JIMEA | Jurnal Ilmiah MEA (Manajemen, Ekonomi, dan Akuntansi)
Vol. 9 No.2, 2025

IMPROVEMENT OF DECISION-MAKING PROCESS ON SELECTING CONSTRUCTION DESIGN ALTERNATIVE FOR THE NORTH ELEVATED TOLL ROAD (NETR) PROJECT CASE OF PT XYZ

Nastiti Ramadhyanti[1]; Utomo Sarjono Putro[2]
School of Business and Management, Institut Teknologi Bandung, Bandung[1,2]
Email : nastiti_ramadhyanti@sbm-itb.ac.id[1]; utomo@sbm-itb.ac.id[2]

ABSTRACT

This study addresses the inefficiency in the decision-making process of PT XYZ for selecting the basic design of the North Elevated Toll Road (NETR) project. Initially driven solely by cost considerations, the previous approach overlooked critical factors such as environmental impact, social implications, construction complexity, and land acquisition processes. Through the application of the Analytic Hierarchy Process (AHP) and Value Engineering (VE), this research proposes a more comprehensive decision-making model. Primary data were collected via in-depth questionnaires and focus group discussions involving key stakeholders within PT XYZ. The results highlight the importance of adopting a multi-criteria framework to avoid project delays, minimize risk, and improve long-term feasibility. By integrating financial and non-financial criteria, the study identifies the most suitable design alternative and proposes an implementation plan for its adoption. This model aims to support more accountable and strategic infrastructure decisions within PT XYZ and similar organizations in future projects.

Keywords : Toll Road; Infrastructure Development; Multi-Criteria Decision-Making (MCDM); Analytic Hierarchy Process (AHP); Value Engineering (VE); Project Evaluation; Design Alternatives; PT XYZ; NETR Project

ABSTRAK

Penelitian ini membahas ketidakefisienan dalam proses pengambilan keputusan PT XYZ dalam pemilihan desain dasar proyek Jalan Tol Layang Utara (NETR). Pendekatan sebelumnya yang hanya berfokus pada aspek biaya dinilai mengabaikan faktor penting lainnya seperti dampak lingkungan, implikasi sosial, kompleksitas konstruksi, dan proses pembebasan lahan. Melalui penerapan metode Analytic Hierarchy Process (AHP) dan Value Engineering (VE), studi ini mengusulkan model pengambilan keputusan yang lebih komprehensif. Data primer dikumpulkan melalui kuesioner mendalam dan diskusi kelompok terarah (FGD) bersama para pemangku kepentingan utama di PT XYZ. Hasil penelitian menunjukkan pentingnya kerangka kerja multi-kriteria guna menghindari keterlambatan proyek, meminimalkan risiko, dan meningkatkan kelayakan jangka panjang. Dengan menggabungkan kriteria finansial dan non-finansial, studi ini berhasil mengidentifikasi alternatif desain paling tepat dan menyusun rencana implementasi untuk pelaksanaannya. Model ini diharapkan dapat mendukung keputusan infrastruktur yang lebih akuntabel dan strategis, baik di PT XYZ maupun perusahaan sejenis pada proyek-proyek selanjutnya.

Kata Kunci : Jalan Tol; Pengembangan Infrastruktur; Pengambilan Keputusan Multi-Kriteria (MCDM); Proses Hirarki Analitik (AHP); Rekayasa Nilai (VE); Evaluasi Proyek, Alternatif Desain; PT XYZ; Proyek NETR

INTRODUCTION

Toll roads in Indonesia began to be built in 1978, with a length of 46 kilometers connecting Jakarta and Bogor. By 2024, the total length of toll roads in Indonesia has reached ±2,893 kilometers, stretching from the islands of Sumatra, Java, Kalimantan and Bali. Over the past decade, Indonesia has started a comprehensive infrastructure development program with the goals of enhancing connectivity, regional accessibility, and economic integration. Building and growing networks of toll roads is one of the agenda's main goals. These initiatives seek to improve trade and tourism between regions, lessen traffic, and cut transportation costs (Asian Development Bank, 2022; World Bank, 2020).

The expansion of toll road infrastructure aligns with Indonesia's strategic goals under its National Long-Term Development Plan (Rencana Pembangunan Jangka Panjang Nasional, RPJMN). This includes supporting the country’s economic growth and achieving equitable development. Toll road projects are also an essential part of Indonesia's public-private partnership (PPP) framework, which encourages collaboration between the government and private sectors to accelerate infrastructure development (Asian Development Bank, 2022). The RPJMN of Indonesia, which encourages infrastructure investment to lessen inequality, support regional development, and enhance national logistics performance, is in line with these developments. By investing in toll road networks, the government aims to integrate regions, reduce transportation costs, and facilitate trade. Such evidence supports the importance of continued investment in toll road projects in Indonesia to ensure sustainable economic growth.

In Indonesia, toll road operations are managed by various entities known as BUJT encompassing both state-owned enterprises (Badan Usaha Milik Negara, BUMN) and private companies. These BUJTs are responsible for the financing, technical planning, construction, operation, and maintenance of toll roads. The regulatory oversight of these entities is conducted by the BPJT under KemenPUPR.

As of 2024, data from the BPJT indicates that there are 58 Toll Road Business Entities across Indonesia. These entities play a pivotal role in the financing, construction, operation, and maintenance of the nation's toll road infrastructure. One of Indonesia's top private infrastructure firms, PT XYZ (from this point on, PT XYZ), focuses on the construction and operation of toll roads. In one of Indonesia's biggest metropolitan areas.

A crucial toll road extension for PT XYZ, the North Elevated Toll Road (NETR) project, was once intended to be a single-sided double-decker construction, however, following a strategic assessment, the business determined that by lowering construction expenses, improving land use efficiency, and expanding long-term operational flexibility, implementing 3 other alternative designs may provide greater value engineering.

Emphasizes the importance of refining the company's current decision-making process which a single criteria decision-making process that concern on the budget of the construction only for selecting alternative designs. This study will address the shortcomings of the current decision-making approach, with a focus on improving how alternative designs are evaluated in terms of not only construction costs but also and other non-financial impacts. By considering these additional criteria in the decision-making process, the study will propose a more comprehensive decision model to enhance the decision-making process for the future projects.

To achieve the objectives of this study, there are two research questions (RQ) compiled by the author that must be answered, namely:

1. What multi-criteria decision-making model can be developed to improve the evaluation of alternatives for toll road infrastructure projects?
2. How can this improved model help determine the best alternative by integrating technical, environmental, social impact and land acquisition process factors alongside financial considerations?

LITERATURE REVIEW

The main theoretical framework used in this study is Multi Criteria Decision Making (MDCM) which is Analytic Hierarchy Process (AHP) as a very famous decision-making tools that include a multi criteria and multi alternatives. As comparison this study also use Value Engineering (VE) to find the preferable basic design alternative for NETR Project.

Multi Criteria Decision Making (MDCM)

As previously stated about the deficiency current decision-making process which only using single criteria budget constrain decision making therefore improvement is needed by using a collection of decision-making techniques and procedures known as multi-criteria decision making (MCDM) which involves evaluating options in relation to several, frequently conflicting criteria. Cost, time, quality, safety, and sustainability are just a few of the variables that must be balanced while making decisions in the construction sector, such as choosing a contractor, a design, or project management techniques. N. Buhshan (2004) stated that commonly there are eight steps for decision making process (Figure 1) the model must show the relation between the goal, criteria and alternatives.

Analytic Hierarchy Process (AHP)

As a multi-criteria decision-making tool, AHP aligns the priorities of alternatives resulting under various criteria, ensuring consistency and rationality in the decision-making process. To support this process, pairwise comparisons are conducted for pre-defined criteria, which are evaluated by experts to ensure objectivity. The AHP method organizes the decision-making process into a hierarchical structure that descends from the overall goal to criteria, sub-criteria, and alternatives across successive levels. Furthermore, the decision-making process utilizes a numerical scale for pairwise comparisons, which quantifies the relative importance of one factor compared to another. This scale ranges from 1-9 (Figure 2).

Value Engineering (VE)

According to the Technical Guidelines for Value Engineering issued by Bina Marga (2022), Value Engineering is defined as a structured and systematic decision-making process conducted by a multidisciplinary team. This process aims to achieve the best possible value for a project while maintaining the necessary functional quality and performance standards. The selection of the proposed route for the NETR project refers to the matrix issued by the Directorate General of Infrastructure Financing through Circular Letter No. 02/SE/Dp/2024 concerning the Guidelines for Preparing Feasibility Studies for Toll Road Projects, specifically in Appendix 10. This matrix classifies assessment criteria into two main categories: technical and non-technical aspects. This approach is based on the formula outlined in the *Guidelines for the Implementation of Value Engineering* (No. 11/SE/Db/2022), which defines value as the product of function and performance divided by cost: $\text{Value} = \frac{\text{Function} \times \text{Performance}}{\text{Cost}}$

Conceptual Framework

The Conceptual Framework (see Figure 1) illustrates the central problem addressed in this research, referred to as the input in the study. The conceptual framework of this research illustrates the process of analyzing and improving the current decision-making approach used in the NETR toll road project. This study aims to enhance the decision-making process by transitioning from a single criterion to a multi-criteria approach. Based on a literature review of similar toll road projects, a comprehensive set of criteria has been formulated, including investment cost, construction complexity, environmental impact, social impact, and land acquisition process considerations. To weigh the importance of each criterion, the Analytic Hierarchy Process (AHP) method will be applied through in depth questionnaire and as comparison method this study also will use Value Engineering (VE) with weighing method by focus group discussion (FGD) with project stakeholders. The four available alternatives will be compared using this model to identify the preferred basic design. To find the most appropriate multi-criteria decision-making (MCDM) approach for selecting the alternative basic design for the NETR Project, both the Analytic Hierarchy Process (AHP) and Value Engineering (VE) methods will be applied. The results of each method will then be compared to determine which approach offers the most suitable and effective solution for PT XYZ, considering the company's specific project objectives and constraints

RESEARCH METHODOLOGY

Method is a method of work that can be used to obtain something. While the research method can be interpreted as a work procedure in the research process, both in searching for data or disclosing existing phenomena (Zulkarnaen, W., et al., 2020:229).

Data Collection Methods

The primary data collection method used in this study includes in-depth questionnaires and FGD with internal stakeholders (see Figure 3):

1. *In Depth Questionnaires for The NETR Project Planning Team:* This study selected 5 key internal stakeholders who have interest & influence in determining basic design for NETR Project. The selected respondents then conducted pairwise comparisons of criterias and alternatives, using a scale of 1–9 for their assessment. The importance of each criterion and alternatives was determined using AHP.

Pairwise comparisons were presented in the form of questionnaires collected from a total of 5 internal stakeholders which can express the strength of preferences using a numerical rating scale, known as basic value scale, shown in Figure 2.

The stakeholders make a pairwise comparison between the criteria and the different alternatives that have been provided, as shown in Table 1. and Table 2. The results of the pairwise comparison will then be processed using SuperDecision software to find the best alternative based on AHP analysis.

2. *Focus Group Discussion (FGD) for The NETR Project Planning Team:* As comparison FGDs obtained within the planning team of NETR Project to make a weighing on each aspect technical and non-technical aspects for Value Engineering analysis.

Secondary data is obtained from project-related documents such as NETR project profile, feasibility studies from similar projects, policy regulations, technical reports, budget documentation and academic literature ensuring the analytical framework is align both theory and practical relevance.

RESULTS AND DISCUSSION

Developing Criteria

The decision-making process for selecting the most suitable alternative basic design for the NETR Project is guided by five main criteria. The criteria include technical and non-technical aspects (Table 3) Some of these criteria are defined by relevant government regulations, project data, company documents while others are established based on the company's internal considerations.

Structure of Analytic Hierarchy Process (AHP)

The relationship between goals, alternatives and criteria is developed in the form of a hierarchical structure, which aims to determine the decision to choose an alternative basic design for NETR Project. This is explained in the AHP Hierarchy structure as shown in Figure 4.

Pairwise Comparison of AHP-Model

Pairwise comparisons were conducted using a questionnaire distributed to stakeholders involved in the planning team of the NETR Project. The resulting data were analyzed and presented to the CEO to support the selection of the most suitable basic design alternative. The questionnaire will be given from the level of assistant manager of investment to Directors. Respondents will complete an in-depth questionnaire involving pairwise comparisons between each criterion, as well as ratings of the alternatives. For each comparison, they will select which option is preferable between the two (Table 1). This process will be repeated across all five criteria. In addition, the four design alternatives will be evaluated by comparing them one-on-one under each individual criterion (Table 2).

Synthesize the Results to Determine the Best Alternative Solution

From the results of the pairwise comparison of criteria and alternative in Table 4 and Table 5, synthesize calculations with SuperDecision software, with the results shown in Figure 5.

Consistency Ratio

The quality of the decision is determined by how consistently the decision-maker makes decisions along the pairwise comparisons. Consistency Ratio should be less than 0,01, at both the criteria and alternative levels as shown in Figure 5. This indicates that the respondents' pairwise comparisons are consistent (acceptable).

AHP Analysis Conclusion

Based on the results of the analysis and calculations with Super Decision AHP, the synthesis of the results of the pairwise comparison (Figure 6) as shown below:

1. Alternative 1 = 33%
2. Alternative 2 = 24.9%
3. Alternative 3 = 8.6%
4. Alternative 4 = 33,4%

` The AHP synthesis results show that the preferable alternative is alternative 4 with 33,4%. This indicates that stakeholders view that this alternative is the most feasible alternative to be implemented for NETR Project. The highest weight criteria is Land Acquisition with 46,5% means that this is the most important criteria in deciding NETR Project basic design alternative.

Value Engineering Calculation

By using input from expert discussions and applying a clear calculation method, VE makes it easier to compare alternatives in a more balanced and structured way. The goal is to choose a design that offers the best overall value, not just the cost-effective solution.

The Table 6 presents the result of the Value Engineering analysis for four alignment alternatives under consideration for the NETR Project. The assessment is divided into two main categories Technical Aspects with a total weight of 32% and Non-Technical Aspects 68%. Each main aspect is further broken down into sub-categories and specific criteria used to evaluate the design alternatives.

The final result shows the total value score for each alternative. Alternative 4 ranks highest with a total score of 86.67, indicating the most balanced performance when both technical and non-technical factors are considered. It is followed by Alternative 2 (80.14), Alternative 1 (75.80), and finally Alternative 3 (68.43), which has the lowest score due to its weaker performance in both technical and cost-related aspects. This value becoming the base of calculation for VE, to find the preferable alternative of basic design for NETR Project.

Table 7 show the VE calculation using the formula that has been stated before, and the result shows that alternative 4 has the highest value of engineering with 7,23 because the obstacle in land acquisition process is the least from other alternatives made alternative 4 is the most feasible for NETR Project basic design.

CONCLUSION

This study introduced a multi-criteria decision-making framework using the Analytic Hierarchy Process (AHP) and Value Engineering (VE). Both methods helped evaluate four alternative basic designs for the NETR project by incorporating financial and non-financial criteria. The results emphasized that adopting a multi-criteria approach enables more balanced and accountable decisions.

It can be concluded that the Analytic Hierarchy Process (AHP) is more suitable for use in PT XYZ's decision-making process, as it helps reduce the subjectivity often found in Focus Group Discussions (FGDs). FGDs can sometimes lead to biased weight assignments due to group dynamics or dominant opinions. In contrast, AHP offers a more objective and individual-based evaluation method, making the results more consistent and reliable

Based on the calculation results presented earlier, Alternative 4 emerged as the most preferable basic design for the NETR Project. This decision considers all relevant criteria, including environmental impact, social concerns, construction complexity, and land acquisition.

10/05/2025 |Accepted : 09/06/2025 |Published : 10/08/2025
P-ISSN; 2541-5255 E-ISSN: 2621-5306 | Page 2431

REFERENCES

Asian Development Bank. (2022). *Indonesia's Infrastructure Development Strategy*. ADB Publications.https://www.adb.org/publications

Bhushan, N., & Rai, K. (2022). *Strategic Decision Making: Applying the Analytic Hierarchy Process*. Springer.

Mareschal, B. (1988). *Weighting and Aggregation in Multi-Criteria Decision Analysis: An Empirical Study*. European Journal of Operational Research, 36(3), 350–361. https://doi.org/10.1016/0377-2217(88)90117-3

Ministry of Public Works and Housing. (2023). *PERMEN PUPR No. 6 Tahun 2023 tentang Penyelenggaraan Jalan Tol*. Jakarta: Kementerian PUPR. Ministry of Public Works and Housing. (2020). *PERMEN PUPR No. 20 Tahun 2020 tentang Penyelenggaraan Jalan Tol*. Jakarta: Kementerian PUPR.

Saaty, T. L. (1980). *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. McGraw-Hill.

Saaty, T. L., & Vargas, L. G. (2012). *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process* (2nd ed.). Springer.

SuperDecisions. (2022). *Decision Support Software for AHP and ANP*. Creative Decisions

Foundation. https://www.superdecisions.com

World Bank. (2020). *Indonesia Infrastructure Sector Assessment Program*. World Bank Publications. https://www.worldbank.org/en/country/indonesia

Triantaphyllou, E. (2000). *Multi-criteria decision making methods: A comparative study*. Springer.

Direktorat Jenderal Pembiayaan Infrastruktur Pekerjaan Umum dan Perumahan. (2020). *Pedoman pelaksanaan rekayasa nilai bidang jalan dan jembatan*. Kementerian PUPR.

Sahoo, S. K., & Goswami, S. S. (2023). *A comprehensive review of multiple criteria decision-making (MCDM) methods: Advancements, applications, and future directions*. Decision Making Advances, 1(1), 25–48. https://doi.org/10.31181/dma1120237

Baker, D., Bridges, D., Hunter, R., Johnson, G., Krupa, J., Murphy, J., & Sorenson, K. (2001). *Guidebook to decision-making methods* (WSRC-IM-2002-00002). U.S. Department of Energy.

Kumah, A., Nwogu, C. N., Issah, A.-R., Obot, E., Kanamitie, D. T., Sifa, J. S., & Aidoo, L. A. (2023). Cause-and-effect (fishbone) diagram: A tool for generating and organizing quality improvement ideas. *Global Journal on Quality and Safety in Healthcare*, Advance online publication. https://doi.org/10.36401/JQSH-23-42

Sabaei, D., Erkoyuncu, J., & Roy, R. (2015). A review of multi-criteria decision making methods for enhanced maintenance delivery. *Procedia CIRP, 37*, 30–35. https://doi.org/10.1016/j.procir.2015.08.086

Erdogan, S. A., Šaparauskas, J., & Turskis, Z. (2019). A multi-criteria decision-making model to choose the best option for sustainable construction management. *Sustainability, 11*(8), 2239. https://doi.org/10.3390/su11082239

Dean, M. (2022). *A practical guide to multi-criteria analysis* [Technical report]. University College London. https://doi.org/10.13140/RG.2.2.15007.02722

Kumar, S., & Yadav, B. S. (2019). A comprehensive review of multi-criteria decision-making approaches in project management. *International Journal of Scientific & Technology Research, 8*(10), 1456–1462.

Zaher, H., Saeid, N. R., & AbdAlla, R. S. (2020). Multi-criteria decision making approach for managing risks in construction projects. *International Journal of Advanced Research in Engineering and Technology (IJARET), 11*(11), 1292–1303.

Zulkarnaen, W., Fitriani, I., & Yuningsih, N. (2020). Pengembangan Supply Chain Management Dalam Pengelolaan Distribusi Logistik Pemilu Yang Lebih Tepat Jenis, Tepat Jumlah Dan Tepat Waktu Berbasis Human Resources Competency Development Di KPU Jawa Barat. *Jurnal Ilmiah MEA (Manajemen, Ekonomi, & Akuntansi)*, *4*(2), 222-243. https://doi.org/10.31955/mea.vol4.iss2.pp222-243.

FIGURE AND TABLE

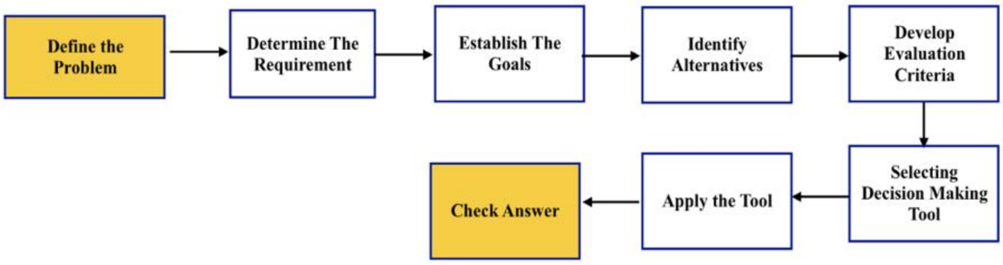


Figure 1. Decision Making Process

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Essential importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	When compromise is needed between two

Figure 2. Saaty's Scoring for AHP (Saaty & Vargas, 2012)

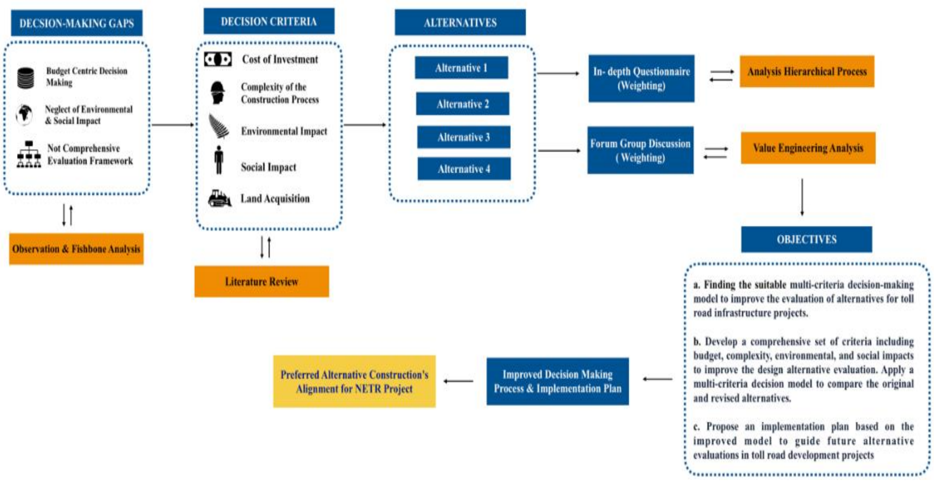


Figure 2. Conceptual Framework

10/05/2025 |Accepted : 09/06/2025 |Published : 10/08/2025
P-ISSN; 2541-5255 E-ISSN: 2621-5306 |

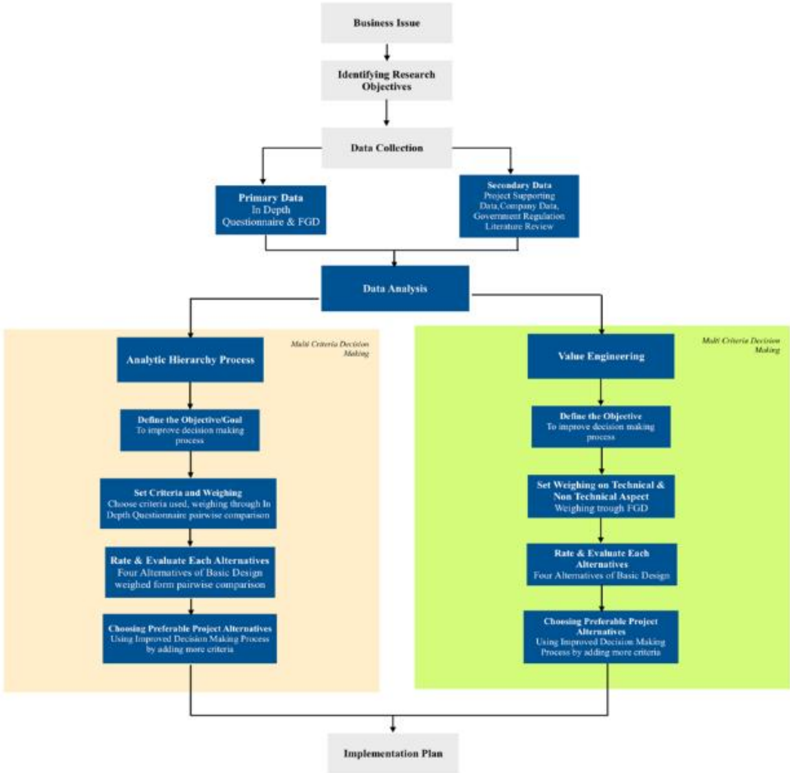


Figure 3. Research Design

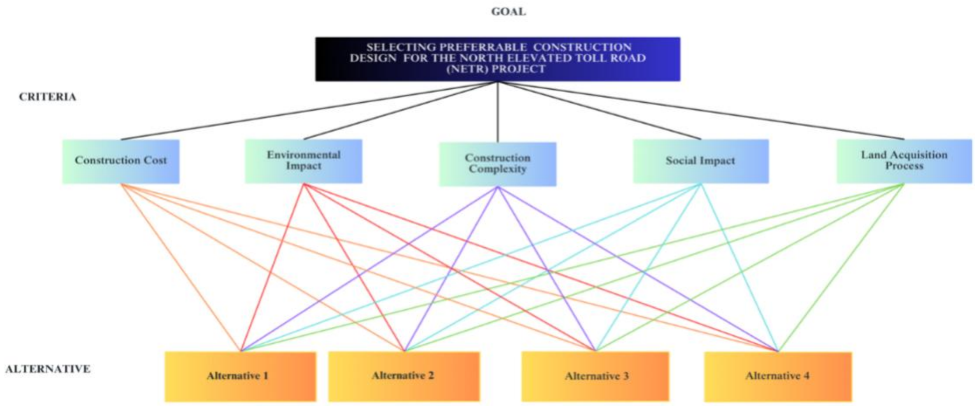
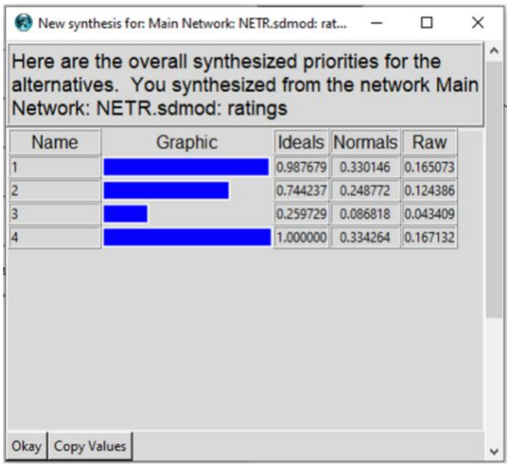


Figure 4. AHP Structure for NETR Project

Figure 5. Analysis Results of SuperDecision AHP Software



New synthesis for: Main Network: NETR.sdmod: rat...

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Main Network: NETR.sdmod: ratings

Name	Graphic	Ideals	Normals	Raw
1		0.987679	0.330146	0.165073
2		0.744237	0.248772	0.124386
3		0.259729	0.086818	0.043409
4		1.000000	0.334264	0.167132

Okay Copy Values

Figure 6. Alternatives Synthesized Priorities

Table 1. Pairwise Comparison for Criteria

Criteria	Pairwise Numerical Rating																	Criteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Construction Cost																		Environmental Impact
Construction Cost																		Social Impact
Construction Cost																		Land Aqcuisiton
Construction Cost																		Construction Complexity
Environmental Impact																		Social Impact
Environmental Impact																		Land Aqcuisiton
Social Impact																		Land Aqcuisiton
Construction Complexity																		Environmental Impact
Construction Complexity																		Social Impact
Construction Complexity																		Land Aqcuisiton

Table 2 Pairwise Comparison between Alternatives

Alternatives	Pairwise Numerical Rating																	Alternatives
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Alternative 1																		Alternative 2
Alternative 1																		Alternative 3
Alternative 1																		Alternative 4
Alternative 2																		Alternative 3
Alternative 2																		Alternative 4
Alternative 3																		Alternative 4

Table 3. Developing Criteria Description

No.	Criteria	Description
1	Cost of Construction	This refers to the total cost needed to carry out the project. It includes the actual construction expenses, the cost of acquiring land, and any compensation that must be paid. While cost has often been a major consideration, in this context it may be seen as less critical compared to other challenges.
2	Environmental Impact	Infrastructure projects are expected to minimize their effect on the environment. In most cases, the impact tends to be negative, so the focus is on how to reduce or manage that impact. This could involve controlling pollution, protecting green spaces, or ensuring that construction doesn't damage the surrounding ecosystem.
3	Social Impact	Construction activities can affect many people living or working near the project area. The impact can be either positive (such as better access or economic opportunities) or negative (like noise, disruption, or displacement). This criterion considers how the project might influence the daily lives of the local community.
4	Land Acquisition	Getting land for the project is often one of the most difficult steps. It involves legal processes, negotiations, and compensation, which can take a lot of time and resources. In many cases, acquiring land takes longer than the construction itself. Because of that, this becomes a major factor in planning the project.
5	Complexity of Construction Process	This relates to how difficult it is to carry out the construction work. Since the NETR project is large and located in a dense area, it may require heavy equipment, special methods, and cause traffic or disruption. Reducing complexity helps ensure the project runs smoothly and avoids unnecessary delays.

Table 4. Synthesize Matrix for Criteria

Criteria	Construction Cost	Environmental Impact	Social Impact	Land Acquisition	Construction Complexity
Construction Cost	1	0,425	0,644	0,384	0,699
Environmental Impact	2,353	1	1,32	0,268	0,450247636
Social Impact	1,553	0,757575758	1	0,207	0,416319734
Land Acquisition	2,604	3,731	4,831	1	3,731343284
Construction Complexity	1,431	2,221	2,402	0,268	1

Table 5. Synthesize Matrix for Alternatives

	Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Construction Cost	Alternative 1	1	0,234	4,129	2,639
	Alternative 2	4,274	1	4,478	3,641
	Alternative 3	0,242	0,223	1	0,523
	Alternative 4	0,379	0,275	1,912	1
	Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Environmental Impact	Alternative 1	1	1,888	3,728	3,949
	Alternative 2	0,530	1	3,728	2,352
	Alternative 3	0,268	0,268	1	0,461
	Alternative 4	0,253	0,425	2,169	1
	Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Social Impact	Alternative 1	1	0,461	2,862	0,839
	Alternative 2	2,169	1	3,288	0,478
	Alternative 3	0,349	0,304	1	0,441
	Alternative 4	1,192	2,092	2,268	1
	Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Construction Complexity	Alternative 1	1	3,438	4,317	3,641
	Alternative 2	0,291	1	4,129	2,352
	Alternative 3	0,232	0,242	1	0,392
	Alternative 4	0,275	0,425	2,551	1
	Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Land Acquisition	Alternative 1	1	2,702	2,825	0,361
	Alternative 2	0,370	1	2,702	0,253
	Alternative 3	0,354	0,370	1	0,299
	Alternative 4	2,770	3,953	3,344	1

Table 6. Weighing Criteria for Value Engineering Method

No	Activities	Unit	Alternative 1			Alternative 2		Alternative 3		Alternative 4a	
			Total Weight (%)	Value	Weight (%)	Value	Weight (%)	Value	Weight (%)	Value	Weight (%)
1	**Technical Aspect**		32,00		25,66		26,79		19,87		25,14
A	**Geometric**		23,00		20,96		21,76		15,16		20,10
i	Toll road length	Km	4,00	10,40	3,53	10,04	3,53	16,22	2,19	9,98	3,56
ii	Acess road (on/off ramp)	Km	2,00	2,87	1,96	2,87	1,96	2,81	2,00	2,89	1,95
iii	Number of river lanes	section	2,00	6,00	2,00	6,00	2,00	6,00	2,00	6,00	2,00
iv	Elevated length	Km	3,00	12,91	2,99	12,91	2,99	19,04	2,03	12,87	3,00
v	Number of special bridges	segment	4,00	5,00	3,20	4,00	4,00	10,00	1,60	8,00	2,00
vi	Crossing with existing toll road	Km	4,00	9,00	4,00	9,00	4,00	13,00	2,77	10,00	3,60
vii	Crossing with existing non toll road	section	4,00	11,00	3,27	11,00	3,27	14,00	2,57	9,00	4,00
B	**Topography**		1,00		0,68		1,00		0,68		1,00
i	Length of flat area	km	1,00	12,91	0,68	12,91	1,00	19,04	0,68	12,87	1,00
ii	Length of hill area	km	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C	**Construction**		8,00		4,02		4,04		4,04		4,04
i	Duration of construction acitivty	Month	4,00	36,00	4,00	36,00	4,00	36,00	4,00	36,00	4,00
ii	Accesibility along construction phase	Km	2,00	8,00	0,01	12,00	0,02	12,00	0,02	12,00	0,02
iii	Flexitbility staging of construction		2,00	8,00	0,01	12,00	0,02	12,00	0,02	12,00	0,02
1	**Non-Technical Aspect**		68,00		50,14		53,35		48,56		61,35
A	**Economic & Financial**										
i	Construction Cost	Rp	12,00	9,28 T	11,43	8,83 T	12,00	10 T	10,60	9,93 T	10,67
B	**Construction Complexity**		8,00		5,98		5,82		4,49		6,88
i	Disruption to existing traffic	Km	2,00	0,70	2,00	0,95	1,47	0,95	1,47	0,95	1,47
ii	Length across industrial/warehouse/office area	Km	2,00	0,63	0,35	0,62	0,35	0,65	0,34	0,11	2,00
iii	Length across housing area	Km	2,00	1,85	1,63	1,51	2,00	2,28	1,32	2,14	1,41
iv	Existing Utility	Km	2,00	12,91	1,99	12,91	1,99	19,04	1,35	12,87	2,00
C	**Environmental Aspect**		25,00		19,28		21,93		20,45		21,54
i	Forest area		15,00	7,58	10,75	5,56	13,48	11,71	12,53	9,31	12,70
	- Mangrove Vegetation	Ha	10,50	4,30	4,49	1,32	9,27	1,66	8,95	1,64	8,97
	- Non Mangrove Vegetation	Ha	3,00	0,09	2,98	0,38	2,91	2,81	2,36	2,75	2,37
	-Non-Vegetation	Ha	0,75	2,40	0,55	2,04	0,58	2,31	0,56	0,79	0,68
	- Drainage, river, etc	Ha	0,75	0,79	0,74	1,82	0,72	4,93	0,66	4,13	0,68
ii	Non-forest area		10	14,03	8,53	23,21	8,45	32,59	7,91	19,12	8,83
	- Mangrove Vegetation	Ha	5,00	2,87	4,00	1,60	4,44	2,05	4,29	0,95	4,67
	- Non Mangrove Vegetation	Ha	2,00	5,49	1,67	6,64	1,61	7,87	1,53	5,45	1,68
	-Non-Vegetation	Ha	0,50	2,72	0,43	4,07	0,39	4,26	0,39	2,55	0,43
	- Drainage, river, etc	Ha	0,50	2,31	0,45	2,23	0,41	8,19	0,33	4,21	0,41
	- State owned land	Ha	0,50	0,64	0,47	0,70	0,47	1,26	0,44	0,91	0,46
	- Private owned land	Ha	1,50	0,00	1,50	5,97	1,13	8,96	0,94	5,05	1,19
D	**Land Development Area**		7,00		6,35		6,35		5,91		6,44
i	Land Clearing	Ha	7,00	31,82		31,80		34,15		31,35	
E	**Social Aspect**		**16,00**		4,11		7,25		7,11		16,00
i	Obstacles	area	10,00	9,00	1,11	8,00	1,25	9,00	1,11	1,00	10,00
ii	Social impact	rate	6,00	4,00	6,00	4,00	6,00	4,00	6,00	4,00	6,00
	TOTAL		**100**		**75,8**		**80,14**		**68,43**		**86,67**

Table 7. Calculation for Value Engineering Each Alternative

Alternative	Fuction x Performance (without Constrruction Cost)	Construction Cost (Trillion Rupiah)	Value Engineering Score
Alternative 1	61,38	9,28	6,61
Alternative 2	63,26	8,83	7,16
Alternative 3	53,95	10	5,40
Alternative 4	72,12	9,98	7,23