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Optimizing the location of potato logistics distribution centers using fuzzy AHP

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ABSTRACT

Potato logistics and supply chains in Central Java, Indonesia, in 2025 are experiencing high price fluctuations, with price control usually in the hands of distribution centres. It limits farmers' bargaining power. In addition, the current distribution centre locations are largely inefficient. Therefore, the objective of this study is to determine the most optimal distribution centre location to support price fairness at the farmer level and improve supply chain logistics efficiency. The method used is multi-criteria decision-making (MCDM), namely the Analytic Hierarchy Process (AHP) and the Fuzzy AHP. These two methods are used to compare and evaluate alternative locations. In this study, four decision criteria were considered, namely transportation conditions, raw material availability, market location, and labour wages. The alternatives evaluated were Boyolali, Magelang, Wonosobo, and Semarang. Furthermore, expert assessments were collected from five respondents, including logistics practitioners, academics, entrepreneurs, and distributors. The results of the AHP study show that the market location variable has the highest priority weight (0.4536), followed by transportation conditions (0.2860), raw material availability (0.1602), and labour wages (0.1002). Based on AHP, the composite weights for the Boyolali, Magelang, Wonosobo, and Semarang alternatives are 0.2735, 0.1565, 0.4986, and 0.0714, respectively. Further research is recommended to combine the Analytic Network Process (ANP) to capture the interdependence between decision-making criteria.

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INTRODUCTION

Potatoes *(Solanum* tuberosum *L)* are one of the world's most essential horticultural commodities, apart from rice, wheat, and corn (Yusianto et al. 2021). Potatoes were cultivated by tribes in the Andes Mountains on the border between Bolivia and Peru in South America as early as 8,000 BC. At that time, cultivation was concentrated near Lake Titicaca, on a plain with an altitude of 3,800 m ASL (Campos and Ortiz 2019). Planted in nearly 150 countries (Devaux et al., 2021), it produces around 310 million tons annually. More than 1 billion people worldwide consume potatoes. Over the past ten years, world potato production has increased by an average of 4.5% per year (Hussain 2016). In developing Asian countries, the average output reached 144.62 million tons between 2008 and 2010, accounting for 46% of global potato production.

Even more interesting, the growth rate of potato production is a phenomenon across most regions of the world, with Asia posting an average compound annual growth rate (ACGR) of 3.7% and ranking above five of the seven largest potato-producing countries in the world in the same period (Suarez 2012). With an average annual growth rate of 8.4% and an average annual production of around 1.09 million tons, Indonesia is Southeast Asia's largest potato producer. Meanwhile, in Asia, Indonesia is ranked 10th after Kazakhstan, with production of 2.55 million tons; Kyrgyzstan, 1.36 million tons; and Korea, DPR, 1.60 million tons. China's most significant potato production is in Asia, where 144.62 million tons are produced.

Potatoes are a commodity that focuses on improving agroindustries other than oil palm, rubber, cocoa, tea, coffee, coconut, mango, pineapple, mangosteen, and lanzones (Kementerian Pertanian Republik Indonesia, 2015). Potatoes have an essential role in realizing food security (Devaux et al. 2014), the realization of food sovereignty and the welfare of horticultural farmers potentially supporting food diversification (Yusianto et al. 2022), having good prospects to support diversification programs to create resilient, sustainable food, and that becomes a value-added and competitive performance indicator (Tekalign et al. 2023).

Compared to other vegetable commodities in Indonesia, potato productivity ranks among the top 5, at 18.25 tons/ha, followed by mushrooms (87.61 tons/ha), chayote (68.34 tons/ha), bell pepper (44.91 tons/ha), and cabbage (21.04 tons/ha).

According to the 2020 Central Bureau of Statistics, potatoes are planted in Java, South Sulawesi, North Sumatra, West Sumatra, and Jambi. Indonesia's most extensive potato production is in Wonosobo, Central Java, 272,975 tons. Its location in the Dieng Plateau region makes potatoes grow well. Potato cultivation will be optimal with a maximum daytime temperature below 33°C and a minimum nighttime temperature below 20 °C (Hussain 2016). However, potato production is increasing, rising from 955.49 to 1.094 million tons. Productivity is also relatively low, ranging from 15.94 to 16.7 tons per hectare (Prabaningrum et al. 2014). In addition, there are price fluctuations, so farmers are only recipients of prices and cannot determine prices. Local potatoes also have no potential due to the lack of coordination among institutions involved in potato supply chains in Central Java (Taylor and Dawson 2021). Potato price control is usually determined by traders, from collectors and wholesalers to retailers. So, coordination and collaboration between the potato marketing actors are needed to create more effective and efficient distribution and marketing (Yusianto et al. 2021b).

The potato supply chain consists of several actors: farmers, collectors, wholesalers, retail traders, and final consumers. The first supply chain includes farmers who cultivate land and plant crops. In the middle are individuals or groups whose roles include transporting, sorting, packaging, supervising, and selling (Sarjana et al. 2020). Almost all potato farmers sell their products (97%), consume themselves (0.83%), and make seeds (2.17%). Whereas in the last chain, consumers are. Farmers receive reasonable prices when logistics and supply chains run smoothly without distortion, and all consumers can afford potatoes. Determining the appropriate logistics and distribution centre is one way to ensure logistics and supply chains work well. It is necessary to decide on the location of a good logistics distribution centre to increase economic and social benefits. It will be maximized by balancing supply and demand, transportation, environmental conditions, and other factors. A structured approach, such as systems engineering, is needed to support decision-making on the

optimal geographic location for a distribution centre (Guo-Qin and Hong-Yan 2014).

Decision-making is the most common scientific activity in the real world (Wu et al. 2013). Preference relations help convey information to decision-makers in various decision-making problems. AHP is the method most widely used for multi-criteria, multi-decision-making (MCDM) problems. This method has been extensively studied and continues to be refined. It includes elaborating on all elements of the overall goal and evaluating alternative solutions (Zhang et al. 2020). The AHP is a "measurement method through pairwise comparisons that relies on the judgments of experts to derive priority scales." It has been one of the most widely used MCDM tools (Hariri et al. 2023). Previous researchers have widely used AHP because it is a simple yet powerful tool. AHP can organize problem complexity, measurement, and sound synthesis. AHP helps decision-makers identify and define problems, identify needs, determine decision objectives, manage criteria and sub-criteria, and evaluate alternatives. This method uses a structure: problem modelling, assessment, weight aggregation, and sensitivity analysis. The benefit of this AHP method is that it allows for a hierarchical criteria structure, which can provide better focus when users allocate weights to specific criteria and sub-criteria (Almunawar et al. 2022).

In the last decade, preference relationships have become increasingly important and concerning, and several previous studies have focused on this issue. Researchers have also developed two essential preference relationships: fuzzy and multiplicative (Yusianto et al. 2019). Fuzzy AHP is a valuable MCDM methodology and has seen substantial application in recent years (Hariri et al. 2023). Fuzzy means imprecise or not being exact, and fuzzy AHP is the fuzzy version of AHP (Yusianto et al. 2020). Fuzzy sets were proposed to deal with such vague expressions.

On the other hand, when precisely defined expressions are the point of issue, the conventional set-theoretic approach to crisp sets is used. Using fuzzy AHP for multiple-criteria decision-making requires scientific approaches for deriving weights from fuzzy pairwise comparison matrices. Existing methods for fuzzy AHP weight derivation can be classified into two categories: one is to derive a set of fuzzy weights from a fuzzy pairwise comparison matrix, while the other is to derive a set of crisp weights from a fuzzy pairwise comparison matrix.

Potato logistics and supply chains in Central Java, Indonesia, frequently experience price fluctuations, where price control is largely dominated by traders, resulting in limited bargaining power for farmers. This study aims to determine the optimal location of a potato logistics distribution center to support price fairness and improve supply chain efficiency.

METHOD

Multiple selection criteria are one source of complexity in decision-making (Yusianto et al. 2009). Therefore, a problem-solving technique is needed with the correct method. The computational method developed entirely now is the Decision Support System. Within the MCDM methods, the authors established a model to select the best logistics and distribution centre location in Central Java using AHP and fuzzy AHP (Marimin et al. 2017; Vayvay et al. 2012).

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) was employed to determine the priority of criteria and rank alternative locations for the potato logistics distribution center. The first step involved structuring the decision problem into a hierarchical model consisting of four levels: the overall goal, evaluation criteria, and alternative locations. The goal was to select the optimal logistics distribution center in Central Java. Four criteria were considered, namely transportation conditions, availability of raw materials, market location, and labor wages, while the alternatives included Boyolali, Magelang, Wonosobo, and Semarang.

Next, pairwise comparisons were made for all criteria and alternatives. These comparisons used the 1–9 Saaty scale to express relative importance based on expert assessments. Then, the comparison matrix was normalized by dividing each element by the sum of its column values. The priority weights or eigenvectors (EV) for each criterion and alternative are obtained by taking the average of the normalized values in each row.

In this study, the consistency of the assessments was further evaluated using the Consistency Index (CI) and Consistency Ratio (CR). If the CR value is below 0.10, this indicates

reasonable consistency, is acceptable and ensures the reliability of the experts. Once consistency was confirmed, the final composite weights for each alternative were calculated by multiplying each alternative's priority weight by its corresponding criterion weight and summing the results. The alternative with the highest composite weight was selected as the most suitable logistics distribution center.

Fuzzy AHP

To overcome the uncertainty and subjectivity of expert assessments, the Fuzzy AHP method was used as a complementary approach. In this method, expert linguistic assessments were converted into triangular fuzzy numbers to represent uncertain preferences. A fuzzy pair comparison matrix was constructed for criteria and alternatives using a fuzzy scale corresponding to the Saaty scale. These fuzzy numbers are converted to interval values using an α-cut with α = 0.5. This corresponds to a moderate level of confidence among experts. By averaging the lower and upper limits, this α-cut interval is converted into a sharp value.

The fuzzy numbers are then converted into interval values using the α-cut approach with α = 0.5. Next, these α-cut intervals are converted to crisp values by averaging their lower and upper limits. The resulting crisp matrices were processed following the same steps as the conventional AHP, including normalization, eigenvector calculation, and consistency checking. Finally, the composite weights are calculated by combining the diffused alternative weights with the fuzzy criterion weights. The ranking results obtained from Fuzzy AHP are then compared with those from AHP to evaluate the consistency and robustness in selecting the optimal logistics distribution centre.

This research was conducted on the potato distribution system in Central Java, with alternative distribution centers in Boyolali, Magelang, Wonosobo, and Semarang. This research involved five expert respondents: 1 potato logistics actor from Kejajar, Wonosobo, with more than 15 years of experience; 2 agro-industrial logistics lecturers from IPB University; 1 potato entrepreneur in Wonosobo Regency; and 1 potato distributor at Pasar Johar Semarang.

Problem definition

In logistics and supply chains, potato commodities in Central Java have price fluctuations. Traders usually determine potato price control. So, it is necessary to coordinate the marketing of potatoes. If the supply chain runs well, farmers receive a reasonable price. The purpose of this research is to determine the right logistics distribution centre.

Problem model

This section discusses the problems and classifies them into a four-level hierarchy. The overall goal is placed at level 1, level 2 actors, level 3 criteria, and finally, level 4 decision alternatives. The main goal is to optimize the logistics and distribution centre in Central Java.

The definition of criteria

The criteria to be considered in the selection are transport conditions, availability of raw materials, market location, and labour wages. According to these decision elements, the hierarchy for the problem is presented in Figure 1.

Decision alternative

Decision alternatives correspond to selecting the best distribution centre in Central Java to take location: Boyolali (A1), Magelang (A2), Wonosobo (A3), and Semarang (A4).

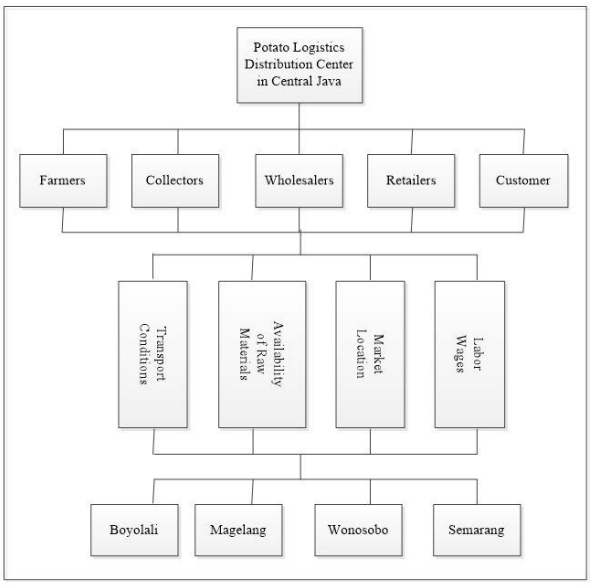


Figure 1 The hierarchy for selection logistics and distribution centre.

RESULT AND DISCUSSION

Decision makers have systematically considered the most adequate problems and criteria for analysis. This research compares three approaches: AHP dan Fuzzy AHP

Decision making using AHP

Of the four criteria, namely transport conditions (C1), availability of raw materials (C2), market location (C3), and labour wages (C4), it is necessary to determine the level of importance. The following matrix results from pairwise comparisons based on data processing using the Super Decision 2.8 application (Table 1). The consistency of judgments was evaluated based on the maximum eigenvalue (EV), consistency index (CI), and consistency ratio (CR).

Table 1 Matrix results in pairwise comparison criteria.

	Criteria				
	C1	C2	C3	C4	EV
C1	1.0000	3.0000	0.3333	3.0000	0.2860
C2	0.3333	1.0000	0.5000	2.0000	0.1602
C3	3.0000	2.0000	1.0000	3.0000	0.4536
C4	0.3333	0.5000	0.3333	1.0000	0.1002

The following are paired matrices for alternatives based on data processing using the Super Decision 2.8 application (Table 2).

Table 2 Paired matrix for transportation conditions criteria.

	Alternative				
	A1	A2	A3	A4	EV
A1	1.0000	0.5000	0.1667	3.0000	0.1266
A2	2.0000	1.0000	0.2500	3.0000	0.1928
A3	6.0000	4.0000	1.0000	6.0000	0.6140
A4	0.3333	0.3333	0.1667	1.0000	0.0664

The pairing matrix for raw material availability criteria can be seen in Table 3.

Table 3 Paired matrix for availability of raw materials criteria.

	Alternative				
	A1	A2	A3	A4	EV
A1	1.0000	2.0000	0.2500	2.0000	0.1817
A2	0.5000	1.0000	0.2000	3.0000	0.1365
A3	4.0000	5.0000	1.0000	7.0000	0.6103
A4	0.5000	0.3333	0.1429	1.0000	0.0714

The pairing matrix for market location criteria can be seen in Table 4.

Table 4 Paired matrix for market location criteria.

	A1	A2	A3	A4	EV
A1	1.00	4.00	0.50	4.00	0.3410
A2	0.25	1.00	0.33	3.00	0.1429
A3	2.00	3.00	1.00	4.00	0.4403
A4	0.25	0.33	0.25	1.00	0.0757

The pairing matrix for labour wages can be seen in Table 5.

Table 5 Paired matrix for labour wages criteria

	A1	A2	A3	A4	EV
A1	1.00	4.00	3.00	5.00	0.5339
A2	0.25	1.00	0.50	3.00	0.1459
A3	0.33	2.00	1.00	5.00	0.2544
A4	0.20	0.33	0.20	1.00	0.0657

The answer can be obtained from the analysis results by multiplying the eigenvalue matrix from the alternative with the criteria weight matrix (Table 6).

Table 6 Matrix of eigenvalues from alternatives with the weighting criteria matrix

	C1	C2	C3	C4	Weight of Criteria
A1	0.13	0.18	0.34	0.53	0.2860
A2	0.19	0.14	0.14	0.15	0.1602
A3	0.61	0.61	0.44	0.25	0.4536
A4	0.07	0.07	0.08	0.07	0.1010

We have carried out comparisons and weighting of decision criteria and sub-criteria. Next, we will compare decision alternatives for each sub-criterion. Then, all decision alternatives and their sub-criteria are evaluated, and the weight calculation for each decision element in the AHP is completed. Based on the priority weights of each alternative, a ranking of each alternative can be determined.

Boyolali = (0.1267x0.2860)+(0.1817x0.1602)+(0.3410x0.4536)+(0.5339x0.1002)= 0.2735;

Magelang = (0.1929x0.2860)+(0.1365x0.1602)+(0.1430x0.4536)+(0.1459x0.1002)=0.1565;

Wonosobo = (0.6140x0.2860)+(0.6103x0.1602)+(0.4403x0.4536)+(0.2544x0.1002)= 0.4986;

Semarang = (0.0664x0.2860)+(0.0715x0.1602)+(0.0757x0.4536)+(0.0658x0.1002)=0.0714.

Similarly, the composite weights for Boyolali, Magelang, Wonosobo, and Semarang are 0.2735, 0.1565, 0.4986, and 0.0714,

respectively. According to AHP, the best alternative is Wonosobo.

Although the effectiveness of the MCDM technique has many advantages in building decisions, researchers have criticized the problem known as ranking reversal (Aires and Ferreira 2018). If there are conditions where the ranking obtained turns out to be worse than the expected conditions, sometimes this can disrupt the ranking process. It is called a rank reversal, and it is common in most MCDM models and approaches (Munier 2016). In the last decade, the issue of alternative ranking reversals has attracted the attention of researchers using the AHP method. Most researchers expressed ranking reversal and have discussed it where a single value represents a pairwise comparison of alternatives. By focusing on the inherent mathematical properties, the AHP method can cause ranking reversals if new options are added or existing alternatives are removed. Meanwhile, the second situation utterly unrelated to the mathematical basis of AHP, where ranking reversals can occur, is the case where the pairwise ratings are stochastic and not a single value (Stam and Silva 1997). If the preference rating is relatively uncertain, someone has an assessment interval.

Consequently, the ranking generated from the AHP analysis may be reversed, i.e., incorrect. Model makers and decision-makers need to be aware of the possibility that a ranking reversal situation will occur. For comparison, in this paper, the fuzzy AHP method is used to assess the relative preferences of alternatives regarding rankings. Interactions and dependencies usually happen in the same hierarchical elements.

Application of fuzzy AHP

Fuzzy AHP is needed when the decision maker provides a vague assessment, and the AHP method cannot resolve this condition satisfactorily. Table 7 shows the comparison matrix of fuzzy paired criteria from expert judgment.

Table 7 Matrix comparison of fuzzy paired criteria from expert judgment

	C1	C2	C3	C4
C1	1	~ 5	~ 5^{-1}	~ 5
C2	~ 5^{-1}	1	~ 3^{-1}	~ 3
C3	~ 5	~ 3	1	~ 5
C4	~ 5^{-1}	~ 3^{-1}	~ 5^{-1}	1

After that, the fuzzy pairing matrix results from expert evaluations regarding transportation conditions are calculated (Table 8).

Table 8 Fuzzy pairing matrix results from expert evaluations in terms of transportation conditions

	A1	A2	A3	A4
A1	1	~ 3^{-1}	~ 7^{-1}	~ 5
A2	~ 3	1	~ 5^{-1}	~ 5
A3	~ 7	~ 5	1	~ 7
A4	~ 5^{-1}	~ 5^{-1}	~ 7^{-1}	1

Fuzzy pairing matrix results from expert evaluations in terms of availability of raw materials as in Table 9.

Table 9 Fuzzy pairing matrix results from expert evaluations in terms of availability of raw materials

	A1	A2	A3	A4
A1	1	~ 3^{-1}	~ 5^{-1}	~ 3
A2	~ 3	1	~ 5^{-1}	~ 3
A3	~ 5	~ 5	1	~ 7
A4	~ 3^{-1}	~ 3^{-1}	~ 7^{-1}	1

Fuzzy pairing matrix results from expert evaluations in terms of market location as in Table 10.

Table 10 Fuzzy pairing matrix results from expert evaluations in terms of market location

	A1	A2	A3	A4
A1	1	~ 5	~ 3^{-1}	~ 5
A2	~ 5^{-1}	1	~ 3^{-1}	~ 3
A3	~ 3	~ 3	1	~ 7
A4	~ 5^{-1}	~ 3^{-1}	~ 7^{-1}	1

Fuzzy pairing matrix results from expert evaluations in terms of labour wages as in Table 11.

Table 11 Fuzzy pairing matrix results from expert evaluations in terms of labour wages

	A1	A2	A3	A4
A1	1	~ 5	~ 3^{-1}	~ 5
A2	~ 5^{-1}	1	~ 3^{-1}	~ 3
A3	~ 3	~ 3	1	~ 7
A4	~ 5^{-1}	~ 3^{-1}	~ 7^{-1}	1

The upper and lower limits of fuzzy numbers are then determined based on the *α-cut* value using the equation:

$\tilde{1}\alpha$ = [1, 3-2α]

$\tilde{3}\alpha$ = [1+2α, 5-2α], $\tilde{3}_{\alpha}^{-1} = \left[\frac{1}{5-2\alpha}, \frac{1}{1+2\alpha}\right]$

$\tilde{5}\alpha$ = [3+2α, 7-2α], $\tilde{5}_{\alpha}^{-1} = \left[\frac{1}{7-2\alpha}, \frac{1}{3+2\alpha}\right]$

$\tilde{7}\alpha$ = [5+2α, 9-2α], $\tilde{5}_{\alpha}^{-1} = \left[\frac{1}{9-2\alpha}, \frac{1}{5+2\alpha}\right]$

$\tilde{9}\alpha$ = [7+2α, 11-2α], $\tilde{9}_{\alpha}^{-1} = \left[\frac{1}{11-2\alpha}, \frac{1}{7+2\alpha}\right]$

The triangular fuzzy value can be converted into the range of α-cut by entering a value. This range is then used in fuzzy numbers from expert judgment to change the fuzzy value into α-cut fuzzy. In selecting logistics and supply chain distribution centres, the value of α = 0.5. Experts have an average level of trust at the time of assessment to make a paired comparison matrix (Table 12).

Table 12 Matrix comparison of fuzzy paired criteria from expert judgment

	C1	C2	C3	C4
C1	1	[4.00, 6.00]	[0.17, 0.25]	[4.00, 6.00]
C2	[0.17, 0.25]	1	[0.25, 0.5]	[2.00, 4.00]
C3	[4.00, 6.00]	[2.00, 4.00]	1	[4.00, 6.00]
C4	[0.17, 0.25]	[0.25, 0.50]	[0.17, 0.25]	1

α-cut fuzzy paired matrix of transportation conditions as in Table 13.

Table 13 *α-cut fuzzy* paired matrix of transportation conditions

	A1	A2	A3	A4
A1	1	[0.25, 0.50]	[0.13, 0.17]	[4.00, 6.00]
A2	[2.00, 4.00]	1	[0.17, 0.25]	[4.00, 6.00]
A3	[6.00, 8.00]	[4.00, 6.00]	1	[6.00, 8.00]
A4	[0.17, 0.25]	[0.17, 0.25]	[0.13, 0.17]	1

Whereas *α-cut fuzzy* paired matrix of availability of raw materials as in Table 14.

Table 14 *α-cut fuzzy* paired matrix of availability of raw materials

	A1	A2	A3	A4
A1	1	[0.25, 0.50]	[0.17, 0.25]	[2.00, 4.00]
A2	[2.00, 4.00]	1	[0.17, 0.25]	[2.00, 4.00]
A3	[4.00, 6.00]	[4.00, 6.00]	1	[6.00, 8.00]
A4	[0.25, 0.50]	[0.25, 0.50]	[0.13, 0.17]	1

α-cut fuzzy paired matrix of market location as in Table 15.

Table 15 *α-cut fuzzy* paired matrix of market location

	A1	A2	A3	A4
A1	1	[4.00, 6.00]	[0.25, 0.50]	[4.00, 6.00]
A2	[0.17, 0.25]	1	[0.25, 0.50]	[2.00, 4.00]
A3	[2.00, 4.00]	[2.00, 4.00]	1	[6.00, 8.00]
A4	[0.17, 0.25]	[0.25, 0.50]	[0.13, 0.17]	1

α-cut fuzzy paired matrix of labour wages as in Table 16.

Table 16 *α-cut fuzz*y paired matrix of labour wages

	A1	A2	A3	A4
A1	1	[4.00, 6.00]	[0.25, 0.50]	[4.00, 6.00]
A2	[0.17, 0.25]	1	[0.25, 0.50]	[2.00, 4.00]
A3	[2.00, 4.00]	[2.00, 4.00]	1	[6.00, 8.00]
A4	[0.17, 0.25]	[0.25, 0.50]	[0.13, 0.17]	1

The random consistency index (RI) value by the matrix size can be seen in Table 17.

Table 17 Random consistency index (RI) based on matrix size

CI	**1**	**2**	**3**	**4**	**5**
RI	0.00	0.00	0.52	0.89	1.11

Size	**6**	**7**	**8**	**9**	**10**
RI	1.25	1.35	1.40	1.45	1.49

Crisp value paired criteria from expert judgment as in Table 18.

Table 18 Crisp value paired criteria from expert judgment

	C1	C2	C3	C4	
C1	1	5	0.21	5.00	0.2971
C2	0.21	1	0.38	5.00	0.1694
C3	3.00	3.00	1	5.00	0.4667
C4	0.21	0.38	0.21	1	0.0668
	0.42	9.38	1.8	16	

Crisp value of transportation conditions as in Table 19.

Table 19 Crisp value of transportation conditions

	A1	A2	A3	A4	
A1	1	0.38	0.15	5.00	0.1309
A2	3.00	1	0.21	5.00	0.2091
A3	7.00	5.00	1	7.00	0.6086
A4	0.21	0.21	0.15	1	0.0514
	11.21	6.59	1.51	18	

Crisp value of the availability of raw materials as in Table 20.

Table 20 Crisp value of the availability of raw materials

	A1	A2	A3	A4	
A1	1	0.38	0.21	3.00	0.1277
A2	3.00	1	0.21	3.00	0.2039
A3	5.00	5.00	1	7.00	0.6024
A4	0.38	0.38	0.15	1	0.0659
	9.38	6.76	1.57	14	

Crisp value of market location as in Table 21.

Table 21 Crisp value of market location

	A1	A2	A3	A4	
A1	1	5.00	0.38	5.00	0.3185
A2	0.21	1	0.38	3.00	0.1353
A3	3.00	3.00	1	7.00	0.4922
A4	0.15	0.38	0.15	1	0.0540
	4.36	9.38	1.91	16	

Crisp value of labour wages as in Table 22.

Table 22 Crisp value of labour wages

	A1	A2	A3	A4	
A1	1	5.00	0.38	5.00	0.3177
A2	0.21	1	0.38	3.00	0.1351
A3	3.00	3.00	1	7.00	0.4899
A4	0.21	0.38	0.15	1	0.0573
	4.42	9.38	1.91	16	

This research calculates the combined weights for all alternative locations, and distribution centres are ranked according to their combined weights. The combined weights for the Boyolali alternative location are:

Boyolali = (0.130996x0.297115)+(0.127717x0.169433)+(0.318465x0.466655)+ (0.317687x0.066797)= 0.2304;

In the same way, the composite weights for Magelang, Wonosobo and Semarang equals :

Magelang = (0.209053x0.297115)+(0.203951x0.169433)+(0.135307x0.466655)+ (0.135143x0.066797)= 0.1688;

Wonosobo = (0.608577x0.297115)+(0.602409x0.169433)+(0.492241x0.466655)+ (0.489906x0.066797)= 0.54531;

Semarang = (0.051373x0.297115)+(0.065924x0.169433)+(0.053987x0.466655)+ (0.057264x0.066797)=0.0554.

The Fuzzy AHP calculation results show that the best alternative is Wonosobo. This result is the same as the AHP result. In this case, whether using AHP or Fuzzy AHP, Wonosobo is the best alternative location. The research results also show that the second-best alternative has the same results. If the condition is that the second alternative is different, then there is a conflict between the two methods when considering a decision by taking the second-best alternative.

RESULT

The results demonstrate that both the Analytical Hierarchy Process (AHP) and Fuzzy AHP produce consistent rankings for the selection of a potato logistics distribution center in Central Java. Among the four evaluated alternatives—Boyolali, Magelang, Wonosobo, and Semarang—Wonosobo emerges as the most preferred location in both decision models. This consistency indicates the robustness of the decision framework, even when uncertainty in expert judgment is incorporated through fuzzy logic. The AHP results show that market location is the most influential criterion, with a priority weight of 0.4536, followed by transportation conditions (0.2860), availability of raw materials (0.1602), and labor wages (0.1002). These findings highlight that proximity to markets and accessibility play a more critical role in logistics center selection than labor cost considerations. This outcome is consistent with the characteristics of horticultural commodities such as potatoes, which are highly perishable and sensitive to distribution delays. Based on the AHP synthesis, Wonosobo achieves the highest composite weight (0.4986), significantly exceeding Boyolali (0.2735), Magelang (0.1565), and Semarang (0.0714). The dominance of Wonosobo is primarily attributed to its strong performance in raw material availability and market accessibility, reflecting its role as the largest potato-producing area in Central Java. This finding suggests that locating distribution centers closer to production hubs can reduce transportation costs, minimize post-harvest losses, and improve price transmission to farmers. The Fuzzy AHP analysis, conducted using an α-cut value of 0.5, confirms the AHP results. Wonosobo again ranks first with a composite weight of 0.5453, followed by Boyolali (0.2304), Magelang (0.1688), and Semarang (0.0554). The similarity between AHP and Fuzzy AHP outcomes indicates that uncertainty in expert judgments does not significantly alter the final decision. This strengthens confidence in the selected alternative and demonstrates that conventional AHP is sufficiently reliable in cases where expert consensus is relatively stable. From a theoretical perspective, this study contributes to the logistics and agro-industrial literature by empirically showing that AHP and Fuzzy AHP can yield equivalent decisions under well-defined criteria and expert agreement. Practically, the results provide evidence-based guidance for policymakers and stakeholders in designing logistics infrastructure to enhance supply chain coordination, reduce price volatility, and support farmer welfare. However, the hierarchical structure applied in this study does not capture interdependencies among criteria, suggesting that future research should adopt the Analytic Network Process (ANP) to better represent complex logistics systems.

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