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Feasibility Analysis of Lake Toba Coastal Roads in Simalungun Regency

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ABSTRACT

The success of development is inseparable from the active participation of the transportation sector. Where the transportation sector is the lifeblood of economic, social, cultural, political and defense-security. The development of the transportation sector is directed at realizing a transportation system that is reliable, highly capable and organized in an integrated, orderly, smooth and comfortable manner; can drive the dynamics of development, the mobility of goods, people and services all at once. Land transportation, one of which is the Road, is a connecting infrastructure by land that is used for human and goods traffic from one place to another. In addition to the aspect of spatial planning activities, the road network has the benefit of directing the growth of an area it traverses, as stated in Regional Regulation no. 10 of 2012 concerning Spatial Planning for the Simalungun Regency, stipulates a transportation network structure plan that is intended to direct the distribution of transportation services and the development of the Simalungun Regency area. At present it is felt that the road on the coast of Lake Toba, Simalungun Regency, is still unable to serve traffic smoothly and safely. There are still locations for these passages that are felt to still need to be addressed to obtain adequate technical feasibility standards, there are still areas that cannot be accessed and have adequate transportation facilities. Determining the economic feasibility of a road maintenance program, it is necessary to analyze the feasibility features economy. In this study, what will be discussed is the feasibility of a road maintenance project with the help of the HDM – III program, then analyzing the output of the program in the form of an analysis of Benefit Cost Ratio, Net Present Value, and Internal Rate of Return. The results of using the HDM-III model show that based on the analysis of road damage, handling with scenario 3 produces better functional road conditions compared to other scenarios. The economic analysis also shows that scenario 3 is more economically feasible than the other scenarios, with minimum maintenance costs and maximum benefits in the form of vehicle operating costs, this is indicated by the NPV, BCR, and IRR values.

Keywords: Feasibility Study, HDM – III, Vehicle Operating Costs, Time Value, NPV, BCR, IRR, Missing Link Planning.

INTRODUCTION

With good facilities and infrastructure, the economy of Simalungun Regency, especially on the shores of Lake Toba, can grow and develop and stimulate growth in other fields. In order to carry out the improvement of the road network, a study is needed in the form of a Feasibility Study in order to identify the need for handling as well as the sections that are feasible to handle. With the feasibility study, it is hoped that all analysis related to technical, economic and work related to it will be obtained, in the context of carrying out studies and handling plans that need to be carried out. Recommendations from this study are expected to be used as material for policy makers in determining implementation strategies that involve technical, economic, environmental and management programs.

Simalungun is the third largest district after Mandailing Natal Regency and Langkat Regency in North Sumatra and has a strategic location and is in the tourist area of Lake Toba - Parapat. Simalungun Regency is

located at an altitude between 0 and 1400 meters above sea level, located between 02036' - 030 18' North Latitude and between 980 32' – 990 35' East Longitude. The total area of Simalungun Regency is a land area of 4372.5 km2.

Administratively, Simalungun Regency has the following boundaries:

- North : Serdang Bedagai District
- South : Toba Samosir Regency
- East : Karo Regency
- West : Batubara District

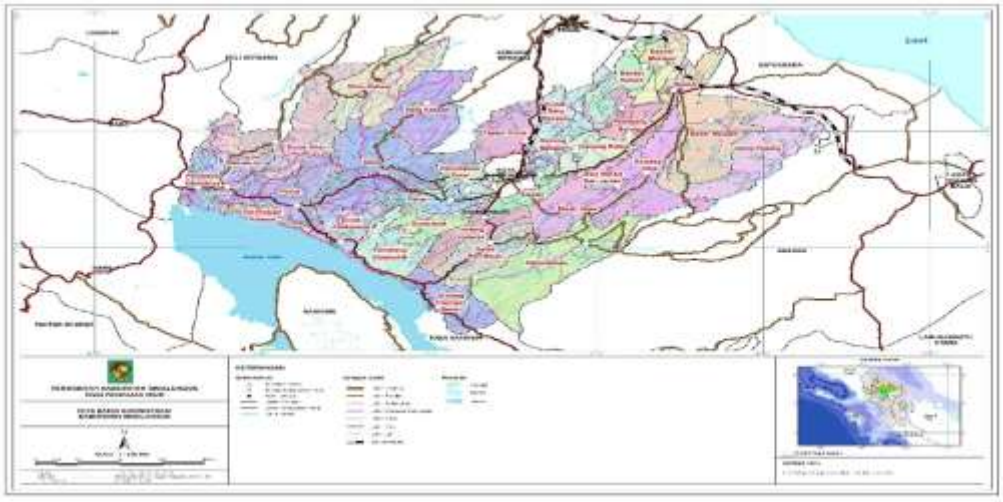
Simalungun Regency consists of 32 sub-districts with the widest sub-district being Hatonduhuan District while the smallest is Haranggaol Horison District with an average distance to the district capital of 30 km where the farthest distance is Silou Kahean District 127 km and Ujung Padang District 113 km.

Table 1. Area by District in Simalungun Regency 2020

No	District	Area (Km^2)
1	Silimakuta	74,16
2	Pematang Silimakuta	79,68
3	Purba	172,71
4	Haranggaol Horison	40,97
5	Dolok Pardamean	67,90
6	Sidamanik	80,88
7	Pematang Sidamanik	137,80
8	Girsang Sipangan Bolon	129,89
9	Tanah Jawa	174,33
10	Hatonduhan	336,26
11	Dolok Paribuan	148,62
12	Jorlang Hataran	93,70
13	Panei	77,96
14	Panombean Panei	73,74
15	Raya	261,56
16	Dolog Masagal	105,77
17	Dolok Silou	302,66
18	Silou Kahean	228,74
19	Raya Kahean	204,89
20	Tapian Dolok	119,89
21	Dolok Batu Nanggar	106,91
22	Siantar	73,99
23	Gunung Malela	96,74
24	Gunung Maligas	51,39
25	Hutabayu Raja	191,43
26	Jawa Maraja Bah Jambi	38,97
27	Pematang Bandar	88,16
28	Bandar Huluan	107,33
29	Bandar	100,69
30	Bandar Masilam	91,22
31	Bosar Maligas	285,43
32	Ujung Padang	228,49
Simalungun		4.372,50

Source: Simalungun Regency in Figures 2021

Figure 1. Topographic map



Likewise with the tourism potential, there are very prospects for developing and synergizing with the Central Government Program, namely the Lake Toba KSPN. Moreover, if all the roads on the coast of Lake Toba Simalungun can be connected properly, then the coast of Lake Toba Simalungun is no less beautiful than other areas based on the description above, then the road construction plan (missing link) in Simalungun Regency must be studied first which has the goal to see whether it is appropriate or not to implement. In addition, the construction of this road (missing link) will require costs, both in terms of construction and maintenance. And the

construction of this road will have an impact on economic growth, the calculation of which is obtained from a comparison of the costs of building a road and its maintenance compared to time efficiency and fuel use. in terms of connectivity or integration of connecting roads to tourist areas, the points of the road that need to be handled immediately as in the submitted proposal, namely the repair of the Bage-Haranggaol-Tigaras-Sipolha Intersection road with a length of 50 kilometers. The road is a ring road in the coast of Lake Toba Simalungun. In addition, road repairs in the city of Parapat.

Research Purposes and Objectives

1. The purpose of this research is to conduct a study of the planned development of the coastal road of Lake Toba in order to support community movements to be more effective and efficient.
2. To take into account whether or not it is appropriate to handle/improve the new road in terms of various aspects and interests so that it can become input to policy makers in determining the investment strategy for the activities to be carried out.

LITERATURE REVIEW

Accessibility And Mobility

Accessibility is a measure of the convenience of how land-use locations interact with each other and how easy and difficult these locations are to be reached through the transportation system (Black, 1981).

Geometric Planning

In Government Regulation Number 34 of 2006 concerning Roads. Article 9 paragraph 3, states that the function of the road in the primary network system is divided into primary arteries, primary collectors, local primary, and primary environment. Classification of roads in Indonesia according to Highways in the Procedures for Geometric Planning of Intercity Roads (TPGJAK) No038/T/BM/1997.

Travel Encumbrance Analysis

The purpose of this loading process is to estimate the volume of traffic on road sections and at intersections if any, and to obtain an estimate of the cost. The travel assignment in this study is carried out directly from one location to another.

Basic Relationship between Volume, Speed and Density According to Tamin (2008), in a movement of traffic on the highway there are 3 (three) main variables used to describe the characteristics of traffic flow, namely:

1. Volume (Flow/Q), is defined as the number of vehicles that pass a certain review point on a road section per unit of time (vehicles/hour).
2. Speed (Speed/Us), is defined as the distance that can be travelled by a vehicle per unit time. The units commonly used are meters/second or kilometers/hour.
3. Density (D), defined as the number of vehicles per unit length of a particular road. The units used are vehicles/ kilometers or vehicles/meters.

Regional Infrastructure Network System Plan

The plan for the infrastructure network system for the Simalungun Regency area includes transportation, energy, telecommunications and water resources infrastructure systems that integrate them and provide services for existing activity functions in the district area.

Main Infrastructure Network System Plan

What is meant by the main infrastructure network system is the regional transportation network. A good transportation network system is a very important aspect in the development of a region because it supports easy access from and to various directions, be it transportation infrastructure, transportation facilities, activity systems, movement systems or network systems. The pattern of movement of people and goods transport can be broadly divided into 2 (two) types, namely:

a. Traffic within local area/movement

Traffic within the regency area will move from city to city or from city to village and from village to village, and vice versa. Generally the movement of traffic flow starts from the village to the sub-district capital area, to the district capital with the intention of working, going to school and shopping. Thus the volume of traffic flow for this type of movement will increase, starting from villages, sub-district cities to district capitals, especially on weekends.

b. Traffic in and out of the area
   In particular, this traffic is coming from cities outside the Simalungun Regency area through existing roads.

Traffic Condition Analysis (Year 2020)

Analysis of traffic conditions in the existing conditions in 2020 can be done by loading traffic. Traffic loading analysis is carried out to determine the amount of load on roads and intersections. The loading model used is loading with the help of Vissim software. Economic Feasibility Calculation Analysis. At this feasibility calculation stage, three investment criteria are used, namely:

NPV (Net Present Value) is a calculation of profits in the form of money or non-financial received or felt by investors during the economic life of the investment. If the NPV ≥ 0, investment decisions can be continued.

IRR (Internal rate of return) is the amount of a certain discount rate that results in a value.

BCR (Benefit Cost Ratio) is a calculation of profit in the form of money or non-financial as long as the NPV is equal to 0. If IRR ≥ bank loan interest rates, investment decisions can be continued.

Road Trace Determination Analysis

Analysis of Determining Road Traces is carried out to calculate the horizontal and vertical alignment sizes which are then used as the basis for calculating excavation and embankment as well as layers of road pavement as the total investment to be issued. The 59.29 Km route plan is used as material for discussion with stakeholders in terms of the construction of the Lake Toba coastal road from Bage to Sipolha. The scoring results with technical variables only serve as a supporting assessment of the continued development plan for road network sections along the shores of Lake Toba and not as a determinant of the feasibility value of a road section.

Table 2. Eligibility level

No	Indicator	Quality	Criteria		Grade	SCORE
1	Economic feasibility Planned Traffic Characteristics	20%	B/C-R	0,5 - 0,6	1	12
				0,6 - 0,7	2	
				0,7 -0,8	3	
				0,8- 0,9	4	
				0,9 -1,0	5	
				1,0 - 1,1	6	
				1,1 -1,2	7	
				1,2 -1,3	8	
				1,3 -1,4	9	
				1,4 -1,5	10	
2	New Path Function	6%	Smooth Traffic		2-5	6
			Area Development		2-5	
3	Social Environmental Impact	16%	Environmental Impact : Noise, Pollution, Water Quality, Soil Degradation, etc	Very good	2	9,6
				Good	4	
			Social Impact, reviewed during pre-construction, construction and post-construction	Currently	6	
				Bad	8	
				Very bad	10	
4	Road Network Development	6%	Likelihood of occurrence :	Big	10	6
			1. Expansion of DAMIJA	Currently	7,5	
			2. The growing class of interconnection roads	Small	5	
			3. Additional district roads	There isn't any	2,5	
5	Planned Traffic Characteristics	12%	Design Speed (km/h)			9,6

Adopted from SNI Pd T-19-2005-B, concerning Guidelines for the Feasibility Study of Roads and Bridges
Source: Consultant Calculation Results for 2022

MATERIALS & METHODS

Data collection

The data collected in this study is divided into 2 types of data, namely:

Secondary Data

a) Data on the total population, area, and division of administrative areas of the Regency Simalungunfrom BPS Simalungun Regency
b) Simalungun Regency RTRW and RUTRK maps from BAPPEDA;
c) Map of the Simalungun Regency Road network from the Public Works Service;
d) The number of motorized vehicles in Simalungun Regency from Traffic Police of Simalungun District Police.

Primary data

The primary data in this study is data obtained from the implementation of the survey in a general way directly in the field, namely:

a. Inventory survey of roads and intersections
b. Traffic enumeration survey (TC and CTMC)
c. Traffic enumeration survey (TC and CTMC)

STATISTICAL ANALYSIS

ANALYSIS OF CURRENT STREET CONDITIONS IN 2020

1. Road Capacity

There are 5 roads around the study area, namely the Simalungun district area. The roads can be seen in the table below:

Table 3. Road Sections in the Simalungun Area1

1.	TONGGING/ BATAS KARO - BAGE		STA	0+000 - 1+870
2.	BAGE - HUTA IMBARU - GAOL		STA	1+870 - 11+540
3.	HARANGGAOL - GAOL		STA	11+540 - 23+300
4.	JALAN PERKOTAAN HARANGGAOL		STA	23+300 - 25+010
5.	HARANGGAOL - SIMPANG SALBE		STA	25+010 - 42+670
6.	SIMPANG SALBE - PELABUHAN TIGARAS		STA	42+670 - 45+230
7.	PELABUHAN TIGARAS - TAMBUN REA		STA	45+230 - 50+100
8.	TAMBUN REA - HUTA II SIPOLHA		STA	50+100 - 54+680
9.	HUTA II SIPOLHA - SIPOLHA		STA	54+580 - 57+790
10.	SIMPANG SIPOLHA - SIPOLHA		STA	57+790 - 59+290

2. Traffic Volume

Traffic volume on roads in the Simalungun Regency is the result of a classified traffic volume enumeration survey.

3. Proportion of Mode usage

From the results of household interviews that have been conducted, the percentage of mode selection for travel is obtained in the study area of Simalungun Regency, as shown in Table 4.

Table 4. Mode Selection Percentage

No	2018	2019	2020	2021	Deviation	LP 2020 (%)	LP average
MP	3.892	2.742	2.320	2.345	25	1,08	1%
Bus	10	13	15	16	1	6,67	
Truck	1.123	1.090	931	1.064	133	14,29	
Motorcycle	19.079	17.566	14.325	14.468	143	1,00	

Source: Consultant Calculation Results for 2022

DETERMINATION ANALYSIS OF TRASE ROADS

A. Route selection

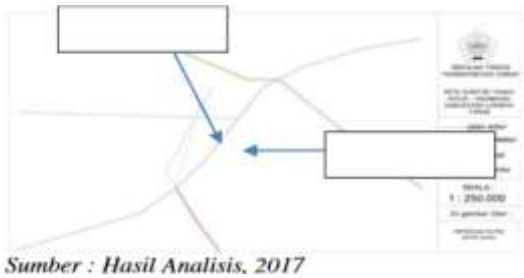
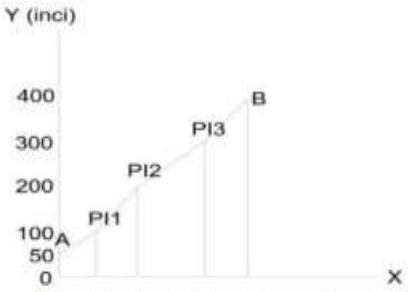


Figure 2. Trace plan

b. Road Trace Planning

Hipsographic map with a scale of 1:250,000, to determine the road alignment and perform calculations of azimuth, bend angles and PI distances.



Sumber : Hasil Analisis, 2017

Figure 3. Graph of Azimuth Angle, PI Distance, and PI Angle

c. Transportation Modeling

Transportation modeling analysis is used to carry out planning analysis using a four-step planning model to find out the estimated trips in the plan year (2021). The stages of the Four step model will be explained below:

1) Travel Revival

2) Travel Distribution

Table 5. Trace Selection Distribution

Trase	Section	STATIONING		Location Description	Long
		Initial STA	Final STA		(Km)
Lake Toba Coastal Road	1	0 + 000	1 +870	TONGGING/ BATAS KARO - BAGE	1,87
	2	1 + 870	11 + 540	BAGE - HUTA IMBARU - GAOL	9,67
	3	11 + 540	23 + 300	HARANGGAOL - GAOL	11,76
	4	23 + 300	25 + 010	JALAN PERKOTAAN HARANGGAOL	1,71
	5	25 + 010	42 + 670	HARANGGAOL - SIMPANG SALBE	17,66
	6	42 + 670	45 + 230	SIMPANG SALBE - PELABUHAN TIGARAS	2,56
	7	45 + 230	50 + 100	PELABUHAN TIGARAS - TAMBUN REA	4,87
	8	50 + 100	54 + 580	TAMBUN REA - HUTA II SIPOLHA	4,58
	9	54 + 580	57 + 790	HUTA II SIPOLHA - SIPOLHA	3,11
	10	57 + 790	59 + 290	SIMPANG SIPOLHA - SIPOLHA	1,5
TOTAL					59,29

Source: Consultant Calculation Results for 2022

So the route chosen according to the criteria above is alternative route 2, when viewed from the criteria for determining the route.

d. Distance Calculation

e. Calculation of Transverse Slope

The terrain classification for this road is flat terrain, for collector roads with flat terrain classification in the 1997 TPGJAK it is stated that the maximum flat road slope for urban roads is 6%, so the planned road meets the requirements.

f. Horizontal Alignment Calculations

$$f_{max} = 0.153$$

$$R_{min} = \frac{60^2}{127(0.06 + 0.153)}$$

$$R_{min} = 133.08\ m$$

$$D_{max} = \frac{181913.53\ x(0.06 + 0.153)}{60^2}$$

$$D_{max} = 3.805$$

1) Determine Superelevation Bend

Determine the superelevation at the Bend PI2:

$$D_d = \frac{1432,39}{Rd}$$

$$= \frac{1432,39}{135}$$

$$= 10,61^0$$

$$e_d = \frac{-0,06x10,61^2}{10,76^2} + \frac{2x0,06x10,61}{10,76}$$

$$= 0,0583 = 5,8\%$$

2) Advanced Superelevation Calculation

Calculation of Transitional Arch (Ls) Based on the maximum travel time (2 seconds) to

cross the transitional arch, the length of the arch is:

$$Ls_{min} = \frac{60}{3,6} x\ 2$$
$$= 33\ m$$

g. Azimuth calculation

h. PI Angle Calculation

Based on the level of achievement of changes in slope. Ls is determined which meets the two criteria mentioned above, so the longest Ls value is chosen, namely 33 meters.

i. Calculation of Bend Measurements
Lc < 20 meters
-29.4 m < 20 meters
Lc < 20 meters, with a speed (Vd = 60km/hour) then meets the S-S requirements (Spiral –
Spiral).

The 2Ts value is more than the superelevation length (Ltotal), so it is eligible for S-S type bend.

j. Calculation of Pavement Widening at the PI Bend. With the information that the largest passing vehicle is a 2 axle truck.
Calculation:
B = n(b' c) (n-1)Td+Z
= 2(2.65+1)+(2-1)0.107+0.54
= 7.95 m
Additional width
E = B-W = 7.95 – (2x3.5) = 0.95 m
B > W

k. Side Freedom Calculation

Vertical Alignment Calculation
1. Calculation of Longitudinal Slope

Plan Speed (Km/jam)	Slope (%)	Critical Length (M)
100	4 5 6	700 500 400
80	5 6 7	600 500 400
60	6 7 8	500 400 300

Table 6. Calculation of Longitudinal Slope

2. Calculation of Vertical Curvature:
Δ = g2 – g1
Δ = 2.56 – (- 1.28)
Δ = 3.84 %
Convenience terms
Lv = V x t
Lv = 60 Km/hour x 2 seconds
Lv = 30 m
Ev = (Δ x Lv)/800
= (3.84 x 30)/800 = 0.144 m
Y = (Δ x X2)/(200 x Lv) = (3.84 x X2)/(200 x 30)
= 0.00064 x X2
m. PV2 vertical arc stationing:
Sta A = Sta PVI2 – ½ Lv
= (0+100) – ½ 30
= 0+85
Sta B = Sta PVI2 + ½ Lv
= (0+100) + ½ 30
= 0+115
n. Vertical arch elevation
Elevation A = Elevation PVI2 – ½ Lv x g1
= 100 – ½ 30 x 1.28
= 80.8 m
Elevation B = Elevation PVI1 + ½ Lv x g1
= 100 + ½ 30 x 1.28
= 119.2 m

RESULT

Calculation of road alignment planning above produce:

1. The length of the planned road from Simalungun is 358 meters.
2. There is one bend that meets the requirements of the S-S type with the bend length 33 meters, additional width at corners 0.95 meters.
3. The maximum horizontal slope on a flat road is 5.8%

BUDGET PLAN

According to the Decree of the Simalungun Regency Regent Number: 188.45/427/ADPEM/2014 dated 27 October 2016 concerning Standard Unit Price of Wages and Building Materials.

Table 7. Budget for Road Development

No	Job description	Long (Km)	Treatment Plan	THE AMOUNT OF COSTS (Rp.)
1	TONGGING/ BATAS KARO - BAGE	1,87	Reconstruction	9.009.000.000,00
2	BAGE - HUTA IMBARU - GAOL	9,67	Reconstruction	46.586.000.000,00
3	HARANGGAOL - GAOL	11,76	Reconstruction	56.654.000.000,00
4	JALAN PERKOTAAN HARANGGAOL	1,71		-
5	HARANGGAOL - SIMPANG SALBE	17,66	Reconstruction	60.990.000.000,00
6	SIMPANG SALBE - PELABUHAN TIGARAS	2,56	Widening	9.954.000.000,00
7	PELABUHAN TIGARAS - TAMBUN REA	4,87		-
8	TAMBUN REA - HUTA II SIPOLHA	4,58		-
9	HUTA II SIPOLHA - SIPOLHA	3,11		-
10	SIMPANG SIPOLHA - SIPOLHA	1,5	Reconstruction	964.000.000,00
			AMOUNT	184.157.000.000,00
Spelled: One Hundred Eighty Four Billion One Hundred Fifty Seven Million Rupiah				

Source: Consultant Calculation Results for 2022

CHARGING ANALYSIS IN 2016

The development of the road network model is used to describe the existing road network, both sections and in the Simalungun area,

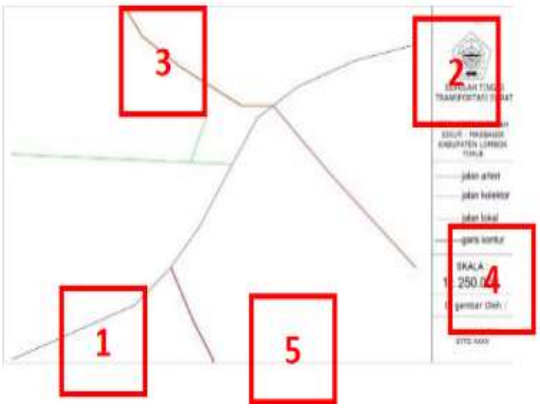


Figure 4. The Road Network in Vissim in the Sikur – Paokmotong Area

a. Model validation with survey results
Traffic modeling at the traffic loading analysis stage above uses
the help of Vissim software.
Decision rule:
Determine the test criteria
H0 : accepted if X2 count < 11.07
H0 : rejected if X2 count > 11.07

Travel Cost Efficiency Analysis

Travel efficiency value, calculated from the value of time and travel costs in the form of consumption

The profit calculation is adjusted to the planned life of the road construction project, namely 20 years.
From the total efficiency calculation table above, it can be seen that the results of calculating the total efficiency of fuel use and the value of travel time each year get the total efficiency value until 2036 of Rp. 2,088,848,017.00.

ENVIRONMENTAL ANALYSIS (EXHAUST EMISSIONS)

In this study, the analysis of vehicle emission load calculations uses the method emission load calculation based on Minister of Environment Regulation No. 12 of 2012.

DISCUSSION

ECONOMIC FEASIBILITY ANALYSIS

a. Benefit Cost Ratio (BCR)

$$BCR = \frac{\text{PV Benefits}}{\text{PV Cost}} = \frac{1,796,738,538}{1,133,537,000} = 1.59$$

BCR value > 1. This means that the road development plan (missing link) Simalungun Regency is feasible to implement. To be able to see how far a the investment made can provide benefits/profits or not, it is necessary

b. Net Present Value (NPV)

Table 8. NPV for road construction in Simalungun District

Economic Indicator Magnitude	Discount Rate						
	5%	10%	EIRR	15%	20%	25%	30%
Net Present Value - NPV (Juta Rp)	-1.351	86.163	1.89	-113.987	-133.417	-146.489	-155.506
Benefit Cost Ratio - BCR	0.76	1,71	**1.07**	0,43	0,32	0,24	0,19
Economic Internal Rate of Return – EIRR (%)	**13,5%**						

NPV value > 0. This means that the road development plan (missing link) Simalungun Regency is feasible to implement.

c. Internal Rate Of Return (IRR)

Simalungun Regency has a prevailing interest rate of 12.03%. This reference is then used as a guideline for calculating the IRR

NPV at a discount rate of 12% = + Rp. 173,508,272

NPV at a discount rate of 20% = + Rp. 289,180,453

NPV at a discount rate of 22% = + Rp. 318,098,498

IRR value > 12.3%. This means planning for the construction of a road (missing link) in Simalungun Regency is feasible to implement.

CONCLUSION

Based on the results of the data analysis that has been done, it can be concluded:

1. In the loading process with the help of the Vissim software, it is known that the performance of the road network in the Sikur-Paokmotong Area in current conditions (2016) and in planned conditions (2021), indicates that with a new connecting road (missing link) in the plan year have better road network performance.
2. The efficiency of annual travel costs due to savings in travel time in 2036 is IDR 217,314,417.00. The cost efficiency of fuel consumption in 2036 is Rp. 1,871,533,600.00 . And the total efficiency of travel costs in 2036 is Rp. 2,088,848,017.00.
3. If you look at the economic feasibility requirements for accepting a project, that is, a project can be accepted if it has an NPV > 0, IRR > the applicable interest rate, and BCR > 1. Based on the results of the analysis, the planned road is deemed feasible to build because it has an NPV of IDR 1,445,902,264, the IRR is more than the interest rate, which is 20.96% and the BCR is 1.

Declaration by Authors

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