Implementation of Fuzzy AHP – TOPSIS for Priority Selection of North Sumatera Palm Caul Fuel Suppliers

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Abstract. The pulp industry has great potential in supporting Indonesia's economic growth due to the potential of vast forests with high-quality trees for pulp production. PT Toba Pulp Lestari, Tbk is a leading pulp company in North Sumatra that uses palm caul (palm husk fiber) as fuel for its multifuel boiler to generate electricity. In an industry that uses palm caul, it is important to prioritize suppliers who can deliver a consistent and reliable supply. This will ensure adequate fuel availability to meet production needs. The quality of palm caul obtained from suppliers can directly affect the combustion process in the boiler. Suppliers who can provide on-time delivery and good service are important factors in prioritizing palm caul suppliers. Reliability in delivery can help maintain an efficient production schedule and avoid disruptions in the supply chain. By prioritizing suppliers, it can be ensured that only suppliers who produce palm caul with good quality, reliable and meet the criteria required by the company will be selected. This research uses the Fuzzy Analytical Hierarchy Process approach and Technique Order Preference by Similarity to Ideal Solution to determine supplier priorities. The results of the analysis show that the quality criteria (0.213) have the greatest influence in the selection of supplier priorities. PT Mujur Willy Abadi (0.669) is the most potential palm caul supplier in North Sumatra. Supplier prioritization helps identify the best suppliers, improve quality and smooth delivery, and improve operational efficiency.

Keywords: Supplier; Palm Caul; Fuzzy AHP; TOPSIS.

1 Introduction

Suppliers in the context of the paper and pulp industry play an important role in driving Indonesia's economic growth. The vast potential of the Industrial Plantation Forest (HTI) industry in Indonesia has made this industry a vital component in human life, meeting various needs such as households, education, offices, industry, trade, and so on[1]. PT. Toba Pulp Lestari, Tbk, is a subsidiary of Royal Golden Eagle (RGE), which is engaged in pulp and chemical production, plantation forest concessions and other activities in accordance with the Company's Articles of Association. To increase competitiveness, companies must provide valuable customer benefits, increasing the efficiency and success of supply chain

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management[2]. Suppliers play a crucial role in the concept of supply chain management because companies work closely with them to supply the raw materials and components needed to manufacture the final product[3]. Companies that perform well and efficiently establish partnerships with suppliers who are able to provide timely and quality supplies. In the process of identifying suitable suppliers, companies must prioritize them carefully and consistently. Comprehensive selection of suppliers' quality, delivery service, price, and management will ensure effective product quality and reduce risks associated with suppliers[4].

Palm caul is very important for smooth production in companies that use boiler machines. This supply is used as fuel to generate 73 MW of electricity through a multi-fuel and recovery boiler that operates 24 hours. Palm caul is a by-product of the palm oil industry used to manufacture biocomposites for automotive, construction, and electronics applications.

PT. Toba Pulp Lestari, Tbk, currently has four palm caul suppliers. However, it still needs a priority supplier. The company must select priority palm caul suppliers to maximize supply chain efficiency. By selecting priority suppliers, companies can achieve supply stability, improve product quality, optimize operations, reduce risk, and encourage innovation. These all contribute to the success and sustainability of the company's business[5].

This research will focus on selecting priority palm caul suppliers. The approach used is the Fuzzy Analytical Hierarchy Process, and the Technique Order Preference by Similarity to Ideal Solution in determining the weight of each criterion used for the supplier priority selection process and rating the performance of palm caul suppliers. The method used in selecting priority palm caul suppliers is expected to be able to increase production efficiency with timely delivery from suppliers, reduce shipping and storage costs due to better inventory management, strengthen relationships with suppliers and increase trust between both parties, improve quality products and customer satisfaction due to the stable supply of suppliers, reducing the risk of inventory shortages and customer loss[6].

2 Research Method

The research conducted is included in the qualitative and descriptive research. The purpose of the results of this study is to provide advice on important criteria and choose priority suppliers of palm caul for companies in North Sumatra. Data collection methods used in this study include primary and secondary data. MCDM (Multi-Criteria Decision Making) data processing method using Fuzzy Analytic Hierarchy Process and Technique for Order of Preference by Similarity to Ideal Solution is an approach used to make decisions by considering several criteria[7].

2.1 Analytic Hierarchy Process (AHP)

AHP, developed by Thomas L. Saaty, is a model that helps decision-making. This model solves complex problems with various factors or criteria in a hierarchy[8]. Saaty explained that a hierarchy represents a complex problem in the form of a multi-level structure, starting from the goal as the first level, then followed by factors, criteria and sub-criteria until it reaches the last level, namely alternatives. In implementing the

Analytical Hierarchy Process, the steps taken are as follows[9]:

a. Define the problem and identify the desired solution

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b. Describe the hierarchical structure of the problem

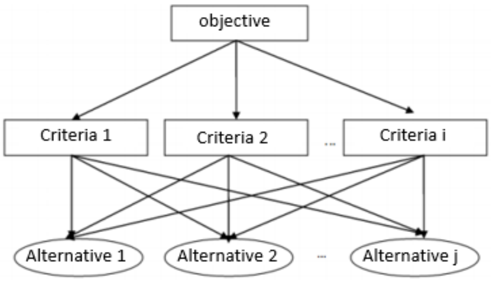

Fig. 1. Hierarchical Structure

Complex problems can be broken down into more detailed levels using a hierarchy as shown in **Figure 1**[10]. This hierarchy consists of several levels, from the primary goal level and the criteria to the alternative level[11]. That helps to understand the problem's structure better and allows stakeholders to see the relationships between the different elements. The stages of calculating AHP are as follows.

1. Make a Pairwise Comparison Matrix

The AHP pairwise comparison matrix is a table used to obtain relative preferences between elements at a hierarchical level[12]. This matrix has a square shape with a size that corresponds to the number of elements being compared as shown in **Table 1**.

Table 1. Pairwise Comparison Matrix

C	A_1	A_2	A_3	A_4	A_n
A_1	a_{11}	a_{12}	a_{13}	a_{14}	a_{1n}
A_2	a_{21}	a_{22}	a_{23}	a_{24}	a_{2n}
A_3	a_{31}	a_{22}	a_{33}	a_{34}	a_{3n}
A_4	a_{41}	a_{42}	a_{43}	a_{44}	a_{4n}
A_n	a_{n1}	a_{n2}	a_{n3}	a_{n4}	a_{nn}

2. Compute the Geometric Mean

If the respondent consists of several people, a calculation called the geometric mean must be carried out to get a single result from several respondents[13].

GeometricMean = √(n&(X1)(X2)…(Xn)) (1)

3. Determine the Priority Weight

This priority is obtained by calculating the eigenvector of the matrix resulting from pairwise comparisons. Obtaining priority weights begins with matrix normalization, followed by calculating the weight vectors to obtain eigenvectors[14].

$$Zj = \sum_{j=1}^{n} a_{ij}, \text{ for } j = 1, 2, \ldots, n \quad (2)$$

$$w_i = \frac{\sum_{i=1}^{n} \frac{a_{ij}}{z_j}}{n} \text{ for } i = 1, 2, \ldots, n \quad (3)$$

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A . w = λmaks. W (4)

4. Consistency Test

Inconsistencies can occur in the AHP model that uses expert perceptions as input[15]. The CI formula used to measure the level of consistency is as follows.

CI = (λmax-n) / (n-1) (5)

Table 2. Random Consistency Index (RCI)

n	RI	n	RI
1	0	6	1.03
2	0	7	1.46
3	0.58	8	1.40
4	0.9	9	1.35
5	1.22	10	1.46

Source: Thomas L. Saaty, 2012

Table 2 contains the consistency index converted to the inconsistency ratio by dividing it by the random index.

CR = CI / RI (6)

CR is calculated to check the consistency between the elements in the pairwise comparison matrix in AHP. If the CR value ≤ 0.1, the comparison of the elements in the pair comparison matrix is relatively consistent. The closer to zero, the more consistent the comparison will be. If CR values > 0.1, that indicates a significant discrepancy between the comparisons.

2.2 Fuzzy Analytic Hierarchy Process (FAHP)

Fuzzy AHP was developed by Chang, using the concept of a triangular membership function (Triangular Fuzzy Number/TFN)[16]. This method is a variation of the AHP method, which combines the idea of fuzzy logic with AHP. The main purpose of this method is to model the uncertainty and imprecision in decision-making involving vague factors[17].

Uncertainty in Fuzzy AHP is used to describe the uncertainty associated with the subjective judgment of decision-makers. In situations where the available information is uncertain or has a degree of uncertainty, fuzzy logic is used to describe and model the finer nuances in comparisons and assessments between elements. Experts are advised to use the linguistic variables listed in **Table 3** below to evaluate the importance of each criterion or element.

Table 3. Fuzzy Scale of Relative Importance

Linguistic Scale	AHP	TFN	Reciprocal TFN
Equal	1	(1, 1, 1)	(1/1, 1/1, 1/1)
Moderate	3	(2, 3, 4)	(1/4, 1/3, 1/2)
Strong	5	(4, 5, 6)	(1/6, 1/5, 1/4)
Very Strong	7	(6, 7, 8)	(1/8, 1/7, 1/6)
Extremely Strong	9	(9, 9, 9)	(1/9, 1/9, 1/9)
Intermediate values	2	(1, 2, 3)	(1/3, 1/2, 1/1)
	4	(3, 4, 5)	(1/5, 1/4, 1.3)
	6	(5, 6, 7)	(1/7, 1/6, 1/5)

	8	(7, 8, 9)	(1/9, 1/8, 1.7)

In the original AHP model, pairwise comparisons use a scale of 1 to 9[18]. The scale used to transform TFN into the AHP scale is listed in **Table 3**. The AHP TFN scale fuzzification graph consists of three points that form a triangle, namely the lower bound, midpoint, and upper bound. Each of these points represents a value on a fuzzy scale.

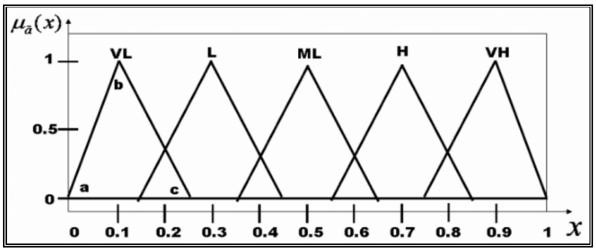

Fig. 2. AHP TFN Scale Fuzzyfication Graph

The fuzzification scale of the comparison between criteria uses the TFN triangular membership function in **Figure 2**, which describes the membership level within a certain range. The fuzzification scale is used to change the relative comparisons between criteria into more flexible fuzzified values. The steps of the AHP fuzzy method[19] are as follows:

1. Implement the AHP Method.
2. Make a Pair Comparison Matrix using the Triangular Fuzzy Number (TFN) Scale.
3. Determine the Priority Fuzzy Synthesis (Si) Value.

   $$\mathrm{Si} = \sum_{j=1}^{m} M_i^{j} \; x \left[\sum_{j=1}^{n} \sum_{j=1}^{m} M_i^{j}\right]^{-1} \quad (7)$$

   and,

   $$\sum_{j=1}^{m} M_i^{j} = \sum_{j=1}^{m} \mathrm{l}j,\ \sum_{j=1}^{m} mj, \sum_{j=1}^{m} uj$$

   M is the TFN Number, and m is the number of criteria in the pairwise comparison matrix.
4. Determine the vector value (V) and the defuzzification ordinate value (d'). If the results obtained from each fuzzy matrix $M2 \geq M1$, with $M1 = (l_1, m_1, u_1)$ and $M2 = (l_2, m_2, u_2)$, then the vector value can be calculated using the following formula. $V(M_2 \geq M_1) = \mathrm{Sup}[(\mu M_1 (x), \min(\mu M_2 (y))]$

   $$v(M_2 \geq M_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1 \\ 0, & \text{if } l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - m_2) - (m_1 - l_1)} \end{cases} \quad (8)$$

   If the resulting fuzzy value is greater than k, M_i (i = 1,2, ..., k), then the vector value can be determined as follows: $W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T$ (9)

   W' is the value of n fuzzy vector weights, d' is the vector weight value of each criterion, and $A_i = 1, 2, \ldots, n$ are the n decision elements.
5. Normalizing the fuzzy vector weights (W)

   $$W = \frac{(d(A_1), d(A_2), \ldots, d'(A_n))}{\sum_{n=1}^{d} A_n} \quad (10)$$

2.3 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The TOPSIS method is a tool for determining decisions made by Hwang and Yoon. If there

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are n alternatives and m criteria in a decision-making problem, then it can be assumed that n alternative points can be mapped to a space with m dimensions[20]. This method uses the calculation of ideal solutions and anti-ideal solutions and shows that the best alternative is the one that has the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution.

A positive ideal solution refers to a solution that is considered a rational choice with an optimal value, while a negative ideal solution is a solution that is regarded as less desirable with a lower value[20]. In the TOPSIS method, the weight for each criterion has been predetermined by the decision maker based on the level of importance. This method is able to solve problems using simple and easy-to-understand concepts and calculate the relative performance of the alternatives to be selected with efficient computation.

1. Normalized decision matrix.
   $$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij^2}}} \quad (11)$$
2. Weighted normalized decision matrix (y_{ij}).
   $$y_{ij} = w_i \text{ x } r_{ij} \quad (12)$$
3. Matrix of positive and negative ideal solutions.
   $A^+ = (y_1^+, y_2^+, \ldots, y_n^+)$
   $A^- = (y_1^-, y_2^-, \ldots, y_n^-)$
4. Value of each alternative for the positive and negative ideal solutions matrix.
   $$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_i^+)^2} \quad (13)$$
   $$D_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_i^-)^2} \quad (14)$$
5. Alternative Preference Value (V_i).
   $$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (15)$$
   The alternatives are sorted from the highest V_i value to the smallest value. The alternative with the highest V_i value is the best solution.

2.4 Research Design

Figure 3 is the steps of the research methodology to apply the Fuzzy AHP and TOPSIS methods in selecting priority suppliers of palm caul fuel.

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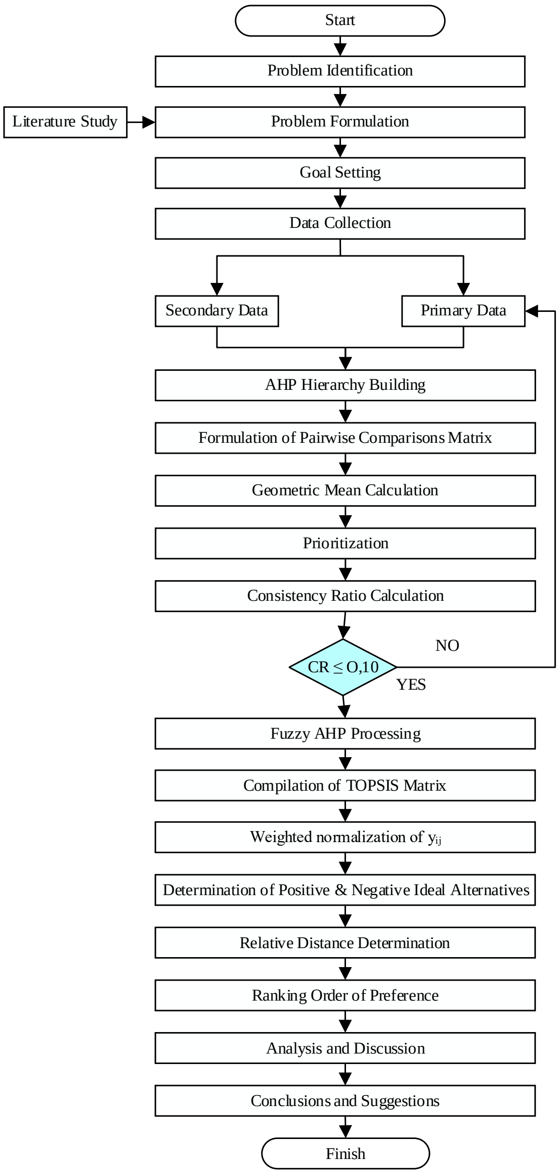

Fig. 3. Research Flow Chart

Primary data in this study were obtained by direct measurement and observation at PT Toba Pulp Lestari, Tbk. Several ways to get primary data are observation, interviews, and discussions, as well as distributing questionnaires. At the same time, secondary data is obtained from various sources such as books, research, journals, and other relevant and competent information sources.

The alternative in this study is a palm caul supplier namely PT Gerbang Sukses Emas, PT Servis Nusantara, PT Mandau Citra Perkasa, and PT Mujur Willy Abadi. In determining the respondents, discussions were held with parties related to palm caul fuel in the company. Based on the discussion results, the number of respondents was three (3), namely buyers, logistics leaders, and end users who are employees included in the Solid Fuel Quality Control (SFQC). These respondents are company employees who are experienced and experts in making decisions regarding the performance of palm caul suppliers. In this research, criteria are used that come from the results of discussions with suppliers and Dickson method. The criteria used are shown in **Table 4**.

Table 4. Supplier Criteria

No	Criteria	No	Criteria
1	Quality	13	Management & organization
2	Delivery	14	Operating controls
3	Performance history	15	Repair service
4	Warranties and claim policie	16	Attitudes
5	Price	17	Impression
6	Production facilities	18	Packaging ability
7	Technical capability	19	Labor relations records
8	Financial position	20	Geographical location
9	Procedure compliance	21	Amount of past business
10	Communication system	22	Training aids
11	Position in industry	23	Reciprocal arrangements
12	Desire of business		

Dickson's ten criteria were considered appropriate for selecting priority palm caul suppliers, namely quality (C1), price (C2), delivery (C3), production facilities (C4), performance history (C5), attitude (C6), management & organization (C7), warranties & claim policies (C8), reciprocal arrangements (C9), communication system (C10).

3 Case Study

3.1 Weighting Based on AHP Method

The results of the geometric mean pairwise comparison matrix between criteria from the three experts are attached in **Table 5** below.

Table 5. Pairwise Comparison Results

C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1,000	1,587	1,817	2,080	2,466	2,466	3,557	3,915	3,107	5,013
C2	0,630	1,000	1,442	2,080	0,693	2,080	1,442	1,442	2,714	2,154
C3	0,550	0,693	1,000	1,145	0,481	1,000	0,874	0,874	1,260	1,000
C4	0,481	0,481	0,874	1,000	0,333	0,333	1,000	1,442	0,693	1,000
C5	0,405	1,442	2,080	3,000	1,000	4,217	4,217	4,217	4,718	4,718
C6	0,405	0,481	1,000	3,000	0,237	1,000	1,587	1,260	1,000	1,000
C7	0,281	0,693	1,145	1,000	0,237	0,630	1,000	0,630	0,630	0,630
C8	0,255	0,693	1,145	0,693	0,237	0,794	1,587	1,000	0,794	1,000
C9	0,322	0,368	0,794	1,442	0,212	1,000	1,587	1,260	1,000	1,000
C10	0,199	0,464	1,000	1,000	0,212	1,000	1,587	1,000	1,000	1,000

The normalization matrix of criteria weights in AHP is used to calculate the final relative weight of each criterion based on pairwise comparisons that have been carried out. This matrix is attached in **Table 6**.

Table 6. Criteria Weight Normalization Matrix

C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	0,221	0,201	0,148	0,127	0,404	0,170	0,193	0,230	0,184	0,271
C2	0,139	0,127	0,117	0,127	0,113	0,143	0,078	0,085	0,160	0,116
C3	0,121	0,088	0,081	0,070	0,079	0,069	0,047	0,051	0,074	0,054
C4	0,106	0,061	0,071	0,061	0,055	0,023	0,054	0,085	0,041	0,054
C5	0,090	0,182	0,169	0,182	0,164	0,290	0,229	0,247	0,279	0,255
C6	0,090	0,061	0,081	0,182	0,039	0,069	0,086	0,074	0,059	0,054
C7	0,062	0,088	0,093	0,061	0,039	0,043	0,054	0,037	0,037	0,034
C8	0,056	0,088	0,093	0,042	0,039	0,055	0,086	0,059	0,047	0,054
C9	0,071	0,047	0,065	0,088	0,035	0,069	0,086	0,074	0,059	0,054
C10	0,044	0,059	0,081	0,061	0,035	0,069	0,086	0,059	0,059	0,054

Table 7 is the final priority value for each criterion based on calculations using the AHP method.

Table 7. Criteria Weight Normalization Matrix

C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	0,215	0,121	0,073	0,061	0,209	0,079	0,055	0,062	0,065	0,061

The next step is to calculate the Consistency Index and Consistency Ratio.

λmaks = 10,456

CI = ((λmaks- n))/((n-1)) = 0,051

CR = CI/RI = 0,034

Based on the calculation above, it is known that the Consistency Ratio (CR) value is equal to 0.034. This value is less than 0.1, so the assessments made by the three respondents are consistent and considered accurate and usable.

3.2 Weighting with Fuzzy AHP Method

After going through the data processing process with the AHP method, the next step is to convert it into a Fuzzy pairwise comparison matrix to get the weight or priority of the criteria. This process starts with as shown in **Table 8**.

Table 8. Defuzzyfication

C	C1	C2	C3	C4	C5	C6	Defuzzification	
	l	m	u	l	m	u	Weights	Normalized
C1	1,913	2,454	2,931	0,138	28,205	27,488	18,610	0,213
C2	1,210	1,419	1,606	0,088	16,313	15,056	10,485	0,120
C3	0,670	0,852	1,095	0,048	9,795	10,268	6,704	0,077
C4	0,588	0,684	0,823	0,043	7,863	7,720	5,209	0,060
C5	1,891	2,390	2,873	0,137	27,476	26,943	18,185	0,208
C6	0,718	0,880	1,056	0,052	10,111	9,898	6,687	0,076

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C7	0,511	0,620	0,831	0,037	7,121	7,795	4,984	0,057
C8	0,604	0,712	0,862	0,044	8,180	8,086	5,437	0,062
C9	0,650	0,765	0,903	0,047	8,788	8,468	5,768	0,066
C10	0,622	0,719	0,836	0,045	8,265	7,842	5,384	0,062
Total	9,377	11,494	13,817				87,453	1,000
R	0,072	0,087	0,107					

After the defuzzification process is complete, a crisp value is obtained which represents the level of importance or priority of criteria or alternatives in Fuzzy AHP. The defuzzification process is very important because it converts fuzzy values into information that is easier to interpret and use in decision making. In the end, the ranking of each criterion is obtained as shown in **Table 9**.

Table 9. Fuzzy AHP Criteria Ranking

Criteria	Normalized Weights	Ranking
C1	0,213	1
C2	0,208	2
C3	0,120	3
C4	0,077	4
C5	0,076	5
C6	0,066	6
C7	0,062	7
C8	0,062	8
C9	0,060	9
C10	0,057	10

The results of the criteria ranking provide information that criterion C1 (0.213) has a higher level of importance or priority in the context of this research analysis because the criteria with the highest fuzzy priority value will get the highest rank.

3.3 Ranking with TOPSIS Method

The process of evaluating alternatives using the TOPSIS method begins with getting an assessment from an expert for each alternative, namely A1 (PT Gerbang Sukses Emas), A2 (PT Jaringan Servis Nusantara), A3 (PT Mandau Citra Perkasa) and A4 (PT Mujur Willy Abadi). Then data processing is carried out until the preference value of each alternative is obtained. The geometric mean for each alternative by multiplying the normalized value of alternatives in each criterion and then calculating the square root of n (number of criteria) of the multiplication result is presented in **Table 10**.

Table 10. Geometric Mean of Alternative Ratings

A	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	3,302	3,000	3,634	3,000	4,000	3,302	3,302	3,302	3,000	2,520
A2	2,520	2,621	3,000	3,634	3,302	4,000	3,302	3,302	3,302	2,520
A3	3,302	4,000	4,000	4,217	4,000	4,000	4,000	4,000	4,217	4,000
A4	4,642	4,000	5,000	4,217	4,309	4,000	4,642	4,309	4,642	4,309

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The normalization results on the alternative assessment matrix by calculating the relative value of each cell can be seen in **Table 11**.

Table 11. TOPSIS Normalization Matrix (R)

A	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0,468	0,434	0,457	0,395	0,510	0,430	0,429	0,440	0,390	0,367
A2	0,357	0,379	0,377	0,478	0,421	0,521	0,429	0,440	0,429	0,367
A3	0,468	0,578	0,503	0,555	0,510	0,521	0,519	0,533	0,548	0,582
A4	0,658	0,578	0,629	0,555	0,550	0,521	0,603	0,574	0,603	0,627

The yij matrix in **Table 12** is the matrix generated after multiplying the R matrix with the criteria weight vector. This criterion weight vector reflects the level of importance of each criterion in decision making. The yij matrix produces a weighted score for each alternative in each criterion.

Table 12. Weighted Decision Matrix Y_{ij} (Y)

A	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0,100	0,052	0,035	0,024	0,106	0,033	0,024	0,027	0,026	0,023
A2	0,076	0,045	0,029	0,028	0,088	0,040	0,024	0,027	0,028	0,023
A3	0,100	0,069	0,039	0,033	0,106	0,040	0,030	0,033	0,036	0,036
A4	0,140	0,069	0,048	0,033	0,114	0,040	0,034	0,036	0,040	0,039

Based on the calculation results in **Table 13**, it is known that the alternative that has the shortest distance to the positive ideal solution and the longest distance to the negative ideal solution is A4.

Table 13. Distance to Positive and Negative Ideal Solution

Alternative	Di^+	Di^-
A1	0,054	0,031
A2	0,071	0,037
A3	0,052	0,035
A4	0,036	0,072

The final stage of data processing using the TOPSIS method is to calculate preference values and alternatives so as to sort alternatives based on preference values to find out the best alternative.

Table 14. Preference Value of Alternatives

Alternative	Preferences	Percentage	Ranking
A1	0,363	20,471%	3
A2	0,342	19,273%	4
A3	0,400	22,569%	2
A4	0,669	37,687%	1

Based on **Table 14**, it is known that the highest ranked alternative with a preference value of 0.669 and a percentage of 37.7% is A4 (PT Mujur Willy Abadi).

4 Conclusion

Each criterion has a weight or priority obtained using the Fuzzy Analytical Hierarchy Process method. The importance level of each criterion is sorted from the criteria with the highest weight to those with the lowest weight, that is, Quality (0.213), price (0.208), delivery (0.120), performance history (0.077), production facilities (0.076), attitude (0.066), management and organization (0.062), reciprocal arrangements (0.062), warranties and claim policies (0.060), communication system (0.057).

The ranking of each supplier is obtained using the TOPSIS method. PT Mujur Willy Abadi is the best supplier of palm caul. This supplier has a preference value of 0.669 and a percentage value of up to 37.7%. The second is PT Mandau Citra Perkasa, with a preference value of 0.400 and a percentage value of 22.6%. The third is PT Gerbang Sukses Emas, with a preference value of 0.363 and a percentage value of 20.5%. The fourth in the priority selection of palm caul suppliers is PT Network Servis Nusantara, with a preference value of 0.342 and a percentage value of 19.3%, so the most prioritized palm caul supplier is PT Mujur Willy Abadi.

References

[1] P. Prihatin and A. Wicaksono, "The Conflict in Indonesia's Forestry Sector: A Case Study of a Community Conflict with Company Industrial Plantation Forest (HTI) in Pelalawan Riau Province," European Alliance for Innovation n.o., Dec. 2020. doi: 10.4108/eai.25-10-2019.2300538.

[2] M. R. Linda and G. Thabrani, "Supply Chain Management Practices on Competitive Advantage with Supply Chain Performance as Moderating Variable," *Adv. Econ. Bus. Manag. Res.*, vol. 192, no. Piceeba, pp. 469–480, 2021.

[3] A. La Rocca, A. Perna, I. Snehota, and F. Ciabuschi, "The role of supplier relationships in the development of new business ventures," *Ind. Mark. Manag.*, vol. 80, pp. 149–159, 2019, doi: 10.1016/j.indmarman.2017.12.008.

[4] A. M. Aamer, "Suppliers Evaluation and Selection : A Comprehensive Model to Minimize the Risk Associated with Quality and Delivery," 2005.

[5] H. Siagian, Z. J. H. Tarigan, and F. Jie, "Supply chain integration enables resilience, flexibility, and innovation to improve business performance in covid-19 era," *Sustain.*, vol. 13, no. 9, pp. 1–19, 2021, doi: 10.3390/su13094669.

[6] B. Balkhi, A. Alshahrani, and A. Khan, "Just-in-time approach in healthcare inventory management: Does it really work?," *Saudi Pharm. J.*, vol. 30, no. 12, pp. 1830–1835, 2022, doi: 10.1016/j.jsps.2022.10.013.

[7] N. S. Sitohang, M. I. Irawan, H. S. Saragi, A. Saragih, and R. Simanjuntak, "Prioritizing Load Break Switch Placement: Application of Fuzzy AHP-TOPSIS Approaches," in *2023 IEEE 3rd International Conference in Power Engineering Applications (ICPEA)*, 2023, pp. 32–37. doi: 10.1109/ICPEA56918.2023.10093205.

[8] A. Ishak, Asfriyati, and V. Akmaliah, "Analytical Hierarchy Process and PROMETHEE

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as Decision Making Tool: A Review," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 505, no. 1, 2019, doi: 10.1088/1757-899X/505/1/012085.

[9] A. Abdillah, "Implementation of The Analytical Hierarchy Process (AHP) Method in The Laptop Election Decision Support System for Students and Community in Medan City," *ZERO J. Sains, Mat. dan Terap.*, vol. 5, no. 2, pp. 21–33, 2022, doi: 10.30829/zero.v5i2.11123.

[10] M. Hussain, M. M. Ajmal, M. Khan, and H. Saber, "Competitive priorities and knowledge management: An empirical investigation of manufacturing companies in UAE," *J. Manuf. Technol. Manag.*, vol. 26, no. 6, pp. 791–806, 2015, doi: 10.1108/JMTM-03-2014-0020.

[11] H. Esen, "Analytical Hierarchy Process Problem Solution," in *Analytic Hierarchy Process*, P. F. De Felice and D. A. Petrillo, Eds., Rijeka: IntechOpen, 2023, p. Ch. 1. doi: 10.5772/intechopen.1001072.

[12] D. adello Setiawan, R. Riki, and Y. C. Giap, "Design of Acceptance Decision Support System for New Employees in the Technician Position Using AHP and TOPSIS Methods at CV. Techindo Global Solution," *bit-Tech*, vol. 1, no. 2, pp. 65–73, 2018, doi: 10.32877/bt.v1i2.5.

[13] W. R. Augusty, W. P. Wijayanti, G. Prayitno, D. Dinanti, A. Subagiyo, and D. W. Adrianto, "Sebagai Desa Wisata Pertanian Berkelanjutan Di Kota Batu the Priority of Sidomulyo Village Development Strategy As a Tourism Village for Sustainable Agriculture , Batu City," vol. 21, no. 1, pp. 0–1.

[14] N. Ni'mah and Y. Anang, "Information System Development of Master's and Doctoral Study Task Recommendation Using Fuzzy AHP," *Proc. Int. Conf. Data Sci. Off. Stat.*, vol. 2021, no. 1, pp. 914–934, 2022, doi: 10.34123/icdsos.v2021i1.212.

[15] M. Sarman, M. Ariyanti, and H. Irawan, "Decisions Analysis of Contractor Selection PT . Ericsson Indonesia Using Analytical Hierarchy Process Method," pp. 1–9, 2018.

[16] A. Santoso, R. Rahmawati, M. Jurusan Statistika FSM Universitas Diponegoro, and S. Pengajar Jurusan Statistika, "APLIKASI FUZZY ANALYTICAL HIERARCHY PROCESS UNTUK MENENTUKAN PRIORITAS PELANGGAN BERKUNJUNG KE GALERI (Studi Kasus di Secondhand Semarang)," *J. Gaussian*, vol. 5, no. 2, pp. 239–248, 2016, [Online]. Available: http://ejournal-s1.undip.ac.id/index.php/gaussian

[17] D. Pamucar, M. Deveci, F. Canıtez, and D. Bozanic, "A fuzzy Full Consistency Method-Dombi-Bonferroni model for prioritizing transportation demand management measures," *Appl. Soft Comput.*, vol. 87, p. 105952, 2020, doi: https://doi.org/10.1016/j.asoc.2019.105952.

[18] Harker P., "Incomplete pairwise comparisons in the analytic hierarchy process," *Math. Model.*, vol. 9, no. 11, pp. 837–848, 1987.

[19] Y. Liu, C. M. Eckert, and C. Earl, "A review of fuzzy AHP methods for decision-making with subjective judgements," *Expert Syst. Appl.*, vol. 161, p. 113738, 2020, doi: https://doi.org/10.1016/j.eswa.2020.113738.

`

[20] M. T. J. Ansari, F. A. Al-Zahrani, D. Pandey, and A. Agrawal, “Güvenilir sağlık yazılımı geliştirme için etkili güvenlik gereksinimleri mühendisliği yaklaşımının seçimine yönelik bulanık TOPSIS tabanlı bir analiz,” *BMC Med. Inform. Decis. Mak.*, vol. 20, no. 1, pp. 1–13, 2020.