Priorities for Rural Electricity Infrastructure Development in South Sulawesi Province Using Analytical Hierarchy Process Method

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Abstract. The Electricity access in rural areas of South Sulawesi still faces inequality even though the national electrification ratio has exceeded 99%. Complex geo-graphical conditions and limited resources make determining priorities for electricity infrastructure development a major challenge. This study uses the Analytical Hierarchy Process (AHP) method to determine the priorities of villages that are not yet connected to the PLN electricity grid. Six main criteria were established, namely forest area, electrification method, infrastruc-ture, electricity supply, distance from the grid, and population. Data was ob-tained through official documents and focus group discussions with PT PLN (Persero) South Sulawesi Electricity Project Implementation Unit. The anal-ysis results show that the forest area factor has the most dominant weight (44.08%), followed by infrastructure conditions (21.99%) and distance (14.51%). Of the 61 villages analyzed, Lamasi Hulu Village was determined to be the highest priority with a score of 3.29, while Rampi Village was the lowest priority with a score of 1.51. The Consistency Ratio value of 0.0396 (< 0.1) indicates that the calculation results are consistent and acceptable. These findings provide a basis for more objective and data-driven decision-making in supporting the achievement of the 100% electrification target in South Sulawesi.

Keywords: Rural Electrification, Electrical Infrastructure, AHP, Development Priorities, South Sulawesi.

1 Introduction

Access to electricity is a crucial factor in improving the quality of life of rural communities and driving local economic growth. In Indonesia, although the national electrification ratio has reached more than 99%, disparities in access to electricity between regions still exist, especially in remote and disadvantaged areas such as South Sulawesi Province [1]. This region has diverse geographical characteristics, consisting of mountains, forests, islands, and remote areas, which pose unique chal-lenges for the development of electricity infrastructure. Therefore, a systematic and data-driven approach is needed to determine the appropriate and efficient priority locations for rural electricity development.

M. Nohong et al. (eds.), *Proceedings of the 10th International Conference on Accounting, Management, and Economics (10th ICAME 2025)*, Advances in Economics, Business and Management Research 388,
https://doi.org/10.2991/978-94-6239-709-5_135

The main problem in rural electricity development in South Sulawesi Province is the widespread location and limited resources, both in terms of budget, time, and tech-nical personnel, so that not all villages can be electrified at the same time. To ad-dress this challenge, a decision-making method is needed that can accommodate various criteria simultaneously and objectively.

Theoretical studies show that AHP is effective in integrating various assessment aspects such as distance from existing networks, population size, village economic potential, energy gap, and geographical and social conditions [2]. This study aims to fill this literature gap by applying AHP in determining the priority locations for rural electricity development in South Sulawesi Province. The results of this study are expected to provide data-based recommendations to support more accountable and strategic decision-making in efforts to achieve a 100% electrification ratio in an equitable and fair manner.

2 Literature Review

2.1 Rural Electrification Development and Its Problems

The development of electrical infrastructure in rural areas is one of the Indonesian government's strategic agendas in its efforts to promote equitable development and improve community welfare. the national electrification ratio reached 99.83% in 2024, but there are still disparities between regions, particularly in eastern Indonesia and remote inland areas. South Sulawesi Province, which has a geographical landscape of moun-tains, large rivers, and islands, faces challenges in terms of accessibility and limita-tions in the existing network, which hinder rural electricity development.

The lack of electricity not only affects the economic productivity of the community, but also influences access to education, health services, and social stability. There-fore, electricity development interventions need to comprehensively consider tech-nical, social, and economic factors so that their implementation is on target. Issues that arise in rural electricity development include, budget constraints, limited tech-nical resources, extreme geographical conditions, and the mismatch between data and actual needs in the field.

Various approaches have been used to determine priority locations for electricity development, but most are still conventional or top-down, without systematically involving local stakeholders. This opens up opportunities for scientific-based ap-proaches that can objectively address multi-criteria issues. One method that is wide-ly used in the context of infrastructure planning is the Analytical Hierarchy Process (AHP).

2.2 The Analytical Hierarchy Process (AHP) method

The AHP method was first introduced by Thomas L. Saaty in 1980 as a multi-criteria decision-making method capable of breaking down complex problems into a hierar-chical form [3]. AHP enables decision-making through weighting and pairwise com-parisons between criteria, taking into account both quantitative and qualitative as-pects simultaneously. In the context of infrastructure development, AHP has proven effective in helping policymakers prioritize based on relevant criteria.

The AHP process involves the stages of setting objectives, identifying criteria and subcriteria, pairwise comparisons, matrix normalization, and calculation of weights and logical consistency [4]. One of the main advantages of AHP is its ability to accommodate the opinions of experts or local stakeholders, making it an inclusive method in the context of participatory development planning.

In the paired comparison process, numbers on a scale of 1 to 9 are used. This scale represents how important it is for a choice to be selected or prioritized. The scale can be seen in the following table:

Table 1. Pairwise comparison assessment scale

Intensity of Importance	Definition	Explanation
1	Equally important	Both elements are equally important
3	Slightly more important	One element is slightly more important than the other other
5	More important	One element is more important than the others
7	Very important	One element is clearly more absolutely important than the other the others
9	Absolutely more important	One element is absolutely more important than the other elements
2,4,6,8	Middle value	Values between two values of adjacent considerations that are close together
Reverse	A=1/A	If activity i receives one number compared with activity j, then j has the reciprocal value compared to i..

Source: Saaty, T. L. [3]

In making decisions, it is important to know how good the consistency is because we do not want decisions based on inconsistent considerations. For this reason, it is necessary to calculate the Consistency Index (CI) in the following manner:

$$CI = (\lambda max - n) / n-1 \tag{1}$$

Where:

- λmax : eigen value
- n : number of criteria

Furthermore, a matrix is considered consistent if the Consistency Ratio (CR) value is < 0.10. The Consistency Ratio (CR) value can be calculated as follows:

$$CR = CI / IR \quad (2)$$

Where:

- IR : random consistency index

The random consistency index (IR) values can be seen in the following table:

Table 2. Random consistency index (IR)

Matrix Size	IR Value
1	0
2	0
3	0,58
4	1,90
5	1,12
6	1,24
7	1,32
8	1,41
9	1,45
10	1,49

Source: Saaty, T. L. [3]

2.3 Application of AHP in the Context of Rural Electrification

In Indonesia, several studies have attempted to apply AHP in energy system planning. Diputra. [5] aimed to analyze, identify, and rank various criteria and assessment factors that must be considered in energy planning in Indonesia using the Analytic Hierarchy Process (AHP) method. The results of this study indicate that Indonesia's energy planning should prioritize the security of supply of local energy sources that are environmentally friendly and have relatively stable prices.

A similar study by Wijaya [6] focused on the potential of wind, solar, and biomass energy at the local level, using spatial multi-criteria decision analysis based on Geographical Information System (GIS) and Analytic Hierarchy Process (AHP). The findings show that the potential of Renewable Energy Sources (RES) in West Java Province can be categorized based on the overall suitability level, ranked from highest to lowest, namely solar energy, biomass energy, and wind energy.

In addition, research by Alfina [7] aimed to analyze renewable energy sources and technologies for rural electrification in Indonesia by investigating the most important criteria and sub-criteria that decision makers should consider and analyzing the most suitable renewable energy sources, including small-scale geothermal energy, solar photovoltaics, micro-hydro, wind power, or biomass, for electricity generation in rural areas of Indonesia using the Analytic Hierarchy Process (AHP) method. It was found that the most important criterion was energy source, followed by the environment, socio-politics, technical, and economic criteria as the least important. Meanwhile, for renewable energy technologies in rural areas, micro-hydro development is considered the most suitable renewable energy source, followed by biomass, solar, small-scale geothermal, and wind. Micro-hydro is superior because it is capable of producing stable electricity 24 hours a day, is a very mature technology, is easy to operate, and most of its spare parts are produced domestically, which results in electricity at an affordable price for rural communities.

The integration of AHP with digital tools such as web-based applications or GIS is considered to improve spatial accuracy and decision-making efficiency. Although its implementation in Indonesia is still limited, this approach is highly relevant for regions with complex topography such as South Sulawesi.

Finally, a gap that remains in the literature is the lack of studies that specifically focus on the application of AHP to prioritize electrification locations at the provincial level, taking into account the social, economic, and geographical complexities of the region simultaneously. Most studies are provincial or national in nature and fail to capture the micro-context that is important in rural development. This study aims to fill this gap by developing a locally-based AHP model and adjusting the criteria to the characteristics of the South Sulawesi region.

3 Methodology

3.1 Research Design

This study uses a descriptive quantitative approach with the Analytical Hierarchy Process (AHP) method as the main tool in the multi-criteria decision-making pro-cess. This approach was chosen because it is able to capture the complexity of the issue of prioritizing rural electrification, which involves various technical, social, and geographical aspects.

The research location is South Sulawesi Province, which consists of 3,059 villages, and the selected location was based on villages that do not yet have PLN electricity, namely 61 villages [1]. These conditions pose technical challenges in the construc-tion of electricity networks, making it a representative case study for the application of the AHP method.

The four main stages of this study were identification of criteria, data collection, AHP analysis, and mapping of location priority results. All stages were carried out sequentially to ensure integration between theory and field data.

3.2 Criteria Identification and Data Collection

The identification of assessment criteria was carried out through a discussion study/Focus Group Discussion (FGD) with energy experts tasked with electrifying unelectrified areas, namely PT PLN (Persero) South Sulawesi Province Electricity Project Implementation Unit (UP2K). This process was expected to produce the main criteria considered relevant in determining the priorities for rural electricity development.

Quantitative data was collected through official documents such as performance reports from the Directorate General of Electricity of the Ministry of Energy and Mineral Resources and the Central Statistics Agency.

3.3 AHP Analysis Process and Priority Determination

AHP analysis begins with the development of a hierarchical structure, followed by matrix normalization and eigenvector calculations to obtain the relative weights of each criterion. To test logical consistency, the Consistency Ratio (CR) is calculated. If the CR value is ≤ 0.1, the matrix is considered consistent.

After the criteria weights are obtained, the next step is to assess all villages that do not yet have electricity by assigning scores to each criterion based on field data and indicator values. The village scores are multiplied by the criteria weights to obtain a total score (composite score) for each village.

The result of this process is a priority ranking of villages based on their total scores, which represents the urgency of electricity development in those villages. Villages with the highest scores are considered the highest priority.

4 Results

From the results of the Focus Group Discussion (FGD) conducted with employees of PT. PLN (Persero) UP2K South Sulawesi Province, a hierarchical structure with 3 hierarchical levels was produced, namely:

Level 1 is the objective, namely the priority of rural electricity infrastructure development in South Sulawesi province.

Level 2 is the criteria with 6 types of criteria, as shown in the table below:

Table 3. AHP criteria and rating scale for rural electrification prioritisation.

Criteria	Rating	Explanation
Forest Area	1	Conservation Forests and National Parks
	2	Protected Forest and Production Forest
	3	No obstacles
Electrification Methods	1	Communal Power Plant
	2	Supersun
	3	Extension Grid
Infrastructure	1	No access
	2	Difficult (mud/air/sea/river)
	3	Easy (Access available)
Electricity supply	1	Deficit
	2	Standby
	3	Normal
Distance	1	Very Far (more than 200 km)
	2	Far (151 - 200 km)
	3	Moderate (101 - 150 km)
	4	Near (51 - 100 km)
	5	Very Close (1 - 50 km)
Population	1	Very Few (0-500)
	2	Few (501 - 1000)

3	Moderate (1001 - 1500)
4	Many (1501 - 2000)
5	Very Many (more than 2000)

Source: Author elaboration, 2025

Level 3 is a list of locations that will be prioritized, consisting of 61 villages.

After establishing the hierarchy, the next step is to create a pairwise comparison matrix using the Saaty scale. The pairwise comparison matrix can be seen in the following table:

Table 4. Pairwise Comparison Matrix

Criteria	Forest Area	Electrification Method	Infrastructure	Electricity Supply	Distance	Population
Forest Area	1	5	3	7	4	6
Electrification Method	1/5	1	1/3	3	1/2	2
Infrastructure	1/3	3	1	5	2	4
Electricity Supply	1/7	1/3	1/5	1	1/4	1/2
Distance	1/4	2	1/2	4	1	3
Population	1/6	½	1/4	2	1/3	1
Total	2.0929	11.8333	5.2833	22.0000	8.0833	16.5000

Source: Author elaboration, 2025

From the paired comparison matrix data, eigenvector calculations were then performed to obtain the relative weights of each criterion.

Table 5. Eigenvector

Criteria	Forest Area	Electrification Method	Infrastructure	Electricity Supply	Distance	Population	Principal Eigenvector
Forest Area	0.4778	0.4225	0.5678	0.3182	0.4948	0.3636	0.4408
Electrification Method	0.0956	0.0845	0.0631	0.1364	0.0619	0.1212	0.0938
Infrastructure	0.1593	0.2535	0.1893	0.2273	0.2474	0.2424	0.2199
Electricity Supply	0.0683	0.0282	0.0379	0.0455	0.0309	0.0303	0.0402
Distance	0.1195	0.1690	0.0946	0.1818	0.1237	0.1818	0.1451
Population	0.0796	0.0423	0.0473	0.0909	0.0412	0.0606	0.0603
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Source: Author elaboration, 2025

From the results of the main eigenvector multiplied by 100, the criteria weighting will be obtained with the results indicating that the forest area provides the largest percentage, namely 44.08%, followed by infrastructure at 21.99%, distance at 14.51%, electrification methods at 9.38%, population at 6.03%, and electricity supply at 4.02%.

From the results of the comparison of these criteria, the Consistency Index (CI) can be calculated as follows:

$$CI = (\lambda max - n) / n - 1 \tag{3}$$

$$\lambda max = (2{,}0929*0{,}4408) + (11{,}833*0{,}0938) + (5{,}2833*0{,}2199) + (22{,}0000*0{,}0402) + (8{,}0833*0{,}1451) + (16{,}5000*0{,}0603) \tag{4}$$

$$\lambda max = 6{,}2454 \tag{5}$$

Therefore,

$$CI = (6{,}2454 - 6) / 6 -1 \tag{6}$$

$$CI = 0{,}0491 \tag{7}$$

If the Consistency Index (CI) is zero, the matrix is considered consistent. The inconsistency limit set by Thomas L. Saaty is measured using the Consistency Ratio (CR) with the following calculation:

$$CR = CI / IR \tag{8}$$

$$CR = 0{,}0491 / 1{,}24 \tag{9}$$

$$CR = 0{,}0396 \tag{10}$$

The results show that the Consistency Ratio (CR) calculation yields a value of 0.0396. Since the CR value (0.0396) is < 0.1, it can be concluded that the calculation results are consistent and do not need to be repeated.

The next step is to compare each location with each criterion based on actual conditions in the field by entering the value of each criterion.

Table 6. Assessment of each location

No.	Village	Forest Area	Electrification Method	Infrastructure	Electricity Supply	Distance	Population
1	Bontolebang	3	1	2	2	5	2
2	Menara Indah	3	1	2	2	5	2
3	Tambolongan	3	1	2	2	4	3
4	Polassi	3	1	2	2	4	4

5	Khusus Bahuluang	3	1	2	2	5	1
6	Bonerate	3	1	2	2	2	4
7	Majapahit	3	1	2	2	2	5
8	Batu Bingkung	3	1	2	2	2	3
9	Bonea	3	1	2	2	2	3
10	Lambego	3	1	2	2	3	2
11	Komba Komba	3	1	2	2	3	2
12	Sambali	3	1	2	2	2	3
13	Lamantu	3	1	2	2	2	4
14	Kayuadi	1	2	2	2	4	5
15	Batang	1	2	2	2	4	5
16	Nyiur Indah	1	2	2	2	4	4
17	Tambuna	1	2	2	2	3	3
18	Jinato	1	2	2	2	4	3
19	Rajuni	1	2	2	2	4	5
20	Latondu	1	2	2	2	4	2
21	Tarupa	1	2	2	2	4	3
22	Khusus Pasitallu	1	2	2	2	3	2
23	Kalaotoa	3	1	2	2	1	3
24	Garaupa	3	1	2	2	2	2
25	Lembang Matene	3	1	2	2	1	3
26	Pulo Madu	3	1	2	2	1	4
27	Karumpa	3	1	2	2	2	5
28	Garaupa Raya	3	1	2	2	1	2
29	Mattiro Baji	3	1	2	2	5	3
30	Rewataya	3	1	2	2	5	3
31	Balangdatu	3	1	2	2	5	4
32	Minasa Baji	3	1	2	2	5	3
33	Sapuka	3	1	2	2	1	5
34	Poleonro	3	1	2	2	1	2
35	Doang Doangan Lompo	3	1	2	2	2	2
36	Marasende	3	1	2	2	2	3
37	Mattiro Ujung	3	2	2	2	4	4
38	Lamasi Hulu	3	3	3	3	5	3
39	Lewandi	2	3	2	3	4	2
40	Siteba	2	3	3	3	5	3
41	Simbuang Batutallu	2	3	3	3	4	3
42	Tanete	3	3	3	3	4	2
43	Dewata	3	3	3	3	4	3

44	Tirobali	1	3	1	2	3	3
45	Malimongan	1	3	1	2	3	3
46	Tanamakaleang	1	3	1	2	3	4
47	Padang Balua	1	3	2	2	3	4
48	Padang Raya	1	3	2	2	3	2
49	Embonatana	1	3	2	2	3	4
50	Hono	1	3	1	2	3	2
51	Beroppa	1	3	1	2	3	2
52	Lodang	1	3	1	2	3	3
53	Taloto	1	3	1	2	3	3
54	Hoyane	1	3	1	2	3	2
55	Marante	1	3	1	2	3	3
56	Rampi	1	3	1	2	3	1
57	Onondowa	1	3	1	2	4	2
58	Leboni	1	3	1	2	4	1
59	Dodolo	1	3	1	2	4	1
60	Sulaku	1	3	1	2	4	2
61	Tedeboe	1	3	1	2	3	2

Source : Author elaboration, 2025

After the assessment, the scores were calculated by multiplying each value by the weight of each criterion, and the results were arranged based on the highest values. This resulted in a priority order for rural electricity infrastructure development in South Sulawesi Province. The following table shows the priority results of the calculation.

Table 7. Priotity Order

Priority Order	Village	Forest Area	Electrification Method	Infrastructure	Electricity Supply	Distance	Population	Total Points
		Points	Points	Points	Points	Points	Points	
1	Lamasi Hulu	1.3224	0.2813	0.6595	0.1204	0.7253	0.1809	3.2901
2	Dewata	1.3224	0.2813	0.6595	0.1204	0.5803	0.1809	3.1450
3	Tanete	1.3224	0.2813	0.6595	0.1204	0.5803	0.1206	3.0847
4	Balangdatu	1.3224	0.0937	0.4397	0.0803	0.7253	0.2413	2.9029
5	Mattiro Ujung	1.3224	0.1875	0.4397	0.0803	0.5803	0.2413	2.8516
6	Siteba	0.8816	0.2813	0.6595	0.1204	0.7253	0.1809	2.8493
7	Mattiro Baji	1.3224	0.0937	0.4397	0.0803	0.7253	0.1809	2.8425

8	Rewatay a	1.3224	0.0937	0.4397	0.0803	0.7253	0.1809	2.8425
9	Minasa Baji	1.3224	0.0937	0.4397	0.0803	0.7253	0.1809	2.8425
10	Bontoleb ang	1.3224	0.0937	0.4397	0.0803	0.7253	0.1206	2.7822
11	Menara Indah	1.3224	0.0937	0.4397	0.0803	0.7253	0.1206	2.7822
12	Polassi	1.3224	0.0937	0.4397	0.0803	0.5803	0.2413	2.7578
13	Khusus Bahuluan g	1.3224	0.0937	0.4397	0.0803	0.7253	0.0603	2.7219
14	Simbuan g Batutallu	0.8816	0.2813	0.6595	0.1204	0.5803	0.1809	2.7042
15	Tambolo ngan	1.3224	0.0937	0.4397	0.0803	0.5803	0.1809	2.6975
16	Majapahi t	1.3224	0.0937	0.4397	0.0803	0.2901	0.3016	2.5280
17	Karumpa	1.3224	0.0937	0.4397	0.0803	0.2901	0.3016	2.5280
18	Lambego	1.3224	0.0937	0.4397	0.0803	0.4352	0.1206	2.4921
19	Komba Komba	1.3224	0.0937	0.4397	0.0803	0.4352	0.1206	2.4921
20	Bonerate	1.3224	0.0937	0.4397	0.0803	0.2901	0.2413	2.4676
21	Lamantu	1.3224	0.0937	0.4397	0.0803	0.2901	0.2413	2.4676
22	Lewandi	0.8816	0.2813	0.4397	0.1204	0.5803	0.1206	2.4240
23	Batu Bingkun g	1.3224	0.0937	0.4397	0.0803	0.2901	0.1809	2.4073
24	Bonea	1.3224	0.0937	0.4397	0.0803	0.2901	0.1809	2.4073
25	Sambali	1.3224	0.0937	0.4397	0.0803	0.2901	0.1809	2.4073
26	Marasen de	1.3224	0.0937	0.4397	0.0803	0.2901	0.1809	2.4073
27	Sapuka	1.3224	0.0937	0.4397	0.0803	0.1450	0.3016	2.3829
28	Garaupa	1.3224	0.0937	0.4397	0.0803	0.2901	0.1206	2.3470
29	Doang Doangan Lompo	1.3224	0.0937	0.4397	0.0803	0.2901	0.1206	2.3470
30	Pulo Madu	1.3224	0.0937	0.4397	0.0803	0.1450	0.2413	2.3226

31	Kalaotoa	1.3224	0.0937	0.4397	0.08032	0.1450	0.1809	2.2622
32	Lembang Matene	1.3224	0.0937	0.4397	0.08032	0.1450	0.1809	2.2622
33	Garaupa Raya	1.3224	0.0937	0.4397	0.08032	0.1450	0.1206	2.2019
34	Poleonro	1.3224	0.0937	0.4397	0.08032	0.1450	0.1206	2.2019
35	Kayuadi	0.4408	0.1875	0.4397	0.08032	0.5803	0.3016	2.0303
36	Batang	0.4408	0.1875	0.4397	0.08032	0.5803	0.3016	2.0303
37	Rajuni	0.4408	0.1875	0.4397	0.08032	0.5803	0.3016	2.0303
38	Nyiur Indah	0.4408	0.1875	0.4397	0.08032	0.5803	0.2413	1.9700
39	Padang Balua	0.4408	0.2813	0.4397	0.08032	0.4352	0.2413	1.9186
40	Embonatana	0.4408	0.2813	0.4397	0.08032	0.4352	0.2413	1.9186
41	Jinato	0.4408	0.1875	0.4397	0.0803	0.5803	0.1809	1.9096
42	Tarupa	0.4408	0.1875	0.4397	0.0803	0.5803	0.1809	1.9096
43	Latondu	0.4408	0.1875	0.4397	0.0803	0.5803	0.1206	1.8493
44	Padang Raya	0.4408	0.2813	0.4397	0.0803	0.4352	0.1206	1.7980
45	Tambuna	0.4408	0.1875	0.4397	0.0803	0.4352	0.1809	1.7646
46	Onondowa	0.4408	0.2813	0.2198	0.0803	0.5803	0.1206	1.7232
47	Sulaku	0.4408	0.2813	0.2198	0.0803	0.5803	0.1206	1.7232
48	Khusus Pasitallu	0.4408	0.1875	0.4397	0.0803	0.4352	0.1206	1.7042
49	Tanamakaleang	0.4408	0.2813	0.2198	0.0803	0.4352	0.2413	1.6988
50	Leboni	0.4408	0.2813	0.2198	0.0803	0.5803	0.0603	1.6629
51	Dodolo	0.4408	0.2813	0.2198	0.0803	0.5803	0.0603	1.6629
52	Tirobali	0.4408	0.2813	0.2198	0.0803	0.4352	0.1809	1.6385
53	Malimongan	0.4408	0.2813	0.2198	0.0803	0.4352	0.1809	1.6385
54	Lodang	0.4408	0.2813	0.2198	0.0803	0.4352	0.1809	1.6385
55	Taloto	0.4408	0.2813	0.2198	0.0803	0.4352	0.1809	1.6385

56	Marante	0.4408	0.2813	0.2198	0.0803	0.4352	0.1809	1.6385
57	Hono	0.4408	0.2813	0.2198	0.0803	0.4352	0.1206	1.5781
58	Beroppa	0.4408	0.2813	0.2198	0.0803	0.4352	0.1206	1.5781
59	Hoyane	0.4408	0.2813	0.2198	0.0803	0.4352	0.1206	1.5781
60	Tedeboe	0.4408	0.2813	0.2198	0.0803	0.4352	0.1206	1.5781
61	Rampi	0.4408	0.2813	0.2198	0.0803	0.4352	0.0603	1.5178

Source : Author elaboration, 2025

5 Discussion

The findings demonstrate that forest area, operationalised through forest classification and the extent of protected land, is the most influential criterion for prioritising rural electrification in South Sulawesi. This prominence is consistent with the rural electrification planning literature where environmental and land use constraints are frequently treated as binding feasibility conditions rather than secondary considerations. GIS supported multi criteria analyses repeatedly show that protected areas, forests and other restricted land uses substantially delimit viable corridors for grid extension and, in many contexts, determine whether decentralised alternatives are preferable [8, 9, 10]. From a planning standpoint, electrification projects located within conservation forests, protected forests and national parks typically require additional permitting, stricter environmental safeguards and more complex stakeholder coordination, which collectively increase costs and extend delivery timelines. Accordingly, the high weight assigned to forest area in this study reflects an emphasis on implementation risk and regulatory exposure in addition to purely technical design.

Infrastructure condition and distance from the existing electricity grid emerged as the second and third most influential criteria, reinforcing the centrality of spatial accessibility and network proximity for least cost electrification. Prior studies highlight that distance to the grid, road access, terrain and settlement dispersion are among the most consequential determinants of investment requirements and technology choice, particularly in settings where extending medium voltage lines entails substantial civil works and ongoing maintenance burdens [9, 10, 11]. Evidence from multi criteria and optimisation based approaches likewise indicates that grid connection feasibility is tightly linked to both geographic remoteness and the enabling logistics associated with roads and site accessibility [12]. The present results therefore align with a broader methodological consensus that location and access variables often act as primary drivers of electrification sequencing, because they directly shape capital expenditure, construction practicability and system reliability.

By contrast, electricity supply capacity and population size received comparatively lower weights. This pattern suggests that, within the South Sulawesi context, decision makers are placing greater emphasis on feasibility constraints than on demand side indicators when determining short term priorities. Comparable AHP and fuzzy AHP applications in electrification and energy source selection frequently report that economic and technical criteria dominate the weighting structure, with environmental and social criteria following, while demand proxies such as population size or consumption potential play a supporting role rather than constituting the principal determinant [11, 13, 14]. Importantly, evidence on rural electricity access in the Global South indicates that electrification outcomes are shaped by multidimensional factors, implying that small populations can warrant prioritisation when the barriers to access are structurally severe and the welfare gains from connectivity are high [15]. In this study, the relative de emphasis of population is therefore interpretable as a deliberate prioritisation of villages where geographic isolation, poor infrastructure and land use restrictions intensify delivery complexity and prolong energy poverty.

The resulting composite ranking identifies villages such as Lamasi Hulu, Dewata and Tanete as immediate priorities for electricity infrastructure development due to their high aggregated scores. These outcomes are consistent with the logic of multi criteria decision analysis in which priority is assigned not only on the basis of expected demand, but also on the basis of deliverability, cost drivers and constraints that can impede project execution [11, 12]. Conversely, the low score associated with villages such as Rampi indicates that conventional grid extension may be comparatively inefficient or delayed under existing conditions. In similar contexts, MCDA studies emphasise that settlements facing pronounced spatial and environmental constraints may be better served through alternative electrification strategies, including off grid and microgrid configurations, where siting restrictions and high network extension costs can be mitigated through decentralised solutions [9, 16].

The low Consistency Ratio confirms that the pairwise judgments underlying the AHP weights are internally coherent, supporting the stability of the derived ranking. Consistency diagnostics are widely treated as a core validity check in AHP and fuzzy AHP based electrification planning, providing assurance that the prioritisation is not an artefact of contradictory judgments [11, 13, 14]. Moreover, the integration of expert judgement through a structured focus group discussion strengthens the procedural legitimacy of the weighting process. Stakeholder elicitation, whether conducted through workshops, surveys or facilitated group deliberation, is repeatedly highlighted as essential for ensuring that criteria weights reflect policy realities and implementation constraints, thereby improving the policy relevance of MCDA outputs [13, 16, 17]. Collectively, these features support the use of AHP as a practical decision support tool for provincial electrification planning, particularly where planners must balance environmental compliance, accessibility constraints and investment efficiency.

6 Conclusion

Based on an analysis using the Analytical Hierarchy Process (AHP) method with six main criteria, namely forest area indication, electrification method, infrastructure, electricity supply, distance, and population, the priority weight of each criterion was obtained. The results show that forest area indication has the largest weight (44.08%), making it the most dominant factor in determining the priority of villages that must immediately receive electricity network development. The next most in-fluential factors are village infrastructure (21.99%), distance (14.51%), electrifica-tion method (9.38%), population (6.03%), and electricity supply (4.02%). Although these factors play a smaller role, they are still important technical and environmen-tal considerations.

Based on an assessment of 61 villages without electricity by PT. PLN (Persero) in South Sulawesi, the priority ranking for electricity infrastructure development is Lamasi Hulu Village (3.29015) as the top priority, followed by Dewata Village (3.14508), Tanete Village (3.08475), Balangdatu Village (2.90292), Mattiro Ujung Village (2.85161), etc. The village with the lowest priority is Rampi Village (1.51784). The Consistency Ratio (CR) value of 0.0396 (< 0.10) indicates that the assessment is consistent and acceptable.

Thus, the results of this AHP can be used as a basis for more objective decision-making in rural electricity development planning, as it considers various technical, environmental, and supply conditions in a structured manner.

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