»1}^{m} M\frac{j}{gi} \bigotimes \left[\sum_{I»1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

Table 5: Pairwise comparison between main criteria

	Product			Price			Distribution			Process		
	l	m	u	l	m	u	l	m	u	l	M	u
product	1	1	1	0,5	1	1,5	0,7	1	2	0,5	1	1,5
price	0,67	1	2	1	1	1	0,5	0,67	1	0,5	1	1,5
distribution	0,5	1	1,5	1	1,5	2	1	1	1	0,5	1	2
process	0,67	1	2	0,67	1	2	0,7	1	2	1	1	1

$$(l_1,\ m_1,u_1) \oplus (l_2,m_2,u_2) \oplus (l_3,m_3,u_3) = \left(l_1 + l_2 + l_3, m_1 + m_2 m_3 +, u_1 + u_2 + u_3\right)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{m} M_{gi}^{j}$$

Table 6: Calculation of pairwise comparison addition

	l	m	u
S1	2,7	4	6
S2	2,7	3,6667	5,5
S3	3	4,5	6,5
S4	3	4	7
Total	**11**	**16,17**	**25**

Next Step:

$$\left[\sum_{i=1}^{m}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = (l_i, m_i, u_i)^{-1} = \left(\frac{1}{u_i}, \frac{1}{m_i}, \frac{1}{l_i}\right)$$

$$= \left(\frac{1}{25}, \frac{1}{16,17}, \frac{1}{11}\right)$$

Table 7: Results of comparison pairwise calculation

l1	m1	u1		L2	m2	u2
2,7	4,0	6,0	⊗	0,04	0,06184	0,1
2,7	3,7	5,5	⊗	0,04	0,06184	0,1
3,0	4,5	6,5	⊗	0,04	0,06184	0,1
3,0	4,0	7,0	⊗	0,04	0,06184	0,1

$$S_i = \sum_{J»1}^{m} M\frac{j}{gi} \bigotimes \left[\sum_{I»1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

Table 8: Results of Fuzzy Synthetic Extent

l	m	u	
0,107	0,247	0,545	**S1**
0,107	0,227	0,500	**S2**
0,120	0,278	0,591	**S3**
0,120	0,247	0,636	**S4**

Step-2: Find Vector Weight

The average value of the product is greater than the average value of the final product value of 1

$V(S_1 \geq S_2)$=1

The average value of the product is smaller than the final value distribution of 1.06821096

$V(S_1 \geq S_3)$=$\frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$- = $\frac{0,107 - 0,5}{(0,227 - 0,5) - (0,247 - 0,107)}$- = 1,06821096

The average value of the product is greater than the value of the process, the final result of 1

$V(S_1 \geq S_4)$=1

The average value of the price is smaller than the product, so the final result of 0.95020069

$V(S_2 \geq S_1)$= $\frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$- = $\frac{0,107 - 0,5}{(0,227 - 0,5) - (0,247 - 0,107)}$- = 0,95020069

The average value of the price is smaller than the average value of the distribution, the final value obtained is 1.11910093

$V(S_2 \geq S_3)$= $\frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$- =$\frac{0,107 - 0,591}{(0,278 - 0,591) - (0,227 - 0,107)}$ = 1,11910093

The average value of the product is smaller than the value of the average process, the final value is 1

$V(S_2 \geq S_4)$=$\frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}$ =$\frac{0,107 - 0,636}{(0,247 - 0,636) - (0,227 - 0,107)}$ - 1

The average value of the distribution is greater than the average value of the product, the final value is

$V(S_3 \geq S_1)= 1$

The average value of the distribution is greater than the average value, the final value is 1

$V(S_3 \geq S_2)= 1$

The average value of the distribution is greater than the value of the average process, the final value is 1

$V(S_3 \geq S_4)= 1$

The average value of the distribution is greater than the average produt value, the final value is 1

$V(S_4 \geq S_1)=1$

The average value of the process is greater than the average price value, the final value is 1

$V(S_4 \geq S_2)= 1$

The average value of the process is smaller than the average distribution value, the final value is 0.94350027

$V(S_4 \geq S_3)= \frac{l_1 - u_2}{(m_2 - u_2)-(m_1 - l_1)}$ - $= \frac{0.120-0.636}{(0.247-0.636)-(0.,278-0.120)} = 0{,}94350027$

Step-3: Find vector weight

$d'(A_i)$ = min V$\left(\widetilde{S_i} \geq \overline{S_k}\right)$, k=1,2,..,n; k≠ i

The product average value is greater than the price value and the upper limit of the product value above the average value of the process. The average value of the price is smaller than the average value of the product and is greater than the average value of the distribution, smaller than the average value of the process. The average value of the distribution is greater than the average value of the product, greater than the average value of the price and greater than the average value of the process. The average value of process is greater than the average value of the product, greater than the average value of the price and smaller than the average value of the distribution.

V(S1) = min (S1>S2, S1>S3;S1>S4)) = min(1;1,06821096;1)=1
v(S2)= min (S2>S1, S2>S3;S2>S4)) = min (0,95020069;1,11910093;1)
= 0.95020069
V(S3)= min (S3>S1, S3>S2;S3>S4) = min (1;1;1) = 1
V(S4)= min (S4>S1, S4>S2;S4>S3) = min (1;1;0,94350027) = 0,94350027

Step-4: Find the results of vector weight

$w' = \left(d'(S_1),\ d'(S_2),\ \ldots.,\ d'(S_n)\right)^T$
$d(S_i) = \frac{d(S_i)}{\sum_i d(S_i)}$

$w' = (1,\ 0{,}95020069;\ 1;\ 0{,}94350027)^T$

d(S1) = 0,257
d(S2) = 0,244
d(S3) = 0,257
d(S4)= 0,242

By following the steps as performed, the final value of the weight vector was obtained, product = 0.257; price = 0.244; distribution = 0.257 and process = 0.242.

W = (0,257;0,244;0,257;0,242)

Table 9: Final score of product weight vector

	Satisfied			Interested			Qualified			Weight
Satisified	1	1	1	1	1,5	2	1,5	2	2,5	0.601714397
Interested	0,5	0,7	1	1	1	1	0,5	1	1,5	0.279097438
Qualified	0,4	0,5	0,667	0,7	1	2	1	1	1	0.119188165

Table 10: Final score of price weight vector

	Affordable			Compatible			Cheap			Weight
Affordable	1	1	1	0,5	1	1,5	0,5	1	1,5	0.3333333
Compatible	0,7	1	2	1	1	1	0,5	1	1,5	0.3333333
Cheap	0,7	1	2	0,7	1	2	1	1	1	0.3333333

Table 11: Final score of distribution weight vector

	Strategic			Interesred			Facility			Weight
Strategic	1	1	1	0,5	0,7	1	0,5	0,7	1	0.37748134
Interested	1	1,5	2	1	1	1	0,5	1	1,5	0.31125933
Facility	1	1,5	2	0,7	1	2	1,5	1	1	0.31125933

Table 12: Final score of process weight vector

	Receipt			Service			wifi			Weight
Receipt	1	1	1	1,5	2	2,5	1	1,5	2	0.54324006
Service	0,4	0,5	0,667	1	1	1	1	1,5	2	0.29231988
wifi	0,5	0,7	1	0,5	0,7	1	1	1	1	0.16444006

V. CONCLUSION AND IMPLICATION

The results showed that the product and distribution had the same weight vector of 0.257 and the price was higher than the process. Visitors to the coffee shop are more concerned with more affordable prices and the desired process of service and facilities.

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Satisfaction with the taste of coffee is a great attraction for visitors to visit the coffee shop compared to processed coffee models and forms. The quality of coffee will be chosen by visitors from the beauty of the art offered by coffee shops to visitors.

Cheaper prices are not an indication of visitors to visit the coffee shop, because the value obtained is the same price according to the product even though it is more expensive than general coffee. And the location is not an influence on visitors to visit the coffee shop.

The strategic location attracts visitors to visit the coffee shop from the facilities and other attractions offered by the coffee shop to attract visitors to visit the coffee shop. This is due to facilities and attraction did not affect visitors to visit the coffee shop.

The receipt given by the coffee shop is a priority for visitors to visit the coffee shop rather than the availability of WIFI and good service.

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