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ELECTRE-Based Decision Support Model for LPG Base Location Optimization

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Abstract: The kerosene to LPG (Liquefied Petroleum Gas) 3 kg conversion program since 2007 has successfully improved household energy efficiency, but equitable access to bases in remote areas is still an obstacle. In Tabanan Regency, Bali, eight villages do not have access to 3 kg LPG bases, making it difficult for the community to obtain LPG at the Highest Retail Price (HET) and timely supply. This research develops a decision-making model using the ELECTRE method to recommend optimal base locations based on a case study of four villages: Pupuan Sawah, Dalang, Mundeh, and Belatungan. The model integrates 15 criteria including population density, infrastructure accessibility, existing base distance, and the presence of public facilities with a multi-stakeholder approach. The model is expected to be a tool for LPG agents and policy makers in determining the optimal base location and supporting equitable distribution of subsidized energy.

Keywords: Decision Making Model, 3 kg LPG, ELECTRE, Energy Distribution, LPG Base.

INTRODUCTION

The Kerosene to LPG (Liquefied Petroleum Gas) Conversion Program initiated by the government in 2007 aims to reduce fuel subsidies and provide cleaner, more efficient and affordable fuel. Despite the success of replacing kerosene with 3 kg LPG (Ditjen Migas, n.d.), distribution still faces challenges in terms of equitable access to bases in remote areas, particularly in areas with limited road infrastructure and long distances from distribution centers.

In the context of this study, remote or underserved areas are defined as areas with significant limitations in accessibility to 3 kg LPG distribution facilities. The operational criteria used refer to the dimensions of regional underdevelopment as stipulated in Presidential Regulation No. 63 of 2020, specifically related to criteria for facilities and infrastructure as well as accessibility, including: (1) distance from the nearest LPG station is more than 5 km, (2) road infrastructure conditions with district or village road status with limited accessibility, (3) absence of official LPG stations, causing the community to depend on mobile agents. Although Tabanan Regency is not formally classified as a disadvantaged area, several villages in this region face significant accessibility challenges. In Tabanan district, eight villages do not yet have access to 3 kg LPG bases (PERTAMINA, 2025). Findings from the field indicate a significant impact, with residents of Belatungan village having to travel 5.7 km to obtain LPG. Interviews with the Perbekel indicate that the community faces difficulties due to frequent stock-outs because the village is not registered as a regular subscriber to the agent. Residents have to wait for traveling agents, making the supply of LPG for 827 households with a need for more than 500 cylinders per month uncertain. Interviews with agents of PT Nyuh Gading Sanjiwani and PT Putra

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Sanjiwani revealed that the process of determining the location of new bases is still experiencing problems due to the unavailability of a structured recommendation system , so the locations proposed by prospective sub-agents often do not meet strategic criteria and the distribution of bases is uneven.

Determining the optimal location of LPG 3 kg bases requires a study of various complex factors including accessibility, distance from existing bases, and market potential. Previous studies applied the distribution network development approach (Adegbola et al., 2021), application of the ELECTRE method (Akmaludin et al., 2023), strategic location selection (Bennani et al., 2022)), and market potential analysis (Bruna, 2024. The ELECTRE method excels in analyzing alternatives based on complex criteria through concordance and discordance, accommodates qualitative and quantitative criteria (Lasota et al., 2022), and is effective for decision making with many alternatives in a logistics context. However, research on the location of LPG bases in hard-to-access areas is still limited.

Based on these issues, this study aims to answer the following research questions: How can the ELECTRE method be applied to rank alternative locations for 3 kg LPG depots in remote villages in Tabanan Regency? Which criteria have the most influence on the ranking results for optimal depot locations based on sensitivity analysis?

This research develops a decision-making model using the ELECTRE method to recommend the location of 3 kg LPG bases in four villages of Tabanan Regency. By applying 15 criteria including accessibility, competition, security, cost, and demand, the model produces ranking-based recommendations that can be used by distributors and authorities to identify potential locations and conduct socialization to communities interested in becoming sub-bases, in order to support equitable distribution of subsidized energy.

LITERATURE REVIEW

(Indrianti et al., 2025)optimized the distribution of 3 kg LPG in Yogyakarta through the Green Vehicle Routing Problem to reduce fuel consumption, distance, and cost. Meanwhile, (Oberle et al., 2022)studied gas distribution networks in Germany in the low-carbon energy transition with adaptive planning. Both studies focused on route optimization and network efficiency, rather than base location in underserved areas.

(Taherdoost & Madanchian, 2023)showed the superiority of ELECTRE in assessing alternatives based on qualitative and quantitative criteria. While (Nghiem & Chu, 2022)used hybrid BWM-fuzzy ELECTRE I for lean manufacturing facility layout, demonstrating ELECTRE's ability to integrate complex criteria. Both studies illustrate the flexibility of ELECTRE in multicriteria decision making with different contexts.

(Bairagi, 2022)used fuzzy-based MCDM for warehouse location considering transportation, inventory, and customer proximity. Meanwhile, (Makarevic & Stavrou, 2022)combined BWM and ELECTRE III for manufacturing location based on economic, social, and environmental criteria. However, MCDM research for the location of 3 kg LPG bases in areas with limited accessibility is still limited.

Research on LPG distribution has adopted route optimization and performance evaluation, but studies on determining the location of LPG stations in areas without access using ELECTRE are still limited. Unlike (Noorollahi et al., n.d.), which used Fuzzy-Boolean logic and AHP for the selection of photovoltaic solar power plant locations in Iran without considering infrastructure accessibility criteria for subsidized energy, or (Moradi et al., 2020) who applied AHP-MCDM for wind farm location selection but focused on electrical and topographical criteria without integrating a multi-stakeholder perspective, this study is the first to specifically apply the ELECTRE method for prioritizing the location of subsidized 3 kg LPG depots in underserved areas with limited accessibility in the Indonesian context.

This study integrates three main aspects that distinguish it from previous research: (1) the application of ELECTRE for subsidized LPG depot locations in underserved areas, (2) the integration of 15 comprehensive criteria covering infrastructure accessibility, market competition, security, operational costs, storage capacity, and demand estimates, and (3) the multi-stakeholder perspectives of distributors, village governments, and user communities. The model provides objective and measurable recommendations through systematic sensitivity analysis validation to support the

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equitable distribution of subsidized energy.

Decision Support Systems and Multi-Criteria Decision Making

Decision Support Systems (DSS) help solve complex problems by providing data, models, and algorithms (Ali et al., 2023). LPG base siting is a Multi-Criteria Decision Making (MCDM) problem that evaluates alternatives based on complex criteria such as accessibility, distance, market potential, and security (Martins et al., 2025).

LPG Base Location Criteria

Optimal location selection is based on market potential and competition level by considering land use, physical conditions, transportation access, public facilities, and consumer behavior (Shaikh et al., 2021). Location selection is a multi-criteria problem influenced by accessibility, transportation infrastructure, proximity to consumers, operational costs, and environmental factors (Pajić et al., 2024). Based on interviews with agents of PT Nyuh Gading Sanjiwani and PT Putra Sanjiwani and questionnaires to LPG agents in Tabanan Regency, 15 criteria were obtained which were grouped into five aspects: accessibility and infrastructure (C1-C4), presence of competitors (C5-C6), security (C7-C8), cost and availability of space (C9-C11), and demand (C12-C15).

ELECTRE method

The ELECTRE (*Elimination Et Choix Traduisant la Realité*) method is a multicriteria decision-making method based on the concept of *outranking* through pairwise comparison of alternatives (Akram et al., 2020). This method eliminates unsuitable alternatives through the calculation of *concordance* and *discordance index* with stages:

1. Normalization of the decision matrix, each attribute is converted into comparable values. Each normalization of the xij value can be done by the formula:
   $r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x^2 ij}$
   For $i = 1,2,3...,m$ and $j = 1,2,3...,n$. (1)
   where r_ij is the normalized value of criterion j for alternative i, x_ij is the original value of criterion j for alternative i, m is the total number of alternatives evaluated, and n is the total number of criteria used.
2. Weighting on the normalized matrix, after normalizing each column of the matrix R is multiplied by the weights (W_j) determined by the decision maker. Thus V=RW which is written as:
3. Weighting Determining concordance and discordance
   For each pair of alternatives k and l (k,l = 1,2,3,...,m and k ≠ l) the set of criteria J is divided into two subsets, namely concordance and discordance.
   The concordance set (C_kl) contains criteria where alternative Ak has a better or equal value to alternative Al, indicating support or agreement with the superiority of Ak over Al. Conversely, the discordance set (D_kl) contains criteria where alternative Ak has a worse value than Al, indicating disagreement or rejection of the superiority of Ak.

   Mathematically, it can be expressed as follows:
   $C\_kl = \{j, v_{kj} \geq v_{lj}\}$, for $j = 1,2,3...,n$. (2)
   where C_kl is the set of criteria that support alternative Ak being better than Al.
   $D\_kl = \{j, v_{kj} < v_{lj}\}$, for $j = 1,2,3...,n$.
   where D_kl is the set of criteria that do not support alternative Ak. (3)
4. Calculate the concordance and discordance matrices
   1) Determine the dominant concordance matrix
      The F matrix as the dominant concordance matrix can be built with the help of a threshold value, which compares each concordance matrix element value with the threshold value.

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$C_{ki} \geq c$

2) Determining the dominant discordance matrix
To build the dominant discordance matrix also uses the help of the threshold value
$D_{ki} \geq d$
3) Determining the aggregate dominance matrix
The next step is to determine the aggregate dominance matrix as matrix E, each element of which is the multiplication of matrix element F with matrix element G, as follows:
$E_{ki} = f_{ki} \times g_{ki}$
4) Elimination of less favorable alternatives
Matrix *E* gives the order of choice of each alternative, that is, if *ekl* = 1 then alternative *Ak* is a better choice than *Al*. So the row in matrix *E* that has the least number of *ekl* = 1 can be eliminated. Thus the best alternative is the one that dominates other alternatives (Taherdoost & Madanchian, 2023).

Sensitivity Analysis

Sensitivity tests were conducted to identify, obtain, and compare assessment criteria results to determine the most critical or most sensitive criteria to changes in alternative rankings.

In this study, sensitivity tests were conducted by changing the weight value of each criterion individually by adding ±0.5 and ±1.0, while the weights of other criteria remained at their initial values. Each weight change resulted in a recalculation of the ELECTRE method, starting from matrix weighting to dominant matrix aggregation, so that changes in the order of alternative rankings could be observed. The criteria that caused the most changes in ranking were considered to be the criteria that were most sensitive to the stability of the ranking results. (Sudipa et al., 2022).

Percentage of Ranking Change

The percentage of changes in alternative rankings is used to observe the final results of the sensitivity analysis process, as well as the extent of changes in alternative rank order caused by changes in weight values (Sudipa et al., 2022). The calculation formula can be seen as follows:

$$\frac{T}{i \times A} \times 100 \qquad (4)$$

Description:
T = Total final change in alternative ranking
I = Total weight change
A = Number of attributes or criteria used

METHOD

Phases of Research

The entire research procedure is described in Figure 1 (Flowchart). The research began with the identification of the problem of the absence of 3 kg LPG bases in eight villages in Tabanan Regency. Interviews with agents from PT. Nyuh Gading Sanjiwani and PT. Putra Sanjiwani as well as field observations found that the location determination process was still manual without a structured recommendation system. The ELECTRE method was chosen because of its superiority in handling complex criteria and producing ranking-based recommendations.

Of the eight villages that did not yet have access to 3 kg LPG stations, four villages were selected as study locations, namely Pupuan Sawah, Dalang, Mundeh, and Belatungan. The selection criteria included: (1) adequate road conditions for LPG distribution vehicles, (2) high potential demand for LPG (at least 500 cylinders/month), (3) a significant population, and (4) accessibility for primary data collection. The remaining four villages were not included because the road infrastructure conditions did not meet LPG distribution safety standards, requiring improvements first.

Primary data was collected through agent interviews, criterion weighting questionnaires,

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and field observations to evaluate six alternative locations based on 15 criteria. A total of 50 LPG sub-agents in Tabanan Regency were selected as respondents using purposive sampling with the following criteria: (1) have been operating for at least 2 years, (2) serve areas that cover or are adjacent to the study location, and (3) are willing to provide data related to the criteria for determining the location of the base. The questionnaire was distributed to determine the weight of the criteria based on the perspective of distribution actors using a scale of 1-5. Secondary data was obtained from official village websites, MyPertamina, and Google Maps. The ELECTRE method was applied from normalization to ranking, then validated through sensitivity testing.

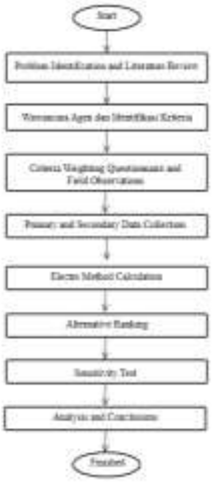

Figure 1 Flowchart

Overview of Decision-Making Model

Decision-making model of 3 kg LPG base location recommendation. The overview or concept flow scheme used is as follows.

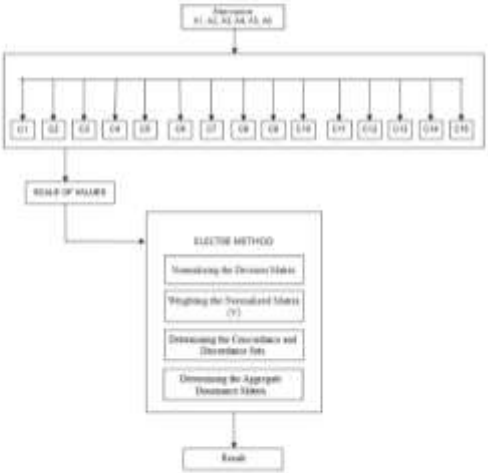

Figure 2 Overview of Model

Figure 2 shows the flow of the model from the input of six alternative locations and 15 criteria to a ranking-based recommendation. The criteria are classified into five aspects: accessibility and infrastructure (C1-C4), presence of competitors (C5-C6), security (C7-C8), cost and space availability (C9-C11), and demand (C12-C15). The ELECTRE method is applied through matrix normalization,

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weighting (scale 1-5), concordance-discordance calculation, and dominant matrix aggregation. The results are validated through sensitivity tests to ensure the stability of the ranking. The model serves as a tool for distributors and authorities in identifying potential locations to be socialized to prospective sub-bases.

RESULT

Alternative Data Analysis

The next step before performing the calculation is to determine the alternatives to be used. Based on Table 1, there are six locations that are used as alternatives in the design of the location recommendation decision model. These locations are obtained through direct observation in the field, as well as based on input from local communities and village officials who understand the condition of the area and the potential of the location to become a 3 kg LPG base.

Table 1 Alternative Data

Code	Alternative
A1	Location 1
A2	Location 2
A3	Location 3
A4	Location 4
A5	Location 5
A6	Location 6

Data Analysis Criteria

Criteria are things that are used as determinants in assessing alternatives. The following criteria were obtained from the results of interviews with LPG agents and the distribution of questionnaires to LPG sub-agents in the study area.

Table 2 Criteria Data

Code	Criteria	Weight	Description	Value
C1	road access to the base location	3	Difficult	1
			Easy enough	2
			Easy	3
			Very Easy	4
C2	there is a main road for gas distribution	5	None	1
			Exists	5
C3	distance between base and main consumer	4	More than 20 Km	1
			11-20 Km	2
			6-10 Km	3
			0-5 Km	4
C4	road conditions accessible to distribution vehicles	5	None	1
			Available	5
C5	other gas stations around the location	5	None	1
			Available	5
C6	distance to other gas stations around the location	4	0-2 Km	1
			3-4 Km	2
			5-8 Km	3
			more than 8 km	5

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C7	environmental safety of the base location	3	Not safe	1
			Fairly Secure	2
			Secure	3
			Very Safe	4
C8	there are fire protection facilities	5	No	1
			Available	5
C9	how much does the base location cost	3	more than 5,000,000 IDR	1
			2,000,000 IDR-5,000,000 IDR	2
			Less than 2,000,000 IDR	3
			Owned	4
C10	does the base have storage capacity	5	No	1
			Exists	5
C11	does the base have a storage area for distribution vehicles	5	No	1
			Yes	5
C12	is the base close to residential areas	3	Not close	1
			Close enough	2
			Close	3
			Very Close	4
C13	LPG gas demand target	3	Low	1
			Moderately High	2
			High	3
			Very High	4
C14	how many consumers (neighborhood/business owners)	3	less than 50	1
			50 -100	2
			100 - 200	3
			more than 200	4
C15	whether the location of the base has the potential for LPG gas demand growth	3	Not sure	1
			Neutral	2
			Tend to be Convinced	3
			Strongly Convinced	4

Based on Table 2 Criteria and Attributes, these criteria are equipped with attributes and a value scale to facilitate the process of calculating alternative values using the Electre method. The determination of criteria, attributes, and weights was based on the results of interviews with LPG agents and the distribution of questionnaires to LPG sub-agents in the study area. This approach is taken so that the criteria used truly reflect the real conditions and needs in the field.

All criteria have been transformed into benefit-type attributes, so that higher values consistently represent more desirable conditions for LPG base locations. Criteria that are naturally cost criteria, such as C9 (location cost), have been converted by giving the highest value (4) to "Ownership" and the lowest value (1) to the highest cost. This transformation ensures consistency in the calculation of the concordance and discordance indices in the ELECTRE method.

Application of Electre Method

Electre method calculation to get the final value and ranking. The stage for calculating the electre method, starting with the collection of criteria values for each alternative as shown in Table 3 below.

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Table 3 Criteria Value of Each Alternative

Alt	Criteria														
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
A1	4	5	4	5	5	3	4	1	4	5	1	4	4	3	3
A2	3	5	4	5	5	2	3	5	2	5	1	2	3	4	3
A3	4	5	4	5	5	3	2	1	4	5	5	2	2	3	2
A4	4	5	4	5	5	3	3	1	3	5	1	3	3	4	3
A5	2	5	4	5	5	3	3	5	4	5	1	3	4	4	2
A6	4	5	4	5	5	2	4	1	2	5	5	4	3	3	3
Total	8,8	12,2	9,8	12,2	12,2	6,6	7,9	7,3	8,1	12,2	7,3	7,6	7,9	8,7	6,6

Example calculations in Table 3, as follows:

$$C1 = \sqrt{4^2 + 3^2 + 4^2 + 4^2 + 2^2 + 4^2} = 8{,}775$$

Calculation of Normalized Matrix (R)

Normalization of the matrix is done to get comparable values for each criterion and alternative.

Table 4 Normalized Matrix (R)

Alt	Criteria														
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
A1	0,5	0,4	0,4	0,4	0,4	0,5	0,5	0,1	0,5	0,4	0,1	0,5	0,5	0,3	0,5
A2	0,3	0,4	0,4	0,4	0,4	0,3	0,4	0,7	0,2	0,4	0,1	0,3	0,4	0,5	0,5
A3	0,5	0,4	0,4	0,4	0,4	0,5	0,3	0,1	0,5	0,4	0,7	0,3	0,3	0,3	0,3
A4	0,5	0,4	0,4	0,4	0,4	0,5	0,4	0,1	0,4	0,4	0,1	0,4	0,4	0,5	0,5
A5	0,2	0,4	0,4	0,4	0,4	0,5	0,4	0,7	0,5	0,4	0,1	0,4	0,5	0,5	0,3
A6	0,5	0,4	0,4	0,4	0,4	0,3	0,5	0,1	0,2	0,4	0,7	0,5	0,4	0,3	0,5
W	3	5	4	5	5	4	3	5	3	5	5	3	3	3	3

The values in table 4 are obtained from dividing the criteria results by the final results. W is the weight of each criterion.

Calculation of Weighting Matrix (V)

Table 5 Calculation of Weighting Matrix (V)

Alt	Criteria														
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
A1	1,4	2,0	1,6	2,0	2,0	1,8	1,5	0,7	1,5	2,0	0,7	1,6	1,5	1,0	1,4
A2	1,0	2,0	1,6	2,0	2,0	1,2	1,1	3,4	0,7	2,0	0,7	0,8	1,1	1,4	1,4
A3	1,4	2,0	1,6	2,0	2,0	1,8	0,8	0,7	1,5	2,0	3,4	0,8	0,8	1,0	0,9
A4	1,4	2,0	1,6	2,0	2,0	1,8	1,1	0,7	1,1	2,0	0,7	1,2	1,1	1,4	1,4
A5	0,7	2,0	1,6	2,0	2,0	1,8	1,1	3,4	1,5	2,0	0,7	1,2	1,5	1,4	0,9
A6	1,4	2,0	1,6	2,0	2,0	1,2	1,5	0,7	0,7	2,0	3,4	1,6	1,1	1,0	1,4

The results in Table 5 of this matrix weighting are obtained from multiplying the normalized matrix results (R) by the Criteria Weighting results (W).

Determining Concordance and Discordance

For each pair of alternatives k and l (k,l = 1,2,3,...,m and k ≠ l) the set of criteria J is divided into two subsets, namely concordance and discordance.

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Pada tabel 6 untuk setiap pasangan alternatif (k,l), kriteria dibagi menjadi concordance set (kriteria di mana k ≥ l) dan discordance set (kriteria di mana k < l).

Table 6 Concordance

C_{kl}	Comparison Result														
C_{12}	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1
C_{13}	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
C_{14}	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
C_{15}	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1
C_{16}	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
C_{21}	0	1	1	1	1	0	0	1	0	1	1	0	0	1	1
C_{23}	0	1	1	1	1	0	1	1	0	1	0	1	1	1	1
C_{24}	0	1	1	1	1	0	1	1	0	1	1	0	1	1	1
C_{25}	1	1	1	1	1	0	1	1	0	1	1	0	0	1	1
C_{26}	0	1	1	1	1	1	0	1	1	1	0	0	1	1	1
.....	(20 lines of calculations for other alternative pairs)														
C_{65}	1	1	1	1	1	0	1	0	0	1	1	1	0	0	1

This process was carried out for all 30 alternative pairs, and the sum of the weights is presented in a concordance matrix (Table 8).

The calculation in Table 7 discordance measures the maximum difference in values in the discordance set, normalized to the maximum overall difference. Formula: d(k,l) = max|Vkj - Vlj| / max(all criteria)

Table 7 Discordance

D_{kl}	Comparison Result														
D_{12}	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
D_{13}	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
D_{14}	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
D_{15}	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
D_{16}	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
D_{21}	1	0	0	0	0	1	1	0	1	0	0	1	1	0	0
D_{23}	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0
D_{24}	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0
D_{25}	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0
D_{26}	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0
.....	(20 lines of calculations for other alternative pairs)														
D_{65}	0	0	0	0	0	1	0	1	1	0	0	0	1	1	0

This process was carried out for all 30 alternative pairs, and the sum of the weights is presented in a discordance matrix (Table 9).

Determination of Concordance and Discordance Matrices

The concordance matrix is calculated by summing the weight values (Table 8), while discordance by dividing the maximum value of the difference in criteria with the maximum value of all criteria (Table 9).

Table 8 Determination of Concordance Matrix

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Concordance Matrix						
	51	54	56	51	54	266
43		44	46	46	41	220
47	42		44	42	47	222
47	54	51		48	48	248
47	53	51	53		45	249
59	54	52	49	41		255
Total						**48,67**

Table 9 Determination of Discordance Matrix

Discordance Matrix						
	3,455	3,455	0,879	3,980	3,657	15,426
0,289		1	0,222	1,646	1	4,157
0,289	1		0,166	1	1,059	3,514
1,137	4,513	6,018		3,98	4,513	20,161
0,251	0,608	1	0,251		1	3,11
0,273	1	0,945	0,222	1		3,44
Total						**1,660**

Dominant Concordance and Discordance Matrices

The dominant concordance matrix is obtained by comparing the matrix value with the threshold. If the value of c ≥ the value of c then f = 1, and if c < c then f = 0. The dominant matrix (F) can be seen in Table 10 as follows:

Table 10 Dominant Concordance Matrix

Dominant Concordance Matrix					
	1	1	1	1	1
0		0	0	0	0
0	0		0	0	0
0	1	1		0	0
0	1	1	1		0
1	1	1	1	0	

Discordance:

Discordance dominant matrix is obtained if the value of d ≥ the value of d then g=1, and if d < d then g=0. The dominant matrix (G) can be seen in Table 11 as follows:

Table 11 Dominant Discordance Matrix

Dominant Discordance Matrix					
	1	1	0	1	1
0		0	0	1	0
0	0		0	0	0
0	1	1		1	1
0	0	0	0		0
0	0	0	0	0	

Determination of Aggregate Dominant Matrix

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Determining the dominant aggregate (E) is obtained by multiplying the F and G matrices which can be seen in Table 12 as follows:

Table 12 Aggregate Dominant Matrix

RESULTS						
Location 1		1	1	0	1	1
Location 2	0		0	0	0	0
Location 3	0	0		0	0	0
Location 4	0	1	1		0	0
Location 5	0	0	0	0		0
Location 6	0	0	0	0	0	

From the calculations carried out, the best alternative ranking results can be seen in Table 13 as follows:

Table1 3 Alternative Ranking Results

Alternative	Location	Ranking
A1	Location 1	1
A4	Location 4	2
A5	Location 5	3
A6	Location 6	4
A3	Location 3	5
A2	Location 2	6

Sensitivity Analysis

The sensitivity analysis calculation process is carried out by changing the weight values of the criteria individually with the addition of +0.5 and +1.0 for each criterion, while the weight of the other criteria remains at the initial value. Each change in criterion weight results in recalculation of the ELECTRE method starting from matrix weighting (V = R × W_new), concordance and discordance index, to aggregate dominance matrix, resulting in a change in the ranking order of alternatives.

From the changes in the ranking order of alternatives, it can be seen the criteria that cause the most number of changes in ranking order, which indicates the level of sensitivity of these criteria to the stability of ranking results. Changes in alternative rankings for each weight variation scenario can be seen in Table 14, as follows:

Table1 4 Changes in Criteria Weight Value

Simulation To-	Criteria (C)	Criteria Weight Value (W) + (n)	Changes in Alternative Ranking	Number of Rank Changes
S0	Baseline	-	A1>A4>A5>A6>A3>A2	0 (No change)
S1	C1	W_{C1} + (0,5)	A1>A4>A5>A6>A3>A2	0 (Not Changing)
S2		W_{C1}+ (1)	A1>A4>A5>A6>A3>A2	0 (Not Changed)
S11	C6	W_{C6} + (0,5)	A1>A6>A4>A5>A3>A2	3
S12		W_{C6} + (1)	A1>A4>A6>A5>A3>A2	2
S13	C7	W_{C7} + (0,5)	**A1>A4>A6>A5>A2>A3**	4
S14		W_{C7} + (1)	**A1>A4>A6>A5>A2>A3**	4
S15	C8	W_{C8} + (0,5)	**A1>A4>A6>A5>A2>A3**	4
S16		W_{C8} + (1)	**A4>A6>A1>A5>A2>A3**	**6**
S17	C9	W_{C9} + (0,5)	A4>A1>A6>A5>A3>A2	4
S18		W_{C9} + (1)	A4>A1>A6>A5>A3>A2	4
S23	C12	W_{C12} + (0,5)	**A4>A1>A6>A5>A2>A3**	**6**
S24		W_{C12} + (1)	**A4>A1>A6>A5>A2>A3**	**6**
...				
S30	C15	W_{C15} + (1)	**A1>A4>A5>A6>A2>A3**	2

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In Table 14 above, it can be seen that the most alternative order changes occur in the addition of the weight of criteria C8(W_{C8} + 1) with 6 alternative order changes, namely A4>A6>A1>A5>A2>A3. Then the next most alternative order changes can be seen in the addition of weights C12 (W_{C12} + 0.5) and C12 (W_{C12} + 1) with 6 alternative order changes, namely A4>A1>A6>A5>A2>A3.

Table 15 Percentage of Weight Change

Simulation To-	Criteria Weight Value + (n)	Percentage Change Ranking
S0	-	0%
S1	W_{C1} + (0,5)	0%
S2	W_{C1}+ (1)	0%
S11	W_{C6} + (0,5)	40%
S12	W_{C6} + (1)	13,33%
S13	W_{C7} + (0,5)	53,33%
S14	W_{C7} + (1)	26,67%
S15	W_{C8} + (0,5)	53,33%
S16	W_{C8} + (1)	40%
S17	W_{C9} + (0,5)	53,33%
S18	W_{C9} + (1)	26,67%
S23	W_{C12} + (0,5)	80%
S24	W_{C12} + (1)	40%
...		
S30	W_{C15} + (1)	13,33%

From Table 15, it can be seen that the percentage of changes in ranking is found in several changes in the weight of the criterion value, namely the weight of the criteriaW_{C7} + (0.5),W_{C8} + (0.5) andW_{C9} + (0.5) by 53.33%. Then the next highest percentage of ranking changes is in the weight of the criteriaW_{C12} + (0.5) by 80%.

Criterion C12 (distance from residential areas) shows the highest percentage change in ranking at 80%. This means that when the weight of C12 is varied, 80% of all alternative pairs experience a change in their relative ranking positions. In other words, changes in the C12 weight cause significant changes in the order of location priority, confirming that proximity to residential areas is the most critical factor in deciding the location of LPG stations in remote areas. This finding is consistent with the conditions in Belatungan Village, where the 5.7 km distance from the nearest station causes access difficulties for 827 households.

Conversely, criterion C8 (environmental safety) shows a lower percentage change in ranking (13.33%), indicating that variations in weighting for this criterion do not dramatically alter the ranking order. This suggests that although safety remains an important consideration, its influence on decision outcomes is more stable than that of accessibility and demand criteria.

For alternatives with identical Net Dominance Score, tie-breaking uses the total discordance index, where lower values indicate better stability and less conflict with other alternatives. The highest ranked locations are prioritized for LPG base construction, while other locations are not recommended due to lower scores on the 15 evaluation criteria. However, these locations can be reconsidered if conditions change such as improved accessibility or demand for LPG. These results show that a combination of the criteria accessibility-infrastructure, presence of competitors, security, cost-land availability, and market competition provide effective guidance for site selection.

CONCLUSION

A decision-making model based on the ELECTRE method has successfully produced objective and measurable 3 kg LPG base location recommendations. Through the evaluation of six alternative locations using 15 criteria, the optimal ranking was obtained as follows: Location 1 (A1) as the top priority, followed by Location 4 (A4), Location 5 (A5), Location 6 (A6), Location 3 (A3), and Location 2 (A2). The results of the sensitivity test carried out through 30 scenarios of weight changes show that

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the model has good stability, with criterion C12 (proximity to residential areas) as the most sensitive criterion (resulting in an 80% change in ranking), followed by criteria C7, C8, and C9 (53.33% each). Location 1 and Location 4 consistently occupied the top two positions in most scenarios, indicating a strong advantage for these two locations. This finding confirms that aspects of market demand and operational security have a significant influence in determining the feasibility of base location. In further development, the model can be integrated with dynamic factors such as population growth projections and geographic information systems (GIS) to produce a more optimal spatial visualization. The model does not merely act as a technical tool, but also serves as a strategic instrument in supporting the equitable distribution of subsidized energy and supporting the achievement of government policy in ensuring equitable access to 3 kg LPG for people in underserved areas, especially in Tabanan District.

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