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Analysis of Strategies to Improve the Financial Feasibility of the Rantauprapat–Kisaran Toll Road Section

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Abstract

The Rantauprapat–Kisaran Toll Road is a strategic part of the Trans-Sumatra corridor that supports connectivity and regional economic development in North Sumatra, Indonesia. However, the baseline financial analysis indicates that the project is not financially feasible, with a Financial Internal Rate of Return (FIRR) of 8.351%, a negative Net Present Value (NPV) of IDR 3,971 billion, and a Payback Period (PP) of 15.95 years. This study aims to identify appropriate strategies for improving project feasibility and assess the sensitivity of financial indicators to key parameters. A quantitative descriptive case study was conducted using Discounted Cash Flow modeling. Financial feasibility was evaluated through NPV, FIRR, and PP, while alternative strategies were assessed using single and combined scenarios involving tariff adjustments, CAPEX and O&M efficiencies, financing optimization, and Viability Gap Funding (VGF). The findings show that no single strategy satisfies all feasibility criteria. Achieving the minimum FIRR would require a tariff increase of 123.45%, VGF support of 62.84% of project costs, or CAPEX and O&M reductions of 56.91%. The optimal combination consists of 10% VGF support, CAPEX and O&M efficiencies, and a financing structure of 70% debt and 30% equity. This scenario produces an FIRR of 11.72%, a WACC of 7.56%, an NPV of IDR 12,658 billion, and a PP of 11.84 years. Sensitivity analysis identifies revenue and CAPEX as the most critical variables, highlighting the importance of revenue assurance and effective cost control.

Introduction

The development of toll road infrastructure has become an important component of Indonesia's strategy to strengthen national connectivity, improve the efficiency of goods and passenger mobility, reduce transportation and logistics costs, and stimulate regional economic development. In a geographically extensive country such as Indonesia, the availability of reliable road infrastructure is particularly important for connecting production centers with markets, distribution networks, ports, and other economic nodes (Hartati et al., 2025; Chilcott et al., 2020; Latief et al., 2026; Rimmer & Dick, 2012). Toll road investment therefore has implications that extend beyond transportation performance because improvements in accessibility can influence regional trade, industrial activity, agricultural distribution, and the competitiveness of local economies. Within this broader infrastructure development agenda, the Trans-Sumatra Toll Road (TSTR) represents a strategic transportation corridor intended to strengthen connectivity across Sumatra and support the movement of people and commodities between major economic regions (Hu et al., 2026; Basri et al., 2024). The financial sustainability of individual toll road sections consequently becomes an important consideration because infrastructure connectivity can only be maintained over the long term

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when the associated investment can be supported by an appropriate financial structure and sustainable operating performance (Du et al., 2023; Meng et al., 2024; Abor et al., 2025; Cacciuttolo et al., 2024; Adeleke et al., 2025).

One of the strategic sections within the TSTR network is the Rantauprapat–Kisaran Toll Road in North Sumatra Province. This toll road connects Labuhanbatu Regency and Asahan Regency and is expected to facilitate the movement of goods and services along the eastern coastal region of North Sumatra. The corridor is particularly relevant to economic activities associated with plantation commodities, trade, and regional distribution (Febrian & Yuza, 2023; Jayathilake et al., 2023; Nurfatriani et al., 2022; Hariyanti & Syahza, 2024). From an infrastructure perspective, the development of this section can improve accessibility and travel efficiency between important economic areas. From an investment perspective, however, the strategic importance of a toll road does not automatically guarantee financial feasibility. Toll road projects require substantial initial capital expenditure, while their long-term revenues depend heavily on traffic realization, tariff levels, operational performance, maintenance expenditure, financing costs, and the ability of the project to generate sufficient cash flows throughout the concession period. Consequently, a project may provide significant public and regional economic benefits while simultaneously facing challenges in achieving commercially acceptable financial returns (Akomea-Frimpong et al., 2022; Volden & Welde, 2022).

The financial feasibility issue is particularly important for toll road investments because the scale and duration of infrastructure investment expose projects to considerable uncertainty (Wraharjo et al., 2022; Suryana & Muttaqien, 2026; Fauzan et al., 2023). Traffic demand may differ from initial projections, construction and operating costs may increase, and the applicable tariff may not always be sufficient to compensate for investment and financing requirements. The relationship between traffic volume and tariff is also not necessarily linear from an investment perspective (Pirouzrahi et al., 2025; Sohaee & Bohluli, 2024; Rodríguez-Sanz & Rubio Andrada, 2023). Higher tariffs may increase revenue per vehicle but may simultaneously affect users' willingness to utilize the toll road, while lower tariffs may encourage traffic but reduce revenue generated per vehicle. Similarly, cost efficiency can improve project cash flow, but excessive reductions in capital expenditure or operation and maintenance expenditure may potentially affect the quality and sustainability of infrastructure services. These conditions indicate that financial feasibility should not be evaluated solely through a single tariff or traffic assumption but should be examined through alternative scenarios that reflect the interaction between project revenues, expenditures, financing, and government intervention (Li et al., 2023; Vickerman, 2024).

The 2020 Final Review Basic Design provides an important basis for evaluating the financial condition of the Rantauprapat–Kisaran Toll Road. The project is projected to accommodate an initial traffic volume of 17,740 vehicles per day, with an average annual traffic growth rate of 3%. Nevertheless, the financial evaluation indicates that the project has not yet satisfied the required investment feasibility criteria. Among the fifteen tariff and traffic growth scenarios evaluated, the Financial Internal Rate of Return (FIRR) ranged from 5.50% to 13.68%, while all scenarios generated negative Net Present Values (NPVs). Even under the most favorable scenario, the FIRR of 13.68% remained below the Weighted Average Cost of Capital (WACC) of 13.95%. At the same time, the corresponding NPV remained negative at IDR 394.20 billion. These findings indicate that the existing combination of traffic assumptions and tariff conditions is insufficient to generate financial returns at a level comparable with the project's cost of capital. The negative NPV further demonstrates that the present value of expected project cash inflows remains lower than the investment and financing requirements. Therefore, identifying feasible strategies to improve the financial performance of the project is not merely a matter of increasing projected revenue but requires

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an integrated assessment of the factors that determine project cash flow (Ridwan et al., 2025; Delapedra-Silva et al., 2022; Ponomarenko et al., 2022).

Financial feasibility analysis is particularly relevant in toll road investment because NPV, FIRR, and Payback Period provide complementary perspectives on investment performance (Wraharjo et al., 2022; Fauzan et al., 2023). NPV measures the economic value generated by a project after considering the time value of money and the required investment, while FIRR indicates the rate of return generated by the project and can be compared with the applicable cost of capital. Payback Period, meanwhile, provides information regarding the time required for the initial investment to be recovered through project cash flows. The use of these indicators together enables a more comprehensive assessment of whether a toll road project can generate adequate returns, recover its investment within a reasonable period, and provide financial performance consistent with investment requirements. Such an approach is particularly relevant when a project initially produces negative NPV and an FIRR below the WACC because the analysis must determine which strategic adjustments are capable of changing the project's financial position (Mielcarz et al., 2025).

Previous studies have identified several approaches that can potentially improve the financial feasibility of infrastructure and toll road investments. Tariff adjustment represents one of the most direct mechanisms for increasing project revenue, although its effectiveness depends on the relationship between tariff levels and traffic demand. Hartoyo and Utomo (2019), for example, demonstrate the importance of sensitivity analysis in assessing the investment prospects of toll road projects because changes in key assumptions can substantially influence project feasibility. On the expenditure side, improvements in capital expenditure (CAPEX) and operation and maintenance (O&M) cost efficiency can contribute to stronger project cash flows by reducing the financial burden over the investment and operational periods. Operational efficiency is therefore an important dimension of investment feasibility because the ability to control project expenditure directly affects the amount of cash available for investment recovery and financial returns (Heizer, 2016; Montgomery, 2020). From the financing perspective, the structure and availability of government support can also influence project viability. Ery and Isrochmani (2022) highlight the relevance of Viability Gap Funding (VGF) as a mechanism for supporting infrastructure projects whose financial returns are insufficient to attract investment under conventional commercial conditions. Similarly, Truong et al. (2020) emphasize that financial sustainability in toll road projects is influenced by multiple factors rather than a single financial variable, reinforcing the need for an integrated approach to evaluating infrastructure investment strategies.

Despite these findings, an important research gap remains. Existing studies have generally examined individual aspects of toll road investment feasibility, such as sensitivity to tariff and traffic assumptions, financing mechanisms, or financial sustainability. However, limited attention has been given to the systematic comparison of alternative financial improvement strategies and their combinations within the specific context of the Rantauprapat–Kisaran Toll Road. This gap is important because a project with an FIRR below its WACC and a negative NPV may not become financially feasible through a single intervention alone. A tariff adjustment, for instance, may improve revenue but may not be sufficient to compensate for the investment gap. Cost efficiency may reduce expenditures but may likewise produce only a partial improvement. Government support through VGF may strengthen the financial structure, but its effectiveness should be assessed in relation to the project's revenue and expenditure characteristics. Consequently, evaluating strategies individually as well as in combination can provide a more useful basis for determining which intervention or combination of interventions has the greatest potential to improve financial feasibility.

This study therefore focuses on evaluating alternative strategies for improving the financial feasibility of the Rantauprapat–Kisaran Toll Road through both single-scenario and

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combination-scenario analyses. The analysis considers strategic interventions related to tariff and traffic assumptions, project cost efficiency, financing arrangements, and government support, insofar as these strategies are represented in the project scenarios. Financial performance is evaluated using Net Present Value (NPV), Financial Internal Rate of Return (FIRR), and Payback Period (PP). By comparing the outcomes of alternative scenarios against the project's financial requirements, the study seeks to identify strategies that can potentially reduce the financial gap and improve investment feasibility. The study contributes to toll road investment analysis by moving beyond the assessment of whether the project is financially feasible under existing assumptions and instead examining how alternative strategic interventions may alter its financial performance. The findings are expected to provide an analytical basis for policymakers, infrastructure investors, and project stakeholders in formulating more appropriate strategies for improving the financial sustainability of toll road development in the Trans-Sumatra Toll Road network.

Methods

Research Design

This study employed a quantitative descriptive approach using a case study method on the Rantauprapat–Kisaran Toll Road project and utilized the Discounted Cash Flow (DCF) model to evaluate the project's financial feasibility. The main indicators analyzed included Net Present Value (NPV), Financial Internal Rate of Return (FIRR), and Payback Period (PBP).

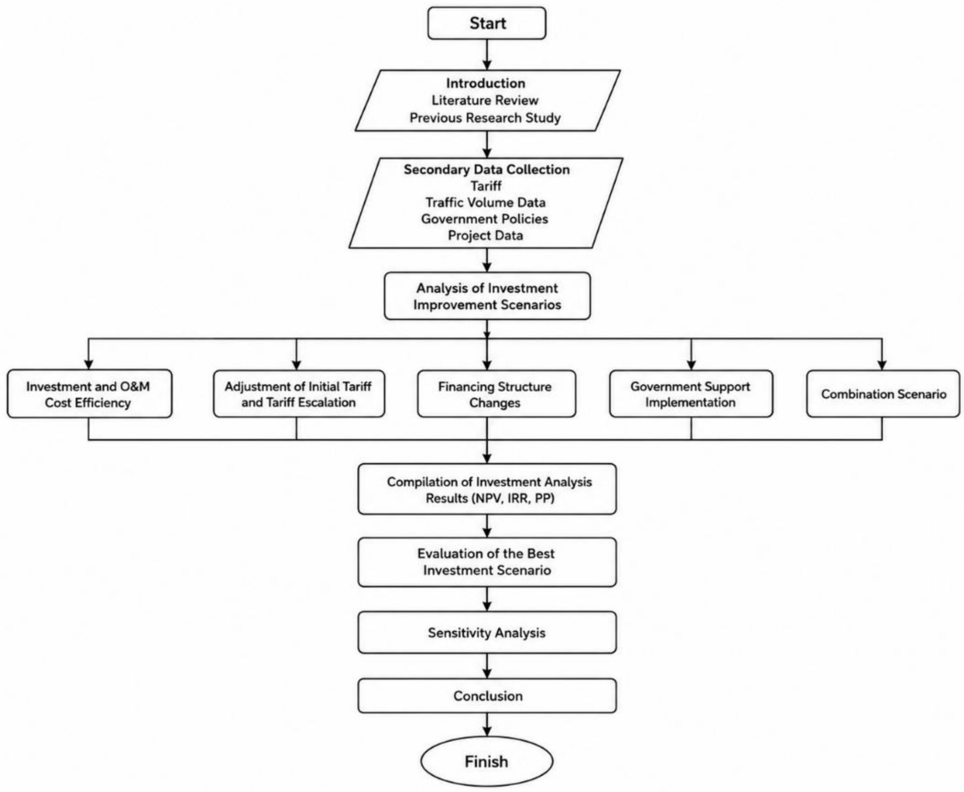

Figure 1. Research Flow Diagram

Data Sources and Data Collection

The study utilizes secondary data obtained from the Basic Design documents, Final Review Basic Design documents, project planning documents, toll road concession regulations, relevant literature, comparable project data, and macroeconomic indicators such as inflation, interest rates, and economic growth. Data collection was conducted through document analysis and literature review.

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Project Cash Flow Model Development

The project cash flow model was developed for a three-year construction period and a forty-year operational period. The main parameters incorporated into the model include investment costs, toll tariffs, traffic volume and growth rates, operation and maintenance costs, financing structure, taxation, cost of debt, cost of equity, and the Weighted Average Cost of Capital (WACC). Cash inflows consist of toll and non-toll revenues, while cash outflows include CAPEX, O&M expenses, taxes, interest payments, and debt repayments.

Financial Feasibility Analysis

Financial feasibility analysis was conducted under the baseline scenario using investment indicators consisting of Net Present Value (NPV), Financial Internal Rate of Return (FIRR), and Payback Period (PBP). The project is considered financially feasible if the NPV is positive, the FIRR is at least equal to the WACC plus 4%, and the PBP does not exceed 30% of the concession period.

Development of Financial Feasibility Improvement Scenarios

Following the evaluation of the baseline condition, several feasibility improvement strategies were tested, including CAPEX and O&M cost efficiency measures, tariff adjustments, financing structure modifications, and government support through Viability Gap Funding (VGF). Each strategy was initially evaluated individually through a single-scenario analysis, after which the most feasible strategies were combined and assessed through combination-scenario analysis. All scenarios were evaluated using the same three financial feasibility indicators.

Sensitivity Analysis

Sensitivity analysis was conducted to measure the effects of changes in revenue, CAPEX, and O&M costs on the FIRR under the selected optimal scenario. This analysis aimed to determine the switching value, defined as the threshold at which changes in project parameters would cause the project to no longer satisfy the financial feasibility criteria.

Results and Discussion

Financial Feasibility Analysis Framework and Baseline Assumptions

The financial feasibility analysis in this study was conducted using the 2020 Final Review Basic Design Report of the Rantauprapat–Kisaran Toll Road as the basis for developing the baseline scenario. The document contains various technical and financial assumptions employed in the project investment evaluation, including toll road length, construction period, operation and maintenance period, investment costs, financing structure, initial toll tariffs, operating expenses, and traffic growth projections. However, this study introduced several adjustments to selected parameters to ensure that the financial model better reflects current corporate conditions and the latest economic policies applicable at the time of the study.

The parameter adjustments did not alter the project's fundamental characteristics but updated the financial assumptions used in the evaluation. The toll road length, construction period, operational period, investment costs, initial tariffs, and traffic growth projections remained consistent with the Final Review Basic Design, while the cost of capital and taxation parameters were updated.

Table 1. Comparison of Assumptions between the Final Review Basic Design and the Research Assumptions

No.	Component	Final Review Basic Design	Research Assumption	Unit	Remarks

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1	Total toll road length	110.02	110.02	km	Unchanged
2	Construction period	3	3	years	Unchanged
3	Operation and maintenance period	40	40	years	Unchanged
4	Investment cost	15,348,563	15,348,563	IDR million	Unchanged
5	Long-term debt	30	30	% of capital structure	Unchanged
6	VGF	-	-	% of capital structure	Unchanged
7	Equity	70	70	% of capital structure	Unchanged
8	Class I tariff	900	900	IDR/vehicle/km	Unchanged
9	Class II tariff	1,350	1,350	IDR/vehicle/km	Unchanged
10	Class III tariff	1,350	1,350	IDR/vehicle/km	Unchanged
11	Class IV tariff	1,800	1,800	IDR/vehicle/km	Unchanged
12	Class V tariff	1,800	1,800	IDR/vehicle/km	Unchanged
13	Non-toll service revenue	1.50	1.50	% of toll revenue	Unchanged
14	Construction cost escalation	6.00	6.00	% per year	Unchanged
15	O&M cost escalation	6.00	6.00	% per year	Unchanged
16	Corporate income tax	30.00	22.00	%	Updated
17	Cost of Debt	11.50	7.44	% per year	Updated
18	Loan tenor	15	15	years	Unchanged
19	Grace period	7	7	years	Unchanged
20	Installment period	8	8	years	Unchanged
21	Cost of Equity	15.00	11.66	% per year	Updated
22	WACC	13.95	9.90	% per year	Updated
23	Traffic growth	3.00	3.00	% per year	Unchanged

The updated cost of capital assumptions reduced the pre-tax cost of debt from 11.50% to 7.44%, the cost of equity from 15.00% to 11.66%, and the Weighted Average Cost of Capital (WACC) from 13.95% to 9.91%. An after-tax cost of debt of 5.80% was used in the WACC calculation. Although the lower discount rate increased the present value of future cash flows, the improvement was still insufficient to render the project financially feasible.

Table 2. Comparison of Cost of Capital Parameters between the Final Review Basic Design and the Research Assumptions

Parameter	Final Review Basic Design	Research Assumptions
Cost of Debt	11.50%	7.44%
Cost of Equity	15.00%	11.66%
WACC	13.95%	9.90%

Summary of Investment Costs for the Rantauprapat–Kisaran Toll Road Project

The total investment requirement, including Value Added Tax (VAT), amounts to IDR 18.301 trillion. Earthworks constitute the largest cost component, followed by pavement works, structural works, and miscellaneous works. These four categories represent the primary cost drivers of the project and indicate the most relevant areas for investigation through value engineering, design optimization, and procurement strategies.

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Project Financing Structure

According to the 2020 Final Review Basic Design Report of the Rantauprapat–Kisaran Toll Road, the project financing scheme consists of a combination of equity financing and bank loans (debt financing) with proportions of 70% and 30%, respectively. This financing structure applies to both construction investment requirements and Value Added Tax (VAT) obligations incurred during the project development period.

Operating Revenue

Operating revenue represents the project's primary cash inflow and is determined by the toll road length, vehicle class tariffs, traffic volumes, periodic tariff adjustments, and non-toll revenues. The accuracy of these assumptions directly affects the values of NPV, FIRR, and PBP.

The Rantauprapat–Kisaran Toll Road has a total length of 110.02 km, a three-year construction period, and a 40-year operating period beginning in 2030. The initial toll tariffs are set at IDR 900 per vehicle-kilometer for Class I vehicles, IDR 1,350 per vehicle-kilometer for Classes II and III, and IDR 1,800 per vehicle-kilometer for Classes IV and V.

Table 3. Basic Parameters for Operating Revenue Projections

Parameter	Final Review Basic Design
Toll road length	110.02 km
Construction period	3 years
Operating period	40 years
Commencement of operation	2030
Class I tariff	IDR 900/vehicle/km
Class II and III tariffs	IDR 1,350/vehicle/km
Class IV and V tariffs	IDR 1,800/vehicle/km
Traffic growth	3% per year
Non-toll revenue	1.5% of toll revenue

The toll tariffs in the financial model are not assumed to remain constant throughout the concession period but are adjusted periodically in accordance with inflation developments and toll tariff adjustment regulations. Based on the assumptions adopted in this study, the Class I tariff increases from IDR 900 per kilometer in 2030 to IDR 4,792 per kilometer in 2068. The same adjustment pattern is applied to the other vehicle classes while maintaining their respective tariff multipliers.

In addition to tariffs, revenue generation is significantly influenced by the Average Daily Traffic (ADT) volume. Traffic projections are based on the Final Review Basic Design assumption of an annual growth rate of 3%. At the commencement of operations in 2030, total ADT is projected to reach 19,921 vehicles per day, increasing to 63,089 vehicles per day by 2069. Traffic composition is dominated by Class I vehicles, accounting for approximately 76% of total traffic volume, followed by Class II vehicles.

Table 4. Summary of Average Daily Traffic Projections for the Rantauprapat–Kisaran Toll Road

Year	Class I	Class II	Class III	Class IV	Class V	Total ADT	Growth Rate
2030	15,163	4,161	497	44	56	19,921	-
2040	20,377	5,592	667	59	75	26,772	3%
2050	27,386	7,516	897	80	101	35,979	3%
2060	36,804	10,100	1,205	107	135	48,352	3%
2069	48,021	13,179	1,573	140	177	63,089	3%

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Source: Final Review Basic Design Report of the Rantauprapat–Kisaran Toll Road, 2020.

Annual toll revenue was calculated based on traffic volume by vehicle class, tariff per kilometer, toll road length, and the number of operating days per year. In addition to toll revenue, the project is assumed to generate non-toll revenue equivalent to 1.5% of toll revenue. The projection results indicate that annual toll revenue increases from approximately IDR 809 billion during the first year of operation to approximately IDR 13.642 trillion at the end of the concession period.

Table 5. Summary of Annual Toll Revenue Projections

Year	Class I Revenue	Class II Revenue	Class III Revenue	Class IV Revenue	Class V Revenue	Total Revenue
2030	549	226	27	3	4	809
2040	1,145	472	56	7	8	1,688
2050	2,390	984	117	14	18	3,523
2060	4,988	2,053	245	29	37	7,353
2069	9,255	3,810	455	54	68	13,642

Unit: IDR billion per year.

Source: Final Review Basic Design Report of the Rantauprapat–Kisaran Toll Road, 2020.

Class I vehicles contribute the largest share of total revenue, accounting for approximately 68–70% of annual toll revenues. Although their tariff rates are lower than those of heavy vehicles, their dominant traffic volume generates the most significant revenue contribution. Revenue growth throughout the concession period is driven by the 3% annual traffic growth rate and periodic tariff adjustments. Therefore, actual traffic realization and tariff adjustment policies represent critical variables that must be carefully managed, as changes in either parameter will directly affect the project's financial feasibility.

Operation and Maintenance Cost Estimation

Operation and maintenance (O&M) costs include toll collection expenses, toll road service costs, road maintenance expenses, and administrative costs. All cost components are assumed to increase by 6% annually, consistent with the assumptions in the Final Review Basic Design.

Table 6. Summary of Operation and Maintenance Cost Projections

Year	Toll Collection	Toll Road Services	Road Maintenance	Administration	Total O&M
2030	33.32	34.63	19.98	19.77	107.71
2040	59.67	62.02	35.78	35.41	192.88
2050	106.86	111.08	64.08	63.41	345.42
2060	191.36	198.92	114.76	113.57	618.60
2069	323.30	336.07	193.88	191.87	1,045.11

Unit: IDR billion per year.

Source: Final Review Basic Design Report of the Rantauprapat–Kisaran Toll Road, 2020.

Total O&M costs increase from IDR 107.71 billion in 2030 to IDR 1.05 trillion in 2069. The largest cost components are toll road services and toll collection activities, which together account for more than 60% of total operating costs. Despite this increase, the growth rate of O&M costs remains lower than the growth rate of project revenues, indicating that the project retains the potential to generate adequate operating cash flows.

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Projected Income Statement and Project Cash Flow

The projected income statement and cash flow were developed based on the Final Review Basic Design, adjusted to reflect the company's current conditions, particularly regarding the cost of capital and corporate tax rates. These projections were subsequently used to calculate NPV, FIRR, and PBP.

During the construction period from 2027 to 2029, the project generated negative cash flows due to investment expenditures totaling IDR 18.301 trillion. Following the commencement of operations in 2030, the project began generating revenues but continued to record accounting losses due to depreciation expenses and interest payments on project debt.

Table 7. Summary of Project Financial Performance Projections

Year	Revenue (IDR Billion)	Net Income After Tax (IDR Billion)	Net Cash Flow (IDR Billion)	Cumulative Cash Flow (IDR Billion)	Cumulative NPV (IDR Billion)
2027	-	-	(5,749)	(5,749)	(5,749)
2028	-	-	(6,093)	(11,842)	(11,293)
2029	-	-	(6,459)	(18,301)	(16,640)
2030	821	(155)	713	(17,588)	(16,102)
2031	846	(137)	732	(16,856)	(15,601)
2032	951	(38)	830	(16,026)	(15,083)
2033	980	27	844	(15,182)	(14,604)
2034	1,102	156	922	(14,259)	(14,128)
2040	1,714	829	1,287	(7,684)	(11,699)
2045	2,369	1,290	1,747	82	(9,994)
2050	3,576	2,163	2,621	11,279	(8,461)
2060	7,463	4,982	5,439	50,380	(5,870)
2069	13,846	9,985	9,985	120,310	(3,971)

Source: Researcher's calculations, 2026.

The project begins to generate positive net income in 2033 and achieves a positive cumulative cash flow in 2045. However, by the end of the concession period, the project still records a negative NPV of IDR 3.971 trillion. This finding indicates that although the project is capable of recovering its investment costs in nominal terms, the rate of return generated remains insufficient to cover the company's cost of capital.

Baseline Financial Feasibility

The final stage of the baseline analysis involved evaluating the financial feasibility of the Rantauprapat–Kisaran Toll Road project based on projected investment costs, revenues, operation and maintenance expenses, financing structure, and project cash flows over the 40-year concession period. The feasibility assessment was conducted using three investment indicators commonly applied in toll road infrastructure evaluation, namely the Financial Internal Rate of Return (FIRR), Net Present Value (NPV), and Payback Period (PBP). The results of the financial feasibility assessment under the baseline scenario are presented in Table 8.

Table 8. Financial Feasibility Results under the Baseline Scenario

Method	Value	WACC/Criteria	Evaluation Result
FIRR	8.351%	WACC + 4% = 13.906%	FIRR < WACC + 4%

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NPV (IDR billion)	(3,971)	NPV > 0	NPV < 0
Payback Period	15.95 years	≤ 12 years	Does not satisfy the criterion

The results indicate that the FIRR of 8.351% remains 5.56 percentage points below the company's minimum investment requirement of 13.906%. The project's NPV is also negative at IDR 3.971 trillion, indicating that the present value of future cash inflows is insufficient to cover both the investment costs and the cost of capital. Furthermore, the payback period of 15.95 years exceeds the maximum acceptable threshold of 12 years by 3.95 years. Therefore, the baseline scenario for the Rantauprapat–Kisaran Toll Road does not satisfy the financial feasibility criteria.

Testing Financial Feasibility Improvement Strategies (Single Scenario Analysis)

Following the baseline assessment, which demonstrated that the project did not meet investment feasibility requirements, the next stage involved testing several financial improvement strategies individually through single scenario analysis. This approach aimed to identify the contribution of each strategy to the investment indicators of FIRR, NPV, and PBP. The first strategy examined was the efficiency of capital expenditure (CAPEX) and operation and maintenance (O&M) costs, as these represent the largest expenditures throughout the toll road life cycle and therefore offer substantial potential for improving financial performance.

CAPEX and O&M Cost Efficiency

The cost efficiency analysis focused on investment costs (CAPEX) and operation and maintenance costs (O&M). CAPEX efficiency was determined through a benchmarking approach by comparing the investment cost per kilometer of the Rantauprapat–Kisaran Toll Road with those of the Pekanbaru–Dumai and Indrapura–Kisaran Toll Roads. The investment costs of the benchmark projects were adjusted using an annual construction escalation rate of 1.364% to ensure comparability in the same base year.

The investment cost of the Rantauprapat–Kisaran Toll Road was found to be approximately IDR 22.51 billion per kilometer, or 13.53% higher, than the average cost of the benchmark projects. Based on this finding, a 15% CAPEX efficiency scenario was established as a simulation of cost optimization rather than as an indication that the baseline investment costs were unreasonable.

In addition, O&M costs were evaluated because they represent a major determinant of project cash flow during the operational period. An O&M efficiency target of 20% was adopted based on the study by Maulana and Pria (2024) on the Manado–Bitung Toll Road, which demonstrated that a 20% reduction in O&M costs improved both IRR and NPV performance. O&M savings were assumed to arise from operational optimization, electronic toll collection technologies, improved labor productivity, and the implementation of condition-based maintenance systems.

Table 9. CAPEX and O&M Efficiency Testing Scheme

Scenario	CAPEX (IDR Billion)	Change from Baseline	First-Year O&M (IDR Billion)	Change from Baseline
Baseline	18,301,000	-	107.71	-
CAPEX and O&M Efficiency	15,561,000	-15%	86.16	-20%

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The implementation of these efficiency measures reduced total investment requirements from IDR 18.301 trillion to IDR 15.561 trillion, while first-year O&M costs decreased from IDR 107.71 billion to IDR 86.16 billion.

Table 10. Results of the CAPEX and O&M Efficiency Scenario

Method	Value	Criteria	Evaluation Result
FIRR	9.33%	≥ 13.90%	Not achieved
NPV (IDR billion)	(1,325.77)	> 0	Not achieved
Payback Period	14.31 years	≤ 12 years	Not achieved

The efficiency scenario increased the FIRR from 8.35% to 9.33%, improved the NPV from negative IDR 3.971 trillion to negative IDR 1.326 trillion, and shortened the payback period from 15.95 years to 14.31 years. Although these improvements were significant, none of the indicators satisfied the company's investment criteria.

Tariff Adjustment

Tariff adjustment was analyzed as a strategy to improve project revenue performance. Changes in toll tariffs directly influence toll revenues, project cash flow, NPV, FIRR, and payback period. However, tariff increases must also consider users' Ability to Pay (ATP) and Willingness to Pay (WTP). According to the Final Review Basic Design, users' ATP was estimated at IDR 1,907/km, whereas WTP was estimated at IDR 336/km. The baseline tariff of IDR 900/km remained below ATP but exceeded WTP. Therefore, tariff increases of 10%, 20%, and 30% were tested as sensitivity scenarios. Assuming a demand elasticity of −0.1, traffic volumes were expected to decrease by 1%, 2%, and 3%, respectively.

Table 11. Results of the Tariff Adjustment Scenarios

Scenario	Method	Value	Criteria	Evaluation
Tariff +10%	FIRR	9.21%	≥ 13.90%	Not achieved
	NPV (IDR billion)	(1,911.06)	> 0	Not achieved
	PBP	14.81 years	≤ 12 years	Not achieved
Tariff +20%	FIRR	9.67%	≥ 13.90%	Not achieved
	NPV (IDR billion)	(682.12)	> 0	Not achieved
	PBP	14.12 years	≤ 12 years	Not achieved
Tariff +30%	FIRR	10.09%	≥ 13.90%	Not achieved
	NPV (IDR billion)	518.56	> 0	Achieved
	PBP	13.54 years	≤ 12 years	Not achieved

The results show that tariff increases improved all financial indicators. The 30% tariff increase scenario produced the best performance, yielding an FIRR of 10.09%, a positive NPV of IDR 518.56 billion, and a payback period of 13.54 years. Nevertheless, the FIRR remained below the required threshold and the payback period exceeded the allowable limit, indicating that tariff adjustments alone are insufficient as a standalone strategy.

Financing Structure Optimization

Financing structure optimization was undertaken by increasing the debt proportion and reducing equity contributions in order to lower the project's cost of capital. The baseline financing structure consisted of 30% debt and 70% equity, while alternative structures of 50:50, 60:40, and 70:30 were tested.

Table 12. Results of Financing Structure Optimization

Debt : Equity	FIRR	WACC	NPV (IDR Billion)	PBP	Evaluation
50 : 50	9.24%	8.73%	1,626.99	14.71 years	Partial

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60 : 40	9.25%	8.14%	3,380.12	14.67 years	Partial
70 : 30	9.28%	7.56%	6,489.04	14.60 years	Partial

Increasing debt financing significantly reduced WACC and improved NPV performance. The 70:30 financing structure generated the best results with a WACC of 7.56% and an NPV of IDR 6.489 trillion. However, FIRR remained below the required threshold and the payback period still exceeded the target.

Government Support through Viability Gap Funding (VGF)

Viability Gap Funding (VGF) represents government support designed to improve the financial viability of economically beneficial but financially unattractive projects. VGF was assumed to reduce investment costs directly, thereby lowering debt and equity requirements proportionally. Scenarios of 30%, 40%, and 50% VGF support were evaluated.

Table 13. Results of VGF Scenarios

Scenario	FIRR	NPV (IDR Billion)	PBP	Evaluation
VGF 30%	10.15%	484.17	13.25 years	Partial
VGF 40%	10.98%	1,259.87	12.34 years	Partial
VGF 50%	12.03%	2,730.86	11.42 years	Partial

The findings demonstrate that VGF substantially improves project feasibility. Nevertheless, even under 50% VGF support, the FIRR remained below the required threshold despite satisfying both the NPV and PBP criteria.

Combination Scenario Analysis

Since none of the individual strategies were capable of satisfying all financial criteria, combination scenarios were developed by integrating VGF, tariff adjustments, CAPEX and O&M efficiencies, and financing structure optimization.

Table 14. Combination Strategy Scenarios

Code	Combination Strategy
K1	VGF 40% + 30% Tariff Adjustment
K2	VGF 40% + CAPEX and O&M Efficiency
K3	VGF 10% + CAPEX and O&M Efficiency + 70:30 Financing Structure

Table 15. Results of Combination Scenario Testing

Scenario	FIRR	WACC	NPV (IDR Billion)	PBP (Years)	Evaluation
VGF 40% + Tariff +30%	14.17%	9.91%	6,821	10.23	Meets all criteria
VGF 40% + CAPEX & O&M Efficiency	14.31%	9.91%	7,078	10.14	Meets all criteria
VGF 10% + CAPEX & O&M Efficiency + 70:30 Financing Structure	11.72%	7.56%	12,658	11.84	Meets all criteria

All combination scenarios satisfied the financial feasibility requirements. Although the VGF 40% plus CAPEX and O&M efficiency scenario generated the highest FIRR, the VGF 10% plus CAPEX and O&M efficiency combined with a 70:30 financing structure produced the highest NPV while requiring significantly lower government support. Therefore, this combination was selected as the preferred strategy due to its balance between financial feasibility, fiscal efficiency, and implementation practicality.

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Sensitivity Analysis of the Preferred Scenario

Sensitivity analysis of the preferred scenario focused on toll and non-toll revenues, CAPEX, and O&M costs. With a WACC of 7.56%, the minimum required FIRR was 11.56%, while the preferred scenario generated an FIRR of only 11.72%, leaving a margin of only 0.16 percentage points above the threshold.

Table 16. Sensitivity Analysis Results Based on FIRR Threshold

Parameter	Direction of Change	Switching Value	Interpretation
Toll and non-toll revenue	Decrease	2.34%	Maximum reduction before FIRR falls below 11.56%
CAPEX	Increase	2.41%	Maximum increase before FIRR falls below 11.56%
O&M costs	Increase	36.01%	Maximum increase before FIRR falls below 11.56%

Revenue was identified as the most sensitive parameter, followed by CAPEX, while O&M costs exhibited substantially greater tolerance. These findings indicate that accurate traffic forecasting and strict investment cost control are essential prerequisites for maintaining the financial feasibility of the preferred project configuration.

Conclusion

The findings indicate that the baseline condition of the Rantauprapat–Kisaran Toll Road project does not satisfy the financial feasibility criteria. The project generates a Financial Internal Rate of Return (FIRR) of 8.351%, which remains below the minimum threshold of WACC plus 4%, while the Net Present Value (NPV) is negative at IDR 3.971 trillion, and the Payback Period (PBP) reaches 15.95 years, exceeding the maximum acceptable limit of 12 years. These results suggest that the project is unable to generate an adequate rate of return under the baseline assumptions employed in this study.

The single-scenario analyses involving CAPEX and O&M efficiency improvements, tariff adjustments, financing structure optimization, and Viability Gap Funding (VGF) demonstrated improvements in the financial indicators but were insufficient to satisfy all feasibility criteria under realistic conditions. Tariff adjustments increased project revenues but were constrained by users' Ability to Pay (ATP) and Willingness to Pay (WTP). CAPEX and O&M efficiency measures improved project cash flows but required substantial cost reductions. Meanwhile, financing structure adjustments and VGF support enhanced NPV performance and shortened the payback period; however, the FIRR remained below the minimum required threshold.

The combination scenario analysis revealed that an integrated approach is more effective than implementing individual strategies independently. The combination of 10% VGF support, CAPEX and O&M efficiency measures, and a financing structure consisting of 70% debt and 30% equity generated an FIRR of 11.72%, a WACC of 7.56%, a positive NPV of IDR 12.658 trillion, and a Payback Period of 11.84 years. Consequently, this combination satisfies all financial feasibility criteria and was selected as the preferred scenario because it minimizes dependence on government support while simultaneously improving cost efficiency and optimizing the financing structure.

Sensitivity analysis further indicates that revenue and CAPEX are the most critical parameters affecting project feasibility. Even a relatively small reduction in revenue may cause the FIRR to fall below the minimum threshold, while increases in CAPEX directly raise investment requirements and reduce NPV. Therefore, the successful implementation of the preferred

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scheme depends heavily on accurate traffic forecasting, revenue assurance, effective investment cost control, O&M efficiency, and prudent financing management.

Future studies are recommended to update traffic projections, ATP, and WTP estimates using more recent data and to incorporate broader economic analyses, social benefits, and project risk assessments. In addition, probabilistic approaches could be employed to evaluate the robustness of the proposed scheme against uncertainties related to traffic demand, construction costs, interest rates, and project completion schedules.

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References

Abor, J. Y., Bekoe, I. K., & Macomber, J. (2025). Issues in airport infrastructure financing. In *The Routledge Handbook of Infrastructure Finance* (pp. 442-454). Routledge. https://doi.org/10.4324/9781032712031-27

Adeleke, O. J., Jovanovich, K. D., Ogunbunmi, S., Samuel, O., & Kehinde, T. O. (2025). Comprehensive exploration of smart cities: A systematic review of benefits, challenges, and future directions in telecommunications and urban development. *IEEE Sensors Reviews*, *2*, 228-245. https://doi.org/10.1109/SR.2025.3569239

Akomea-Frimpong, I., Jin, X., & Osei-Kyei, R. (2022). Managing financial risks to improve financial success of public—private partnership projects: a theoretical framework. *Journal of Facilities Management*, *20*(5), 629-651.

Aruan, R. P. P., Saryatmo, M. A., & Kristina, H. J. (2023). Usulan peningkatan kualitas produksi kemasan karton dupleks produk AA menggunakan metode Six Sigma dan Seven New Quality Tools. *Jurnal Muara Sains, Teknologi, Kedokteran dan Ilmu Kesehatan, 7*(1), 21–32. https://doi.org/10.24912/jmstkik.v7i1.22781

Basri, B., Badaruddin, B., Kusmanto, H., & Ridho, H. (2024, November). Strategic initiatives of the Kampar Regency government in optimizing the Trans-Sumatra toll road to improve the socio-economic welfare of the community. In *Proceeding Medan International Conference on Economic and Business* (Vol. 2, pp. 2104-2113). https://doi.org/10.1061/JMENEA.MEENG-4682

Cacciuttolo, C., Atencio, E., Komarizadehasl, S., & Lozano-Galant, J. A. (2024). Internet of Things long-range-wide-area-network-based wireless sensors network for underground mine monitoring: Planning an efficient, safe, and sustainable labor environment. *Sensors*, *24*(21), 6971. https://doi.org/10.3390/s24216971

Chilcott, C., Higgins, A., McFallan, S., Bruce, C., McKeown, A., Williams, L., ... & Hall, M. H. (2020). *Enhancing small holder linkages to markets by optimising transport and logistics infrastructure*. Final report AGB/2017/036, ACIAR.

Delapedra-Silva, V., Ferreira, P., Cunha, J., & Kimura, H. (2022). Methods for financial assessment of renewable energy projects: A review. *Processes*, *10*(2), 184. https://doi.org/10.3390/pr10020184

Du, J., Wang, W., Gao, X., Hu, M., & Jiang, H. (2023). Sustainable operations: A systematic operational performance evaluation framework for public–private partnership

ISSN: 2716-3865 (Print), 2721-1290 (Online)

transportation infrastructure projects. *Sustainability*, *15*(10), 7951. https://doi.org/10.3390/su15107951

Ery, S., & Isrochmani, M. (2022). The viability gap funding (VGF) scheme in construction assignment LRT Jabodebek Phase 2 project: Economic and financial analysis. *European Journal of Business and Management Research, 7*(4), 139–142. https://doi.org/10.24018/ejbmr.2022.7.4.1526

Fauzan, M., Kuswanto, H., & Utomo, C. (2023). Implementing toll road infrastructure financing in Indonesia: Critical success factors from the perspective of toll road companies. *International Journal of Financial Studies*, *11*(4), 135. https://doi.org/10.3390/ijfs11040135

Febrian, R. A., & Yuza, A. F. (2023). Plantation sector policy governance by the regional government of Riau province (leading commodities study). *Jurnal Ilmiah Peuradeun (JIP), the Indonesian Journal of the Social Sciences*, *11*(1), 345-362. https://doi.org/10.26811/peuradeun.v11i1.802

Hariyanti, F., & Syahza, A. (2024). Economic transformation based on leading commodities through sustainable development of the oil palm industry. *Heliyon*, *10*(4). https://doi.org/10.1016/j.heliyon.2024.e25674

Hartati, V., Fauzi, M., & Salma, M. (2025). Determining the International Hub Port on Sumatra Island Using the Integration of Geographic Information System and Analytical Hierarchy Process Methods. *Spektrum Industri*, *23*(2), 263. https://doi.org/10.12928/si.v23i2.361

Hartoyo, Y., & Utomo, C. (2019). Sensitivity analysis to determine the prospect of toll road investment: Case study Krian-Legundi-Bunder-Manyar toll road. *Traffic*.

Heizer, J. (2016). *Operations management* (11th ed.). Pearson Education India.

Hu, Y., Li, Y., & Xu, M. (2026). The Trans-Sumatra Toll Road and Economic Geography in Indonesia. *Journal of Economic Geography*, lbag039. https://doi.org/10.1093/jeg/lbag039

Jayathilake, H. M., de la Porte, C., Chang, J. W., Edwards, D. P., & Carrasco, L. R. (2023). Transnational evidence for socio-economic factors affecting income and plantation expansion into natural habitats in smallholder rubber. *Resources, Conservation & Recycling Advances*, *18*, 200161. https://doi.org/10.1016/j.rcradv.2023.200161

Latief, Y., Berawi, M. A., Rarasati, A. D., Supriadi, L. S., Berawi, A. R. B., & Hayuningtiyas, I. S. (2016). Mapping priorities for the development of the transportation infrastructure in the provincial capitals of Indonesia. *International Journal of Technology*, *7*(4), 544-552. https://doi.org/10.14716/ijtech.v7i4.2677

Li, W., Yuan, J., Zhang, G., Wei, S., Zhang, B., & Skibniewski, M. J. (2023). Agent-based simulation modeling for the evaluation and dynamic adjustment of project benefits in urban rail transit PPPs. *Journal of Management in Engineering*, *39*(2), 04022074. https://doi.org/10.1061/JMENEA.MEENG-4682

Meng, J., Ye, Z., & Wang, Y. (2024). Financing and investing in sustainable infrastructure: A review and research agenda. *Sustainable Futures*, *8*, 100312. https://doi.org/10.1016/j.sftr.2024.100312

Mielcarz, P., Osiichuk, D., & Struciński, A. (2025). The cost of capital calculation in the project finance settings. *Journal of Banking and Financial Economics*, (2 (24)), 60-75. https://doi.org/10.2139/ssrn.4930937

ISSN: 2716-3865 (Print), 2721-1290 (Online)

Montgomery, D. C. (2020). *Introduction to statistical quality control*. John Wiley & Sons.

Nurfatriani, F., Sari, G. K., Saputra, W., & Komarudin, H. (2022). Oil palm economic benefit distribution to regions for environmental sustainability: Indonesia's revenue-sharing scheme. *Land*, *11*(9), 1452. https://doi.org/10.1108/JFM-03-2021-0036

Pande, P. S., Neuman, R. P., & Cavanagh, R. R. (2002). *The Six Sigma way team fieldbook: An implementation guide for project improvement teams*. McGraw-Hill.

Peraturan Presiden Republik Indonesia Nomor 42 Tahun 2024 tentang perubahan ketiga atas Peraturan Presiden Nomor 100 Tahun 2014 tentang percepatan pembangunan jalan tol di Sumatera. (2024).

Pirouzrahi, Z., Vanelslander, T., & Aghdam, A. N. (2025). Applying system dynamics modelling to modal shift: A systematic review. *Sustainable Futures*, *9*, 100526. https://doi.org/10.1016/j.sftr.2025.100526

Ponomarenko, T., Marin, E., & Galevskiy, S. (2022). Economic evaluation of oil and gas projects: justification of engineering solutions in the implementation of field development projects. *Energies*, *15*(9), 3103. https://doi.org/10.3390/en15093103

Ridwan, S., Syah, T. Y. R., Kustiawan, U., & Nofierni, N. (2025). Financial planning and investment feasibility analysis based on five-year projections using ROI, NPV, IRR, and financial ratios. *Journal La Bisecoman*, *6*(2), 489-506.

Rimmer, P. J., & Dick, H. (2012). Economic space for transnational infrastructure: gateways, multimodal corridors and special economic zones. In *Infrastructure for Asian Connectivity* (pp. 217-253). Edward Elgar Publishing. https://doi.org/10.4337/9781781003138.00016

Rodríguez-Sanz, Á., & Rubio Andrada, L. (2023). Cost–Benefit Analysis of investments in Air Traffic Management infrastructures: A behavioral economics approach. *Aerospace*, *10*(4), 383. https://doi.org/10.3390/aerospace10040383

Sohaee, N., & Bohluli, S. (2024). Nonlinear analysis of the effects of socioeconomic, demographic, and technological factors on the number of fatal traffic accidents. *Safety*, *10*(1), 11. https://doi.org/10.3390/safety10010011

Stamatis, D. H. (2003). *Failure mode and effect analysis*. Quality Press.

Suryana, H., & Muttaqien, Z. (2026). Feasibility Analysis of Toll Road Investment Due to the Risk of Construction Cost Increases and Schedule Changes (Patimban Port Access Toll Road). *Jurnal Media Teknik dan Sistem Industri*, *10*(1), 112-123. https://doi.org/10.35194/jmtsi.v10i1.6014

Truong, T. M. T., Friedrich, H., & Charoenngam, C. (2020). Success factors for financial sustainability of toll road projects: Empirical evidence from China. *Transportation Research Procedia, 48*, 1848–1860. https://doi.org/10.1016/j.trpro.2020.08.219

Vickerman, R. (2024). The transport problem: The need for consistent policies on pricing and investment. *Transport policy*, *149*, 49-58. https://doi.org/10.1016/j.tranpol.2024.02.009

Volden, G. H., & Welde, M. (2022). Public project success? Measuring the nuances of success through ex post evaluation. *International Journal of Project Management*, *40*(6), 703-714. https://doi.org/10.1016/j.ijproman.2022.06.006

Waruwu, A., Tampubolon, V. R., Pratama, M. A., & Putri, D. (2022). Pengendalian kualitas metode Six Sigma untuk mengurangi tingkat kerusakan produk kalender di PT. KLM. *IMTechno: Journal of Industrial Management and Technology, 3*(2), 82–90.

ISSN: 2716-3865 (Print), 2721-1290 (Online)

Wraharjo, M., Susanti, B., & Kadarsa, E. (2022). Financial feasibility analysis of cost and traffic volume: Case study on toll road investment project. *Engineering & Applied Science Research*, *49*(3), 308.

Wraharjo, M., Susanti, B., & Kadarsa, E. (2022). Financial feasibility analysis of cost and traffic volume: Case study on toll road investment project. *Engineering & Applied Science Research*, *49*(3), 308.

Yunian, B. T., Negoro, Y. P., & Priyana, E. D. (2024). Analisis pengendalian kualitas packaging tepung terigu kemasan 25 kg dengan metode Six Sigma dan Failure Mode Effect Analysis. *G-Tech: Jurnal Teknologi Terapan, 8*(2), 1231–1241. https://doi.org/10.33379/gtech.v8i2.4231

ISSN: 2716-3865 (Print), 2721-1290 (Online)