

Choice of Alternatives for Completing Work Tip 182 70 kV GI Namlea– Namrole GI Transmission Project Using Analytical Methods Hierarchy Process (AHP)

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ABSTRACT

Objectives: This study aims to identify the criteria that must be considered in selecting alternative solution for the Tower Intersection Point (TIP) 182 issue on Buru Island, Maluku. The problem emerged after a landslide at the foundation of TIP 182 caused the leg C foundation to sink and the surrounding ground to crack. The research seek to analyze the best alternative solution using the Analytical Hierarchy Process (AHP) method and evaluate the sensitivity of the selected criteria to ensure the robustness of the chosen alternative.

Methodology: Data were collected through Focus Group Discussion (FGD) to formulate relevant criteria and alternative solutions, as well as questionnaires to determine the weight of each criterion. The Analytical Hierarchy Process (AHP) was employed to prioritize and rank the alternatives based on the established criteria. Sensitivity analysis was conducted to assess the stability of the selected alternative under change in criteria weighting.

Findings: The FGD identified three alternatives; relocation of the TIP 182, redesign of TIP 183 and cutting slope. Five main criteria were analyzed in depth; technical aspects, resources, cost, duration and risk. The AHP results indicate that the redesign TIP 183 alternatives is the most optimal solution for addressing the problem at TIP 182 on Buru Island. Sensitivity analysis further confirms that variations in the weights of the technical, resources, cost, duration and risk criteria do not significantly alter the ranking position of the redesign TIP 183 alternative as the most superior option.

Conclusion: The study concludes that redesign TIP 183 is the most appropriate and robust alternative solution for resolving the TIP 182 issue. The application of AHP provides a structured and objective decision-making framework that supports effective project completion and practical implementation on the field, while also offering a foundation for future related research.

Keywords: Sensitivity Analysis; Analytical Hierarchy Process (AHP); Electric Power Transmission Construction; PLN; Tower Intersection Point (TIP).

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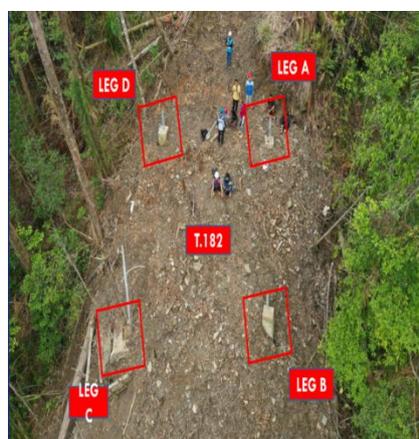
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INTRODUCTION

Data shows that 69.71% of PLN's generation and distribution capacity is concentrated in Java. This indicates an imbalance in electricity infrastructure, posing a challenge for the Indonesian government. To improve the equity of electricity generation and distribution, the government is strengthening the reliability of electricity in the eastern part of Indonesia, one of which is through the 70 kV GI Namlea-GI Namrole transmission project on Buru Island. This project is very important considering the rapid population growth and isolated electricity system that often experiences blackouts, thereby disrupting local economic activities.

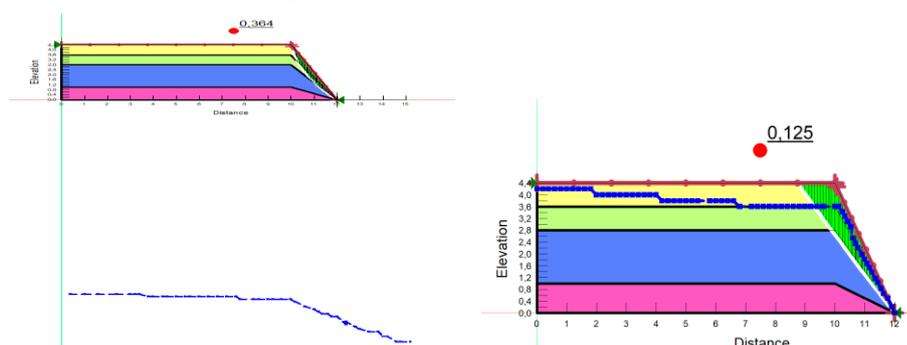
During the process, although the project has reached 83% physical progress, there was an incident where construction at Tower Intersection Point (TIP) 182 encountered a geotechnical problem, which was a landslide at the base of the tower that caused a decline in Leg C and soil cracks. This incident delayed the installation of the tower and threatened the continuity of the project. Subsequently, an investigation of the soil revealed a predominance of clay (59.26% - 90.30% passing the sieve). Meanwhile, limited initial CPT data restricted accurate predictions of soil behavior.

Figure 1. Foundation Landslide TIP 182



Slope stability analysis conducted using GeoStudio shows that the Safety Factor at the TIP 182 construction site is very low (0.364 in dry conditions and 0.125 in saturated conditions), which is well below acceptable standards. These analysis results confirm that TIP 182 has a high risk of failure if construction continues.

Figure 2. FoS Result of Drain and Normal Rain Scheme



To address this issue, four alternatives were proposed: (1) relocating tower 182, (2) eliminating TIP 182 by redesigning TIP 183, (3) stabilizing the slope using slope cutting methods, and (4) constructing a retaining wall at the site of concern. Despite the fact that the technical risks are well understood, an effective solution requires the integrative approach of geotechnical analysis and managerial consideration such as cost, schedule, resources, environmental impact, quality of completion, regulation and stakeholder satisfaction.

This study applies a Multi-Criteria Decision Making (MCDM) approach using the Analytic Hierarchy Process (AHP) to evaluate criteria such as technical aspects, resources, costs, duration, and risks. Although AHP has been widely used in the field of construction, its application in solving problems related to electrical tower construction that considers technical criteria, resources, costs, duration, and risks is still limited. Therefore, this study develops a solution to construction problems through an integrated hierarchical decision structure to expand the application of AHP in transmission project problem solving. The results of this study aim to support rational decision making in solving TIP 182 problems and provide a reference for risk management in similar transmission projects.

Therefore, this study was conducted to answer the questions of what criteria need to be considered in selecting alternative solutions to overcome landslides on TIP 182 in the 70 kV GI Namlea-GI Namrole transmission project, which alternative was chosen for the TIP 182 solution using the AHP method, how sensitive the criteria considered were to the alternative chosen in the TIP 182 solution, and whether the decisions made by the project implementers in the field were consistent or different from the research findings.

LITERATURE REVIEW

Previous research has demonstrated the effectiveness of the Analytical Hierarchy Process (AHP) method in various technical decision-making contexts including project risk management. A study by Aladayleh & Aladaileh (2024) found that the AHP method helps managers establish risk priorities and aids decision-making. A further study by Richard Renaldy et al. (2025) used AHP has been applied to rank priority order of risks for a renovation project. Furthermore, another study by Muhammad Danu et al. (2025) discusses the use of AHP to identify risks for projects. AHP has been widely applied in various projects, however, its application in alternative decision-making for transmission projects, particularly the 70 kV GI Namlea – GI Namrole Transmission Project, is still limited.

2.1 Project Management and Electrical Infrastructure

Project management in electricity infrastructure development involves the management of resources and strict project constraints to achieve the objectives of system functionality and reliability (Widi Hartono et al., 2016). Government-funded infrastructure development projects, including the electricity transmission network by PT PLN (Persero), are often characterized by substantial investment, long construction periods, and relatively high investment risk (Zhao dkk., 2025). The success of transmission projects is greatly influenced by the balance between cost, time, and quality, known as the triple constraint concept. The electrical problems in Eastern Indonesia are logistical and geographical challenges, which are often the main causes of uncertainty that can hinder project completion schedules (Wantouw & Mandagi, 2014). In addition to risk mitigation in energy infrastructure projects, one example is wind power plants. In a study by Yousefi et al. (2024), the AHP analysis hierarchy process was used to assess the

weight of electrical, environmental, technological-economic, and geotechnical infrastructure aspects to support the selection of wind farm sites.

2.2 Soil Stability and Slope Mechanics

The stability of a slope is determined by the balance between the retaining force (soil shear strength) and the driving force (structural load and the weight of the soil itself). Various factors contribute to slope stability, including geological conditions, soil mechanical properties, external forces, and hydrological impacts (Bozdemir, 2025). The Safety Factor (SF) is the main indicator for assessing the safety of a slope. The higher the SF value, the better. For structures such as transmission towers, the minimum required FOS value is 1.5. Clay soils with a high percentage of particles passing through a sieve, such as those found at the TIP 182 site, have a high risk of subsidence and collapse when there are significant changes in water content. Therefore, to reduce foundation failure, analysis is performed using software such as Geostudio.

2.3 Transmission Tower and Foundation System

Transmission tower construction is designed to endure extreme mechanical loads, including vertical loads due to the weight of the structure itself and horizontal loads due to cable tension and wind pressure. The selection of AA+9 tower types in areas with large elevation differences increases the complexity of load distribution on the tower legs. Technical factors in route selection are based on an evaluation of transmission line design parameters, which are influenced by geographical conditions (Alfita dkk., 2025). Instability at one of the foundation points due to clay movement can cause structural deformation that can threaten the entire 70 kV transmission line.

2.4 Analytical Hierarchy Process (AHP)

Among the various methods used to assist managers in decision-making, a method that is often used due to its simpler data processing, transparent decision-making structure, and reliable results is the AHP method (Tomczewski dkk., 2024). The Analytic Hierarchy Process (AHP) is a decision-making method that works by breaking down complex problems into simplified structured hierarchies. The main principles of AHP include hierarchy formation, pairwise comparison assessment, and consistency checking. This method can prevent uncertainty or inconsistency in the assessments made by decision makers (Menon & Ravi, 2022). In this study, the AHP method was used to integrate technical variables to produce a ranking of alternative solutions (Wulandari, 2019).

In high-risk projects such as the 70 kV GI Namlea - GI Namrole transmission project in Buru Island, the decision-making process for alternative solutions needs to consider various factors such as technical, cost, resource, duration, and risk factors. Due to the complexity and the number of factors that need to be considered, a multi-criteria framework such as the Analytical Hierarchy Process (AHP) is used.

METHOD

The research methodology was developed to determine alternative solutions for TIP 182. The research steps began with the collection of secondary data from technical project reports, data from the expert assessment of criteria and alternatives, followed by the development of criteria for each alternative solution. The analysis process was conducted using the Analytical Hierarchy Process (AHP) method to produce recommendations for alternative solutions within the research scope.

3.1 Research Design and Location

This study uses a quantitative approach with the Analytical Hierarchy Process (AHP) method to support the decision-making process. The research location focuses on Tower Intersection Point (TIP) 182 in the 70 kV GI Namlea – GI Namrole project in Buru Island, Maluku. This location was chosen based on the urgency of structural failure due to geotechnical conditions (landslides) that prevented the completion of the overall project.

3.2. Data Collection Methods

The data used in this study is primary data and secondary data. The purpose of this study is to arrive at a solution for TIP 182, with the subjects of this study being project stakeholders. Secondary data was obtained from internal project reports, including engineering data, project reports, risk analysis data, land payment documents, and contract documents. Meanwhile, primary data was obtained through Focus Group Discussion (FGD) techniques with experienced experts and project stakeholders to formulate criteria and completion alternatives. The experts selected for this study were people who were considered competent with a minimum of 9 years of experience (in accordance with the general prerequisites in several internal company work frameworks), including management and specialists. The FGD as the basis for assessing alternatives included several criteria, namely technical, resources, costs, duration, stakeholder satisfaction, regulations, risks, and quality. Meanwhile, the alternatives proposed included a Retaining Wall of TIP 182, Relocation of the TIP 182 tower site to other location, Redesign of tower 183, and Cutting Slope on TIP line 181-183 which doesn't meet right of way (RoW) requirements with removing TIP 182 first.

3.3. Decision Hierarchy Structure

Based on the results of problem identification and expert discussions, a decision hierarchy structure reduced to three levels. The first level is the main objective, which is to select the best alternative solution for TIP 182. The second level consists of five main criteria: Soil Stability (Technical), Implementation Cost (Economic), Implementation Time (Duration), Man power or machines (Resources) and Environmental Risk. The third level includes three alternative solutions: (1) Relocation of the tower site with a change in tower type (AA+3 to BB+3), (2) Redesign of tower 183, and (3) Application of the cutting slope method.

3.4. Data Analysis with the Analytical Hierarchy Process (AHP)

Problem simplification and decision making in this study were conducted using the Analytical Hierarchy Process (AHP) method by converting qualitative assessments into quantitative ones. The data analysis process is as follows:

1. Hierarchy Matrix Compilation and Comparison Matrix Assessment

Ten experts assessed the criteria and alternatives using a numerical scale of 1, 3, 5, 7, and 9, as recommended by Saaty (1980). This scale describes the relative importance between two elements. A value of 1 indicates that both elements are equally important, while a value of 9 indicates that one element is much more important than the other. The assessment results from all respondents were used to calculate the geometric mean and rank the alternative solutions.

2. Weight Calculation and Normalization

Weighting for each criterion was done manually by compiling tables. The AHP weighting results were then analyzed using Super Decision V3.2 normalization to ensure the

elimination of redundancy, data integrity, and an efficient data structure for paired comparison assessments.

3. Logical Consistency Testing (Consistency Analysis)

To ensure that expert assessments are logical and consistent and to ensure that the data collected is free from inconsistencies, a Consistency Ratio (CR) calculation was performed using the Super Decision V3.2 application. According to Saaty's theory, assessment results are considered valid and acceptable if the CR value is less than 0.10 ($CR < 0.1$). If this value is not met then the questionnaire assessment needs to be reviewed.

4. Sensitivity Analysis (Sensitivity Analysis)

The final stage is sensitivity analysis on the weights of decision criteria to test the robustness and stability of decision results. This is done by observing how changes in criterion weights or alternative assessments affect the final ranking. The aim is to enable decision makers to identify which variables are most critical (sensitive) and how much change is needed to alter the order of priority. This step is very important to ensure that the solution recommended by the AHP analysis remains robust against changes in management priorities and geotechnical conditions in the field.

RESULTS AND DISCUSSION

4.1. Results of Focus Group Discussion (FGD) and Preliminary Survey

The initial stages of data analysis were conducted through Focus Group Discussion (FGD) and preliminary surveys with project stakeholders and experienced experts. The main objective of this process was to validate and filter the research variables identified in the literature study. Based on the consensus reached in result the FGD and initial surveys, it was agreed that the technical problems in TIP 182 could not be separated from managerial constraints. Therefore, the research criteria were narrowed down to five main points: Soil Stability, Cost, Time, Resources and Risk. Other criteria such as Quality, Regulations and Stakeholder Satisfaction were eliminated. In addition, the FGD and initial surveys successfully formulated three technically feasible alternatives for further study, namely Tower Site Relocation, TIP 183 Redesign, the Cutting Slope and eliminating the Retaining Wall alternative.

Table 1. Ranking of FGD and Preliminary Survey Result

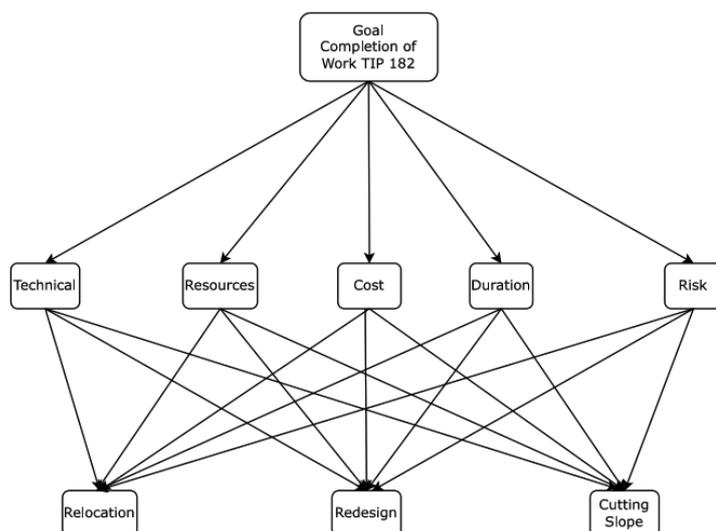
Alternatives	Average	Ranking
Redesign	4,2	1
Relocation	4,1	2
Cutting Slope	3,2	3
Retaining Wall	1,9	4

Criteria	Average	Ranking
Cost	4,4	1
Duration	4,4	2
Technical	4,3	3
Resources	3,4	4
Risk	3,3	5
Quality	2,1	6
Regulation	2	7
Stakeholder Satisfaction	1,7	8

4.2. AHP Hierarchy Design after FGD and Preliminary Survey

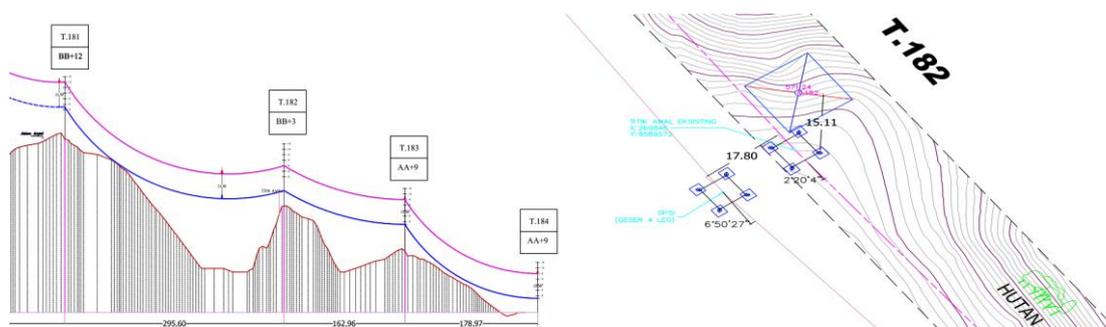
A validated decision hierarchy structure was then developed to provide a visual representation of the relationship between the main objectives, criteria, and alternatives. Level 1 sets the objective of selecting the best solution alternative, Level 2 maps the criteria from the FGD results, and Level 3 contains the solution alternatives. This hierarchical design became the foundation for the development of a paired comparison questionnaire instrument used to extract expert preferences in a structured manner. Based on the decision hierarchy for the TIP 182 project, three alternatives were produced, namely:

Figure 3. Research Design Hierarchy



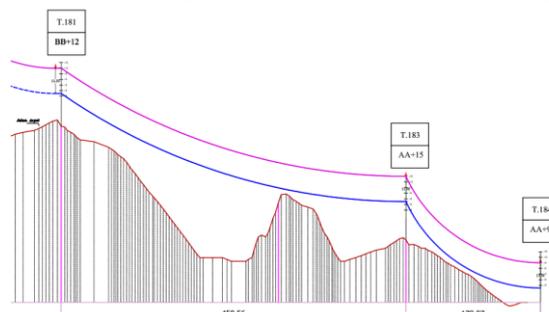
1. The first alternative, relocation of TIP 182, offers the opportunity to move the tower to a more stable location, thereby reducing the level of risk. New location is not far from the original location and doesn't require new land acquisition.

Figure 4. Long Profile Alternative Relocation



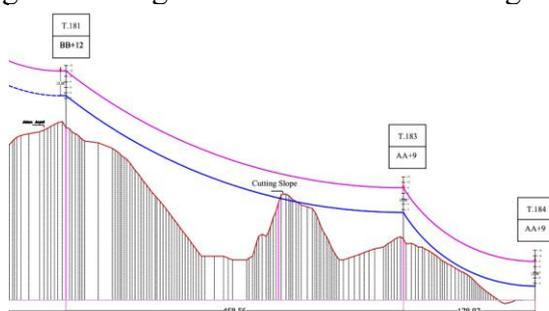
2. The second alternative, special tower redesign on TIP 183, allows the use of structures with special capacities and configurations to accommodate difficult geometries without having to relocate. Tower 183 is taller than previous design to accommodate the right of way (ROW) transmission line

Figure 5. Long Profile Alternative Redesign



- The third alternative namely cutting the slope, focuses on direct improvements to the ground contour by cutting and stabilizing the slope on the right of way (RoW) line at TIP 181-183 by removing TIP 182 first. The transmission line becomes direct from TIP 181 to 183.

Figure 6. Long Profile Alternative Cutting Slope



4.3. Results of Pairwise Comparison Matrix Analysis

After the questionnaire data was collected, a pairwise comparison matrix was compiled to determine the relative importance of each element. The pairwise comparison analysis process was carried out using the Analytical Hierarchy Process (AHP) method. The assessment was carried out using a numerical scale of 1, 3, 5, 7, and 9 as recommended by Saaty (1980) through the distribution of questionnaires to 10 experts. This scale represents the intensity of relative importance between the two elements being compared. A value of 1 indicates that both elements are considered equally important, a value of 3 indicates that one element is slightly more important, a value of 5 indicates that one element is more important, a value of 7 indicates that one element is much more important, while a value of 9 indicates that one element is significantly more important.

1. Weighted Research Criteria Results

Table 2. Criteria Weighting Result

	CRITERIA						
	Technical	Resource	Cost	Duration	Risk	Average	Ranking
Technical	1,00	1,59	0,94	0,85	0,90	1,057	3
Resource	0,63	1,00	1,00	0,61	0,42	0,732	5
Cost	1,06	1,00	1,00	0,90	0,82	0,956	4
Duration	1,17	1,63	1,12	1,00	0,38	1,060	2
Risk	1,12	2,37	1,21	2,65	1,00	1,670	1

Weighting results show that risk criteria have the highest weight, followed by duration, technical aspects, costs, and resources. In general, the results show that risk and duration tend to be given higher priority than other criteria. This indicates that in selecting alternative solutions for TIP 182 on Buru Island, project risk and duration criteria are the main considerations, while other criteria are given lower priority.

2. Alternative Research Weighting Results

Table 3. Alternative Weighting Result

ALTERNATIVES TO TECHNICAL CRITERIA					
	Relocation	Redesign	Cutting Slope	Average	Ranking
Relocation	1,00	0,72	1,39	1,04	2
Redesign	1,39	1,00	2,03	1,47	1
Cutting Slope	0,72	0,49	1,00	0,74	3

ALTERNATIVES TO RESOURCE CRITERIA					
	Relocation	Redesign	Cutting Slope	Average	Ranking
Relocation	1,00	0,45	0,80	0,75	3
Redesign	2,24	1,00	1,46	1,57	1
Cutting Slope	1,25	0,68	1,00	0,98	2

ALTERNATIVES TO COST CRITERIA					
	Relocation	Redesign	Cutting Slope	Average	Ranking
Relocation	1,00	0,39	1,38	0,92	2
Redesign	2,58	1,00	1,87	1,82	1
Cutting Slope	0,72	0,53	1,00	0,75	3

ALTERNATIVES TO DURATION CRITERIA					
	Relocation	Redesign	Cutting Slope	Average	Ranking
Relocation	1,00	0,50	0,85	0,79	3
Redesign	1,98	1,00	1,78	1,59	1
Cutting Slope	1,17	0,56	1,00	0,91	2

ALTERNATIVES TO RISK CRITERIA					
	Relocation	Redesign	Cutting Slope	Average	Ranking
Relocation	1,00	1,06	1,45	1,17	3
Redesign	0,94	1,00	1,12	1,02	2
Cutting Slope	0,69	0,90	1,00	0,86	1

The weighted results show that the redesign alternative has the highest weight. The alternative with the highest weight will be identified as the most optimal solution to address the problems encountered at the TIP 182 location. Based on Figure 6, the TIP 183 redesign alternative has a relatively higher weight than the other two alternatives. Based on technical criteria, resources, costs, and duration, the TIP 183 Redesign alternative has the highest average weighting of 1.47, 1.57, 1.82, and 1.59. Meanwhile, in terms of risk, the TIP 183 Redesign alternative ranks second as an alternative with moderate risk potential with a value of 1.02. The results of the analysis of alternative solutions using the Analytical Hierarchy Process (AHP) method show that the TIP 183 redesign alternative is the best alternative for the TIP 182 project solution. Meanwhile, the TIP 182 relocation and cutting slope alternatives are only superior under certain conditions but are not consistent across all criteria. This indicates that the redesign

approach provides the best balance between risk control, time efficiency, technical feasibility, cost affordability, and resources.

4.4. Results of Normalization and Consistency Analysis using Super Decision V3.2

The normalization and synthesis processes were carried out using Super Decision V3.2 software to obtain accurate global weights. Based on the calculation results of all assessments at the criteria and alternative levels, the CR value was below 0.1. Thus, the paired comparison process was declared consistent, and the priority weights obtained were considered valid, reliable, and suitable for use as a basis for decision making. In accordance with Saaty's axiom, a Consistency Ratio (CR) value < 0.1 indicates that the experts' assessments have excellent logical consistency and the calculation results are accountable.

Figure 7. Pairwise Comparison Matrix

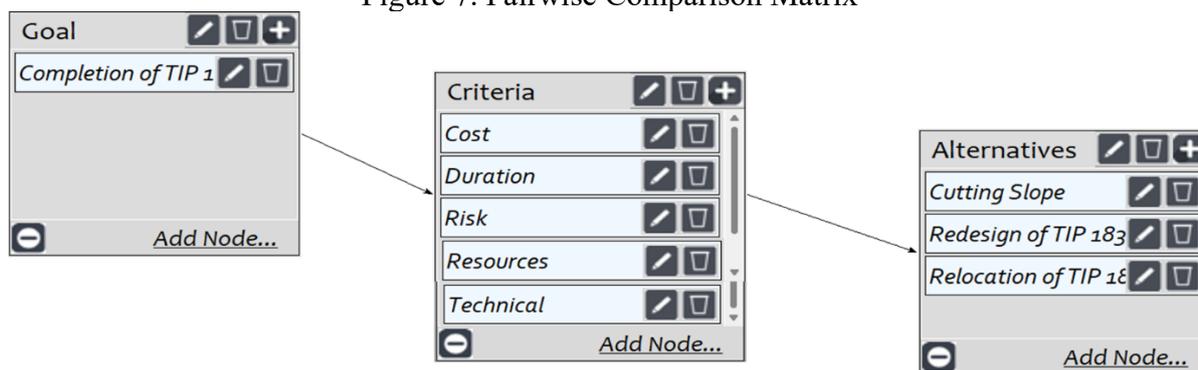


Table 4. Results of Normalization Analysis on Alternatives

Name	Raw	Normals	Ideals
Cutting Slope on ROW Line 181-183	0.144651	0.289302	0.659713
Redesign of TIP 183	0.219263	0.438526	1.000000
Relocation of TIP 182	0.136086	0.272172	0.620653

The normalization results show that based on all criteria considered, the “Redesign TIP 183” alternative is the most ideal option to implement. Ideal values are used to show the ratio of comparison to the best alternative (the highest value is given 1.000), so that the redesign of TIP 183 becomes the benchmark, while other alternatives have values below it in proportion to their distance from the best alternative. In these results, the TIP 183 redesign alternative has the highest Normals value of 0.4385, indicating that this alternative is the highest priority option compared to the other two alternatives. Meanwhile, the cutting slope and TIP 182 relocation alternatives have normals weights of 0.2893 and 0.2722, respectively, which means that both have a relatively lower priority level.

A consistency analysis is then performed to ensure that the collected data is free from inconsistencies. In the Analytic Hierarchy Process (AHP) method, the Consistency Ratio (CR) value serves as the main parameter for validating the quality and reliability of assessments in the paired comparison matrix. CR measures the extent to which the assessments of respondents or decision makers are logical and do not contradict each other. The inconsistency value must be below the tolerance limit recommended by the AHP method, which is < 0.1 . However, if at

any stage CR value $> 0,1$ was found, the assessment was considered inconsistent and needed to be reviewed.

Table 5. Results of Consistency Analysis on Alternatives

Inconsistency: 0.02891	
Cost	0.18316
Duration	0.18538
Risk	0.30212
Resources	0.132271
Technical	0.19663

In these results, risk criteria have the highest weighting, indicating that risk factors are the main consideration or, in other words, the criteria with the greatest influence in determining the best alternative, while resources are the factor with the lowest relative influence. The inconsistency value is below 0,1, so it can be concluded that the assessment given is consistent and logically acceptable.

Table 6. Results of Alternative Consistency Analysis Against Criteria

Inconsistency : 0.05381		Inconsistency : 0.00027	
Cutting Slope	0.28456	Cutting Slope	0.27628
Redesign	0.45622	Redesign	0.48357
Relocation	0.25922	Relocation	0.24015
Inconsistency : 0.00449		Inconsistency : 0.00444	
Cutting Slope	0.22568	Cutting Slope	0.28222
Redesign	0.52305	Redesign	0.33563
Relocation	0.25127	Relocation	0.38215
Inconsistency : 0.04447			
Cutting Slope	0.22568		
Redesign	0.52305		
Relocation	0.25127		

All assessment at the criteria and alternative levels produced CR value below 0,1. Thus the paired comparison process was declared consistent and the priority weights obtained were considered valid, reliable and suitable for use as a basis for decision making. The output from this stage confirms that the TIP 183 Redesign Alternative significantly ranks highest.

4.5. Results of AHP Sensitivity Analysis on Decision Criteria Priority Weights

To test the robustness of the decision, a sensitivity analysis was conducted by simulating changes in criterion weights. The application of sensitivity analysis in the MCDM process is very important to ensure the robustness of the final decision (Sihotang, 2023). Sensitivity analysis on decision criteria can occur due to additional information that causes decision makers to change their assessment. This change in assessment causes a change in the order of priority of alternatives (Widaningsih, 2017).

The results show that changes in criterion weights are sensitive to changes in the ranking of some alternatives, while other alternatives are stable or robust. The overall results show that the TIP 183 redesign alternative has a stable ranking in almost all simulations of criterion weight changes. This stability shows that the decision to choose the TIP 183 redesign is robust,

i.e., it does not change easily even if the criterion weights are modified, is not sensitive to changes in criterion priorities, and remains superior under various conditions and planning assumptions.

The sensitivity analysis in this study has very important implications for the transmission project implementation strategy. The results show that the TIP 183 redesign alternative is relatively stable in first place. This indicates that the results of the 183 redesign alternative decision are stable (robust) and consistent as an alternative solution to TIP 182.

Figure 8. Results of Sensitivity Analysis of Changes in Technical Criteria Weighting on the Ranking of Relocation, Redesign and Cutting Slope Alternatives

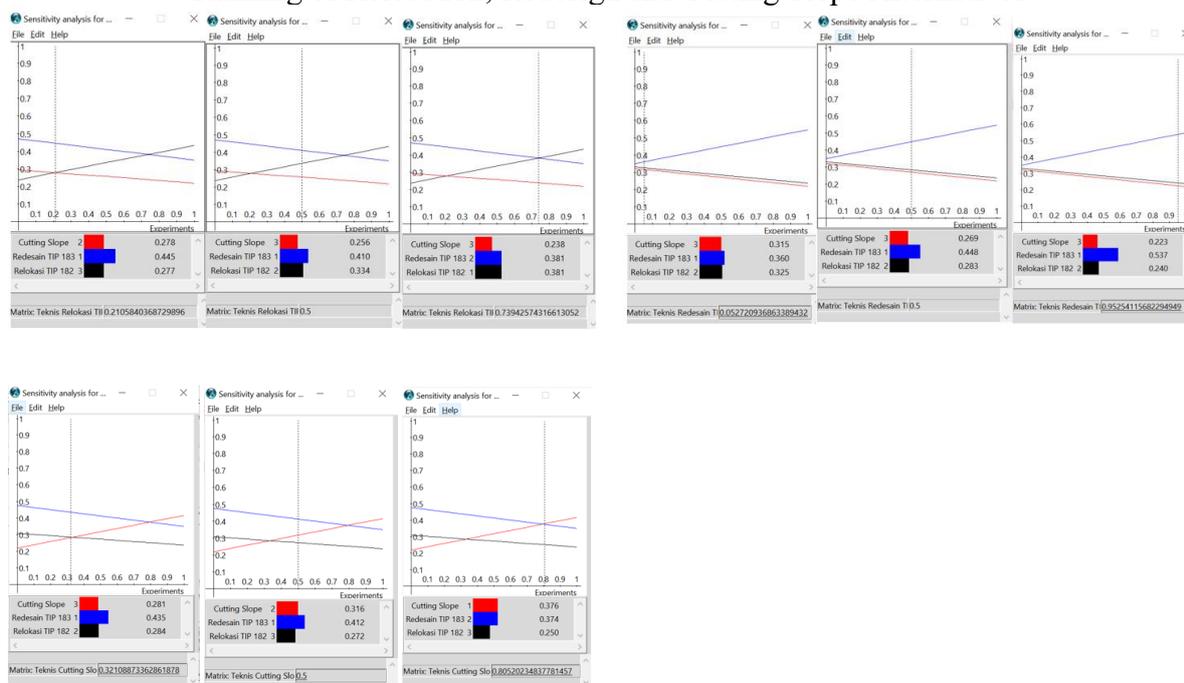
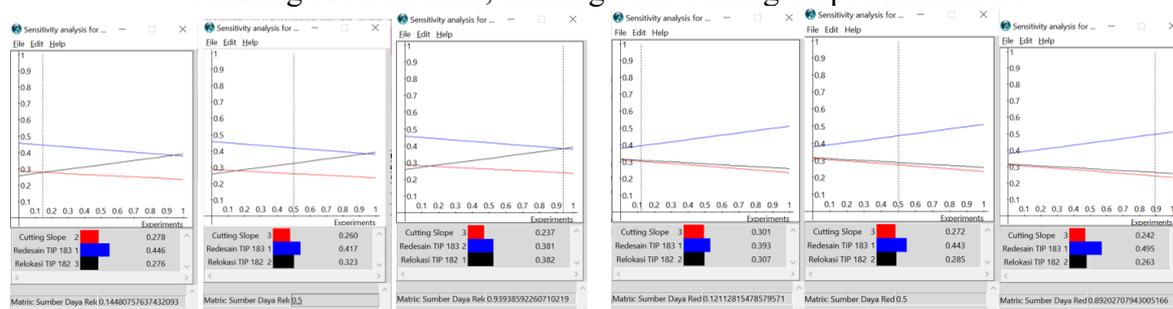


Figure 9. Results of Sensitivity Analysis of Changes in Resources Criteria Weighting on the Ranking of Relocation, Redesign and Cutting Slope Alternatives



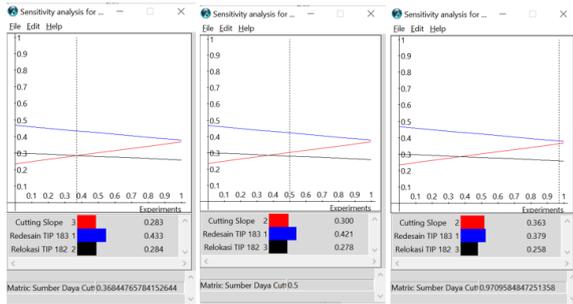


Figure 10. Results of Sensitivity Analysis of Changes in Cost Criteria Weighting on the Ranking of Relocation, Redesign and Cutting Slope Alternatives

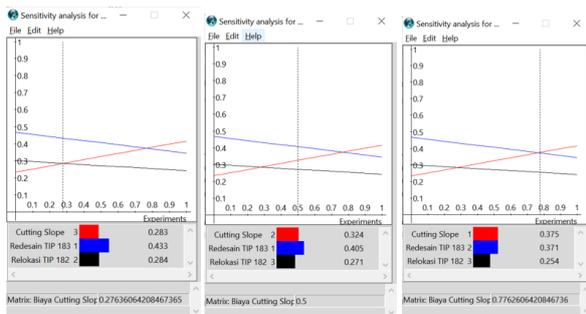
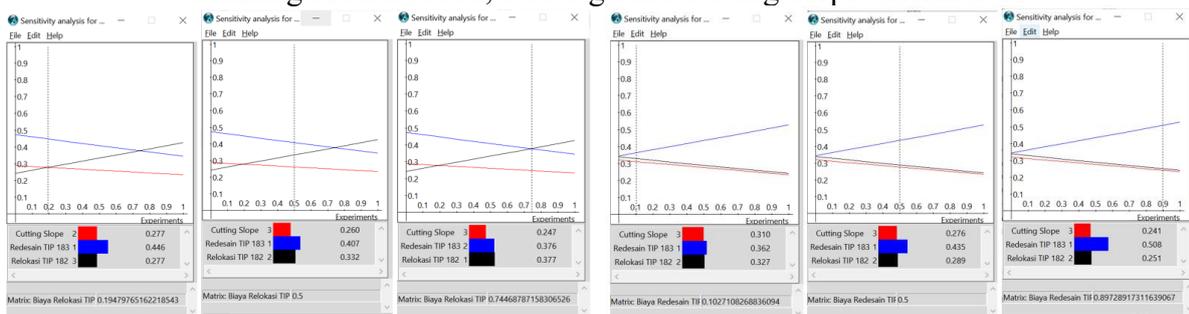
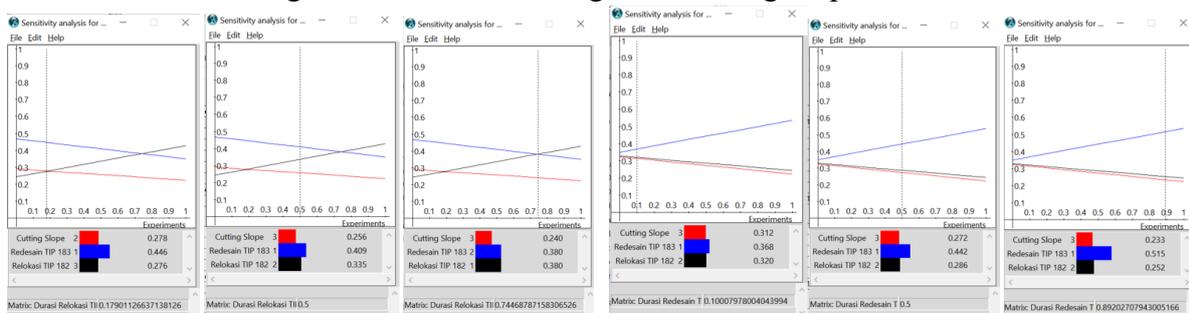


Figure 11. Results of Sensitivity Analysis of Changes in Duration Criteria Weighting on the Ranking of Relocation, Redesign and Cutting Slope Alternatives



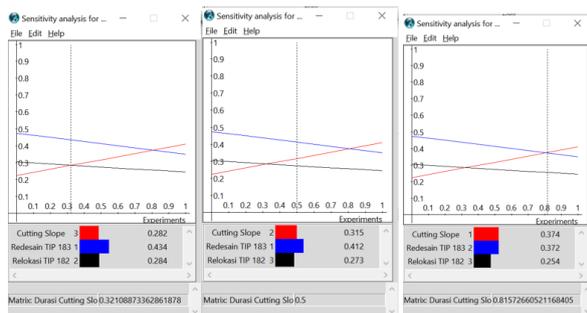
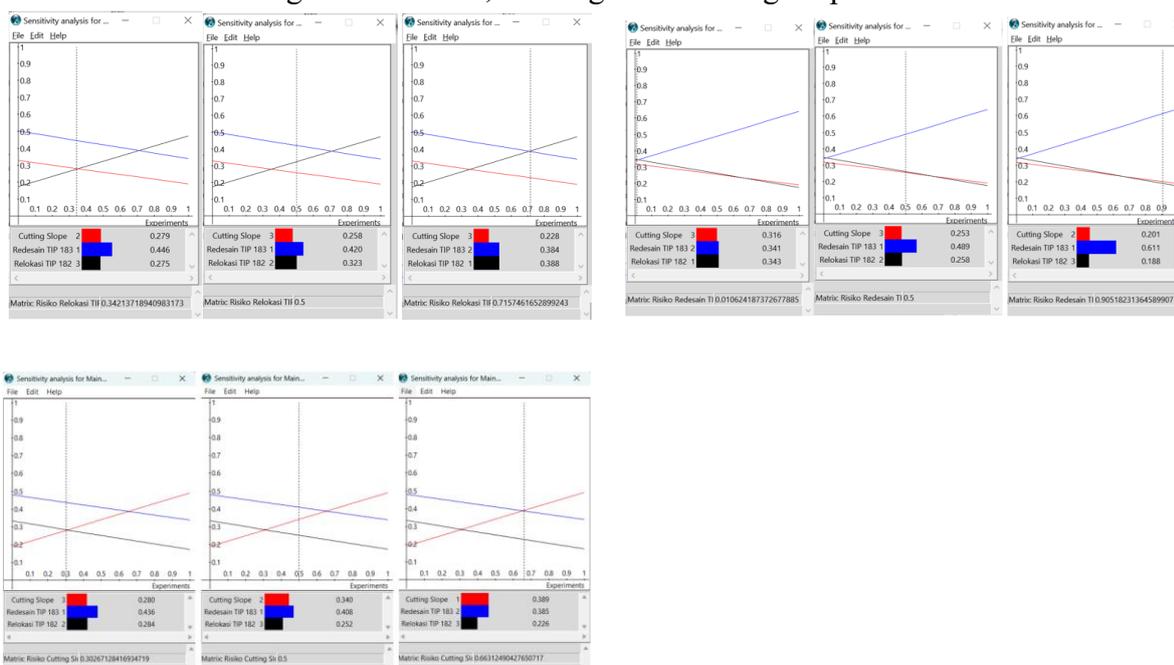


Figure 12. Results of Sensitivity Analysis of Changes in Risk Criteria Weighting on the Ranking of Relocation, Redesign and Cutting Slope Alternatives



The sensitivity analysis results show that the TIP 183 redesign alternative consistently ranks higher than other alternatives in terms of technical criteria, resources, costs, duration, and risks. In practice, the project team has chosen to relocate the tower in order to meet the deadline, therefore this study provides a significant contribution as an evaluation tool. This study emphasizes the importance of a systematic multi-criteria decision-making approach to ensure the selection of technical solutions in future projects.

4.6. Holistic Discussion of Analysis Results

This holistic discussion is based on the integration of findings in this study.

The first step is to filter the criteria through a Focus Group Discussion (FGD) and a Likert scale survey involving 10 experts. This first step resulted in 5 main criteria, namely technical, resources, cost, duration, and risk, with an average score of >3.00, which are considered feasible and used as criteria for further analysis using the AHP method.

Alternative weighting in the AHP method is performed using a 1-9 rating scale (Saaty, 1980). In this study, the use of the AHP method reflects an approach in decision-making theory

whereby the process of selecting alternatives is carried out rationally. The results of the study show that the TIP 183 redesign alternative is the best alternative to TIP 182. Furthermore, a sensitivity analysis was conducted, which proved that the TIP 183 Redesign is a robust alternative, where its ranking remains stable even when there are fluctuations in the weights of other criteria.

Related to project risk management, the application of AHP in this study helped select the alternative solutions with low project risk. The TIP 183 redesign alternative was assessed to have moderate risk potential that could still be controlled through structural design adjustments. The TIP 183 redesign alternative is able to reduce the risk of design changes in the middle of the work while supporting overall cost and time efficiency.

The alternative resilience of the TIP 183 redesign has significant managerial implications for project planning efficiency and flexibility. The implementation of the TIP 183 redesign will help provide certainty for management in drawing up work schedules, as delays are necessary due to design revisions. Strategically, the TIP 183 Redesign alternative provides a technical solution to the TIP 183 problem and contributes to long-term efficiency improvements. The TIP 183 Redesign alternative will incur additional costs during the initial stages of the project, but it will result in cost reductions over the project cycle. This will improve the reliability of the TIP 183 transmission infrastructure on an ongoing basis.

Although in practice, field implementers relocated the tower site due to time constraints, the results of this study provide an important contribution as an evaluative reference (Widi Hartono et al., 2016). The integration between geotechnical technical parameters and AHP-based decision management proves that an interdisciplinary approach can produce objective, systematic recommendations that are ready to face extreme scenarios in future electrical infrastructure projects.

4.7. Managerial Implications of Projects

The selection of alternative design recommendations for TIP 183 has significant implications for the technical aspects of the project, namely providing flexibility in project planning, minimizing risk, improving efficiency in inter-agency coordination, increasing preparedness for extreme scenarios, and providing options for long-term risk mitigation. This study found that the AHP method can be used by managers in decision-making. For managers, the resilience of this study's results, namely the TIP 182 Redesign alternative, provides certainty for project management in preparing work schedules, procuring materials, and coordinating between functions. The results of the analysis in this study can optimize efficiency and support long-term risk mitigation because the TIP 183 Redesign can reduce dependence on unstable field conditions.

CONCLUSION

Based on the results of research on the selection of alternative solutions for landslides on TIP 182 using the AHP method, the following conclusions can be drawn.

Conclusion:

1. Technical criteria, resources, costs, duration, and risks are considered feasible for use in selecting alternative solutions to the TIP 182 problem, while quality criteria, regulations, and stakeholder satisfaction are eliminated and not considered in selecting alternative solutions to overcome landslides at Tower Intersection Point (TIP) 182 in the 70 kV GI Namlea transmission project. - GI Namrole project.

2. The results of the analysis of alternative solutions using the AHP method indicate that the TIP 183 Redesign alternative is the best alternative for TIP 182.
3. The decision result for the Redesign 183 alternative is stable (robust) and consistent as a solution alternative for completion of work TIP 182, indicating that the AHP model used has good reliability in supporting decision-making related to the handling of the TIP 182 landslide.

Recommendations:

1. Future similar studies are advised to explore the sub criteria of each main criterion in order to produce a more specific and detailed analysis of technical and environmental conditions.
2. In future similar projects, field verification of the Analytical Hierarchy Process (AHP) analysis results should be conducted to compare theoretical calculations with actual post-implementation performance of the selected solution.
3. The results of this study can serve as a useful evaluative reference for project implementers in planning similar projects, particularly in selecting optimal solutions to geotechnical problems in transmission areas.

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