

# Selecting the best rayon in customer's perspective using fuzzy analytic hierarchy process

E G Sonjaya<sup>1</sup>, E Paulus<sup>2</sup>, A Hidayat<sup>3</sup>

Department of Computer Sciences, Universitas Padjadjaran, Bandung, Indonesia

Email: egsonjaya@gmail.com, erick.paulus@unpad.ac.id, akik@unpad.ac.id

**Abstract:** Annually, the best *Rayon* selection is conducted by the assessment team of PT.PLN (Persero) Cirebon with the goal to increase the spirit of company members in providing an improved service for customers. However, there is a problem in multiple criteria decision making in this case, which is the importance intensity of each criterion in the selection are often assessed subjectively. To solve this problem, *Fuzzy Analytical Hierarchy Process* are used to cover AHP scale deficiency in the form of '*crisp*' numbers. So, it should be considered to use *Fuzzy logic approach* to handle uncertainty. Fuzzy approach, especially triangular fuzzy number towards AHP scale, are expected to minimize the handling of subjective input, which then will make a more objective result. Thus, this research was conducted to help the management or assessment team in the selection of the best *Rayon* with a more objective selection in according to the company criteria.

**Keyword:** Multiple Criteria, Fuzzy Analytical Hierarchy Process, Triangular Fuzzy Number

## 1. Introduction

Rayon is a subunit under the Area which helps a closer customer service and electricity distribution network. The Rayon formation is based on the number of customers in the region, with a purpose to improve customer services. The quality and spirit given by the Rayon can help the progress of a company to actualize their vision and mission, based on interviews from the company.

The best Rayon selection is conducted by the assessment team, which includes the Head of Planning and Evaluation Division, and Area Manager. The best Rayon is chosen based on their achievement of targets determined by the company by various criteria. Each criterion has a different scale/intensity of urgency. The best Rayon selection is completed by manual calculation, which multiplying the urgency scale score with the Rayon score and then summed up. And then, the Rayon with the highest score will be chosen as the best Rayon.

Problems which are faced with this selection process is that the assessment team cannot select the best Rayon accurately because the score of every criterion are based on the assessment team subjectivity. Thus, the final result of the best Rayon is still uncertain (*fuzzy=blurred or unclear*). The inaccuracy of the score given by the assessment team will have an impact on the process of decision making, which will make the decisions less precise. These problems can be solved by building a Decision Support



System (DSS) to reduce the subjectivity of the assessment team in selecting the best Rayon. Therefore, the Fuzzy Analytical Hierarchy Process (F-AHP) method can be used to solve the problems.

F-AHP method solves the problem of thinking using fuzzy set theory concepts and hierarchical structure analysis [1]. Essentially, the F-AHP method is an improvement method of the AHP, which usually uses real number calculations, to the F-AHP which uses fuzzy number calculations. F-AHP is a more developed method from the AHP method as it is combined with the fuzzy concept approach. F-AHP is designed to cover the weaknesses of AHP, which lies in the problem of subjective criteria. Some fuzzy AHP implementation on college ranking [2], risk assessment [3] and the best metro station [4] is succeed and give promising results

The selection of the best Rayon which uses the F-AHP method is expected to help the Planning and Evaluation Division of PT.PLN (Persero) Cirebon Area to make the best decision that can be done fairly and precisely.

## 2. Research Methods

### 2.1. Fuzzy Analytical Hierarchy Process (FAHP)

F-AHP is a combination of the AHP method with a fuzzy concept approach [4]. Because the AHP concept basically excludes unclear personal considerations, AHP has been improved by using a fuzzy logic approach. In the FAHP alternative criteria, comparison in pairs is indicated by linguistic variables. FAHP approach, Triangular Fuzzy Number (TFN) is used for falsification process from a crisp comparison matrix [5] [6]. Blurred data will be in the TFN. Each membership function is defined in 3 parameters which include I, M, and U, where I is the lowest possible score, M is the middle possible score, and U is the highest possible score at the decision interval for the decision makers. The score of I, M, and you can also be determined by the decision makers. In this article, the writers propose three parameters of fuzzy numbers to represent Saaty scale (1-9) according to their importance, i.e. [1]

$$\tilde{1} \equiv (1, 1, 1)$$

$$\tilde{x} \equiv (x - 1, x, x + 1); \forall x = 2, 3, \dots, 8$$

$$\tilde{9} \equiv (9, 9, 9)$$

(1)

Triangular Fuzzy Number (TFN) can show the subjectivity of a paired computability or can show a definite degree of vagueness (uncertainty). In this case, linguistic variables can be used by the decision makers to represent the uncertainty of data, in case of any inconvenience with TFN. TFN and its linguistic variables corresponding to the Saaty scale are shown in the following table [1]:

**Table 1.** Triangular Fuzzy Numbers and linguistic variable

Definition	Saaty Scale	TFN
Equally Important	1	(1,1,1)
Moderately more important	3	(2,3,4)
Strongly More Important	5	(4,5,6)
Very strongly more important	7	(6,7,8)
Extremely more important	9	(9,9,9)
Intermediate Values	2,4,6,8	(1,2,3), (3,4,5), (5,6,7), and (7,8,9)

To do local priorities of the fuzzy pairwise comparison matrix, there are various methods developed by previous experts. By combining AHP procedures with arithmetic operations for fuzzy numbers, local priority can be obtained using the following equation [7]:

$$S_i = \sum_{j=1}^m M_{g_i}^j \otimes \left[ \sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j \right]^{-1} \quad (2)$$

Where:

$S_i$  = fuzzy synthetic extent

$g_i$  = goal set ( $i = 1, 2, 3, \dots, n$ )

$M_{g_i}^j$  = Triangular Fuzzy Number ( $j = 1, 2, 3, \dots, m$ )

$$S_i = \left( \sum_{j=1}^m l_j ; \sum_{j=1}^m m_j ; \sum_{j=1}^m u_j \right) \otimes \left( \frac{1}{\sum_{i=1}^n u_i} ; \frac{1}{\sum_{i=1}^n m_i} ; \frac{1}{\sum_{i=1}^n l_i} \right) \quad (3)$$

Where:

$l$  = Lower bound score (Lowest possibility)

$m$  = The most promising score (Middle possibility)

$u$  = Upper bound score (Highest possibility)

The formula to determine the pairwise comparison score of  $S_i$ :

$$V(S_i \geq S_k) = \begin{cases} 1; & m_{S_i} \geq m_{S_k} \\ 0; & l_{S_k} \geq u_{S_i} \\ \frac{(l_{S_k} - u_{S_i})}{((m_{S_i} - u_{S_i}) - (m_{S_k} - l_{S_k}))}; & \text{lainnya} \end{cases} \quad (4)$$

Where:

$V(S_i \geq S_k)$  = Comparison score between fuzzy synthetic extent,

$S_i$  = fuzzy synthetic extent score for  $i$  criteria,

$S_k$  = fuzzy synthetic extent score for  $k$  criteria,

$$d'_i = \min(V(S_i \geq S_k) ; \text{for } k = 1, 2, 3, \dots, n; k \neq i, \quad (5)$$

$$W' = (d'_i, d'_{i+1}, d'_{i+2}, \dots, d'_{i+n-1})^T; \quad (6)$$

$$d_i = \frac{d'_i}{\sum_{i=1}^n d'_i} \quad (7)$$

$$W = (d_i, d_{i+1}, d_{i+2}, \dots, d_{i+n-1}) \quad (8)$$

where:

$d'_i$  = values of  $i$  criteria

$W'$  = vector values criteria

$d_i$  = values normalization

$W$  = vector values normalization criteria

$n$  = number of criteria

Arithmetic operation for fuzzy numbers can be seen from the following operation:

$$\begin{aligned} 1. \quad \tilde{n}_1 \oplus \tilde{n}_2 &= (\tilde{n}_{1l} + \tilde{n}_{2l}; \tilde{n}_{1m} + \tilde{n}_{2m}; \tilde{n}_{1u} + \tilde{n}_{2u}) \\ 2. \quad \tilde{n}_1 \otimes \tilde{n}_2 &= (\tilde{n}_{1l} \times \tilde{n}_{2l}; \tilde{n}_{1m} \times \tilde{n}_{2m}; \tilde{n}_{1u} \times \tilde{n}_{2u}) \\ 3. \quad 1/\tilde{n}_1 &= (1/\tilde{n}_{1u}; 1/\tilde{n}_{1m}; 1/\tilde{n}_{1l}) \end{aligned} \quad (9)$$

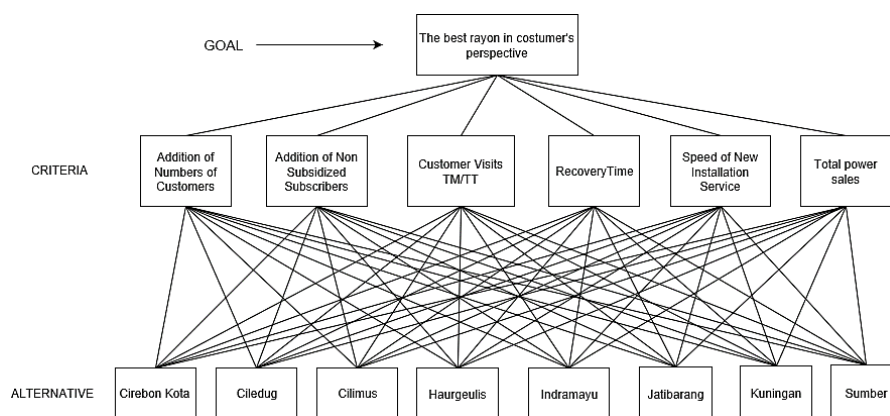
While global priority is obtained by multiplying the normalization of each  $w_j$  criterion scale by normalizing  $d(A_i)$  values and summing all the multiplication results of each criterion. The equation can be written as follows:

$$\tilde{P}_i = (\tilde{w}_1 \otimes d(A_1)) \oplus (\tilde{w}_2 \otimes d(A_2)) \oplus \dots \oplus (\tilde{w}_j \otimes d(A_i)) \quad (10)$$

### 3. Result and Discussion

#### 3.1. Data Collection Result

The interviews with the company results in several criterion and alternatives, which will be used for the best Rayon selection based on the customer perspective. It is then represented in the hierarchical structure. The problems formulated to build hierarchical structure are goal identification, criterion identification, and alternatives identification (rayons) to be assessed. The best Rayon hierarchy structure in customer perspective can be seen in the following picture:



1. The result of interviews from the Head of Distribution Planning says that the best Rayon in the costumer's perspective selection consists of several criteria:
2. Addition of numbers of customers, rayon's achievement in achieving the target of increasing the number of subscribers, using units of subscribers.
3. Addition of non-subsidized subscribers, rayon's achievement in achieving the target of increasing the number of customers, especially for the level of not using subsidies, using units of subscribers.
4. Costumer visits TM/TT, rayon's achievement in achieving the target number of high voltage / high voltage customer visits, using units of subscriber numbers.
5. Recovery time, rayon's achievement in targeted customer service should not be extinguished within a certain time, using units of minutes and calculated based on target number / month.
6. Speed of new installation service, rayon's achievement in achieving the target of a new installation service time is calculated from the day of the new pairs of submissions until completion.
7. Total power sales, rayon's achievement in achieving the target of total sales of electricity.

### 3.2. Data Processing

**3.2.1. Values Score Criteria.** Before determining the matrix of pairwise comparisons between criteria, we first determine the *values* or scale of each criterion. The function of determining the importance, intensity or scale of each criterion is to avoid inconsistency. This is because when we input the score of the comparison between criteria into the matrix in pairs, it is often inconsistent. Therefore, to avoid inconsistency, we need to determine the intensity of interest for each criterion. The interview process is conducted by one person from the Head of Planning and Evaluation Division of the related company. The intensity of importance score is given by the company in the range of 1 to 9.

**Table 2.** Values score criteria on costumer perspective.

Criteria	Point value
K1 Addition of Numbers of Customers	7
K2 Addition of Non Subsidized Subscribers	6
K3 Customer Visits TM/TT	4
K4 Recovery Time	4
K5 Speed of New Installation Service	6
K6 Total Power Sales	8

**3.2.2. Pairwise Comparison Matrix.** The existence of value score can be directly calculated for the AHP pairwise comparison matrix for each criterion. The following is the result of pairwise comparison matrix calculation.

**Table 3.** Pairwise comparison matrix, criteria on costumer perspective

	K1	K2	K3	K4	K5	K6
K1	1	7/6	7/4	7/4	7/6	7/8
K2	6/7	1	6/4	6/4	6/6	6/8
K3	4/7	4/6	1	4/4	4/6	4/8
K4	4/7	4/6	4/4	1	4/6	4/8
K5	6/7	6/6	6/4	6/4	1	6/8
K6	8/7	8/6	8/4	8/4	8/6	1

Then, the score of AHP pairwise comparison matrix (table 4) is converted into a triangular fuzzy equation or Triangular Fuzzy Number (TFN). The F-AHP scale has three scores which include the lowest score (lower, l), the middle score (median, m), and the highest score (upper, u)

**Table 4.** TFN Pairwise comparison matrix criteria on costumer perspective

	K1			K2			K3			K4			K5			K6		
	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
K1	1	1	1	0,167	1,167	2,167	0,75	1,75	2,75	0,75	1,75	2,75	0,167	1,167	2,167	0,875	0,875	1,875
K2	0,857	0,857	1,857	1	1	1	0,5	1,5	2,5	0,5	1,5	2,5	1	1	1	0,75	0,75	1,75
K3	0,571	0,571	1,571	0,667	0,667	1,667	1	1	1	1	1	1	0,667	0,667	1,667	0,5	0,5	1,5
K4	0,571	0,571	1,571	0,667	0,667	1,667	1	1	1	1	1	1	0,667	0,667	1,667	0,5	0,5	1,5
K5	0,857	0,857	1,857	1	1	1	0,5	1,5	2,5	0,5	1,5	2,5	1	1	1	0,75	0,75	1,75
K6	0,143	1,143	2,143	0,333	1,333	2,333	1	2	3	1	2	3	0,333	1,333	2,333	1	1	1

**3.2.3. F-AHP Calculation.** The F-AHP calculation starts from the calculation of fuzzy synthesis score, fuzzy vector and ordinate score, F-AHP vector values, and value priority normalization which will be obtained a global value priority criterion, assisted by using software that is Microsoft excel and web-based application for supporting calculation. The result of F-AHP calculation as follows:

a. Fuzzy synthetic score ( $S_i$ )

**Table 5.** Fuzzy synthetic ( $S_i$ ) on costumer perspective.

Criteria	Fuzzy synthetic score ( $S_i$ )		
	$L$	$M$	$U$
K1	0,057	0,200	0,498
K2	0,071	0,171	0,415
K3	0,068	0,114	0,329
K4	0,068	0,114	0,329
K5	0,071	0,171	0,415
K6	0,059	0,229	0,541

b. F-AHP Vector Score ( $v$ ) and defuzzy ordinate score ( $d'$ )

This process applies a fuzzy approach which is a fuzzy minimum implication (min) function. After comparing fuzzy synthesis scores, defuzzified ordinate score will be obtained This process implements *fuzzy* approach which is a fuzzy minimum implication function with a minimum score of  $d'$ . The result of  $v$  and  $d'$  calculations on costumer perspective is as follows:

1.  $d'(VsK1) = \min(1, 1, 1, 1, 0.938) = \mathbf{0,938}$
2.  $d'(VsK2) = \min(0.925, 1, 1, 1, 0.860) = \mathbf{0,860}$
3.  $d'(VsK3) = \min(0.760, 0.819, 1, 0.819, 0.701) = \mathbf{0,701}$
4.  $d'(VsK4) = \min(0.760, 0.819, 1, 0.819, 0.701) = \mathbf{0,701}$
5.  $d'(VsK5) = \min(0.925, 1, 1, 1, 0.860) = \mathbf{0,860}$
6.  $d'(VsK6) = \min(1, 1, 1, 1, 1) = \mathbf{1}$

c. Fuzzy vector *values* score ( $w'$ )

Based on the ordinate score of each criterion, the vector value score can be obtained as follows:

Costumer Perspective

$$W' = (0.938, 0.860, 0.701, 0.701, 0.860, 1)^T$$

$$\sum W' = 5,068$$

d. Fuzzy vector values score normalization ( $w$ )

Vector values score normalization is where each vector values elements are divided by the number of the vector values itself. It is where the number of values that has been normalized will be equal to 1. Normalization of fuzzy vector values scores criterion is equal to the global priority value score (which is the goal).

Costumer perspective

$$W_{\text{local}} = (0.185, 0.170, 0.139, 0.139, 0.170, 0.198)$$

**3.2.4. Alternative Ranking and Decision Results.** Alternative ranking is a step to determine the final decision. At this process, the activity that occurs is multiplying the local values ( $W$ ) (Criterion *values*) with the alternative score and summed up with each alternative elements in the criterion-affected level. The sum of the score are ranked and resulted in the decision of the best Rayon in multi perspective in PT PLN (Persero) Cirebon Area. The following is the conclusion table of *values* criterion and conclusion of ranking using FAHP.

**Table 6.** Alternative ranking on customer perspective

	K1	K2	K3	K4	K5	K6	TOTAL	F-AHP RANKING
Cirebon Kota	17,523	17,005	13,865	13,865	17,005	18,407	97,672	4
Ciledug	15,739	17,005	13,865	13,865	17,005	19,734	97,214	5
Cilimus	17,549	17,005	13,865	13,865	17,005	19,065	98,355	2
Haurgeulis	12,599	17,005	13,865	13,865	17,005	19,734	94,074	6
Indramayu	11,173	14,908	13,865	13,865	17,005	19,734	90,550	8
Jatibarang	12,898	17,005	13,865	13,865	17,005	19,092	93,731	7
<b>Kuningan</b>	<b>18,526</b>	<b>17,005</b>	<b>13,865</b>	<b>13,865</b>	<b>17,005</b>	<b>18,682</b>	<b>98,948</b>	<b>1</b>
Sumber	17,475	17,005	13,865	13,865	17,005	18,575	97,791	3

It can be concluded that Kuningan Rayon has the highest score compared to other Rayons with a score of 98,948. Then the second position is Cilumus Rayon with a score of 98,355 and the third position is Sumber Rayon with a score of 97,791.

#### 4. Conclusion

Fuzzy AHP can recommend an objective selection by recalculating the important intensity of six criteria to make a decision of the best Rayon. We have investigated nine Rayons based on six criterions as input value. The result shows that the best Rayon Selection of PT PLN (Persero) Cirebon Area on costumer perspective is the Kuningan Rayon with the highest final result scoring at 98,948. This research is also meant to be a recommendation to assist the planning and evaluation division to make decisions.

#### References

- [1] Alias M. A., Hashim, S. Z., & Samsudin S. Int. J. Advance. Soft Comput Appl., vol. 1, no. 1. (2009).
- [2] V. Agarwa, IEEE Int. Conf. Comput. Commun. Control. IC4 2015 (2016)
- [3] J. Tian and Z. F. Yan, J. Appl. Res. Technol., vol. 11, no. 4, 568–577 (2013).
- [4] K. Kepaptsoglou, M. G. Karlaftis, and J. Gkountis, KSCE J. Civ. Eng., vol. 17, no. 5, 1109–1116 (2013).
- [5] X. Zeshui and L. Huchang, Fuzzy Syst. IEEE Trans., vol. 22, no. 4, 749–761 (2014).
- [6] M. Tahri, M. Maanan, M. Maanan, H. Bouksim, and M. Hakdaoui, Prog. Phys. Geogr., vol. 41, no. 3, 268–285 (2017).
- [7] Kahraman, C., Cebeci, U., & Ruan, D. Int. J. Production Economics 87, 171-184 (2004).