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Road widening in west Papua: A design and economic feasibility analysis of urban green infrastructure

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Abstract

Planned road expansion in Manokwari, West Papua, along 6.5 km of the Maruni - - Dr. Esau Sesa in phase I of 2024 will prioritize low-carbon development and climate resilience. Road design enhancement and economic and financial analysis are conducted in this research. In the economic analysis, the National Road Administration Agency, the Head of Public Works and Spatial Planning, and the Regional Development Planning Agency from the regency and provincial collaborated on budget tagging. The proposed design incorporates bicycle lanes, green infrastructure in tree-based pedestrian areas as an energy source for biomass pellets, solar panel-based street lights, drainage along pedestrians to anticipate extreme weather and flooding, rehabilitation of mangroves whose ecosystem function has diminished, and retaining buildings erosion for damaged mangroves. The economic analysis begins with the calculation of the Vehicle Operating Cost (VOC) for large cities using the ratios 1:7 (Light Vehicle, LV) and 1:4 (Heavy Vehicle, HV). Time savings of up to 10 minutes and total VOC contribute to the total savings. Furthermore, an analysis of NPV > 0, IRR > 15%, BEP in the fifth and sixth year, and net B/C ratio > 0 indicates that road improvement is feasible based on economic analysis.

Keywords: Road; Design; VOC; Time savings; Total savings; NPV; IRR; BEP; Net B/C ratio

1. Introduction

An internal feature of the vulnerability identified in this study is the increase in the number of inhabitants and cars, the district and provincial office lines, and the loss in the capacity of the Drs. Esau Sesa - Maruni. According to research in 2021 [1], the road capacity (C) is 2,061 vehicles/hour, the average volume of traffic (Q) is 1,666 vehicles/hour, the degree of road saturation (DS=Q/C) is 0.81, and it is classified as service level D. That is, Jalan Dr. Esau Sesa – Maruni began to become unstable, there was a minor traffic bottleneck with slightly unsafe behavior, and the number of cars was approaching maximum capacity. However, the most recent data show that the current Q value has reached 2,528 vehicles/hour, with a DS value of 1.23 [2], placing it in the F category, which includes limited traffic flow, low speed, volume below capacity, and frequent stops. These factors influence noise, vibration, pollutants, air pollution, emissions, road users, and the convenience of neighboring residential areas [3,4,5,6].

In addition, the plan for developing and expanding road infrastructure has yet to incorporate low-carbon and climate change-friendly development [7]. Consequently, the community and road users are impacted by hydrometeorological disasters that have become more frequent and severe in recent years, and the disaster risk index for West Papua includes the category of hydrometeorological disasters [8,9]. Moreover, a detailed economic feasibility study for road widening needs to be conducted. These concerns are closely related to the study's identified problems.

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Another external opportunity factor involving central government funding is the approval of widening Drs. Esau Sesa - Maruni Street from 4-6 meters to 25 meters along its current 21.43 kilometers length because it is included in the category of primary arterial roads designated as national roads [10]. According to the Manokwari Regency Spatial Planning plan for 2013-2033, the road widening location is in a residential area [11]. As a result, the governments of West Papua Province and Manokwari Regency are attempting to collaborate on the payment of compensation to impacted people based on the Public Appraisal Service Study Team that has been established [7].

The strength of other internal factors is demonstrated by the fact that the existing road infrastructure has facilitated the opening of regional isolation, particularly in Papua, which has very high regional disparities, minimum service standards, influences the investment climate, the socio-economic integration of the people from one region to another, stimulating the economy through the sale of agricultural products and shortening the distance traveled, thereby accelerating the local economy, shortening commutes to work, assisting the functioning of social systems, supporting self-reliance of government and society and others [12, 13, 14].

To address the difficulties and threats of climate change, this study advocates for designing road widening, focusing on developing low-carbon and urban green road infrastructure. At the same time, initiatives to build community resilience in disaster response are a long-term development program of the Government of the Republic of Indonesia based on the Long-Term Strategy for Low Carbon and Development (LTS LCCR 2050). Meanwhile, an economic feasibility analysis will be conducted to determine whether the road widening work that will be carried out will be feasible in the hope of obtaining long-term benefits and having a significant impact on the sustainability of the surrounding community, both directly and indirectly for the users [15,16].

2. Material and methods

2.1. Study area

Road widening based on Environmental Impact Analysis and Manokwari Spatial Plan 2013-2033 consists of section 010 starting at Maruni (0°59'41.90'' South Latitude - 134°1'33.80" East Longitude) - Manokwari City Boundary (0°53'56.92" South Latitude - 134°2'35.35" East Longitude) along 17.52 km and section 010.18.K starting at the City Boundary of Manokwari - Drs. Esau Sesa (0°52'2.80" South Latitude -134o2'46.20" East Longitude) along 3.91 km. However, the economic feasibility calculation in this study only begins in phase I, which runs from Maruni to the West Papua Provincial Police Office along 6.5 km, based on the ability of the West Papua Provincial Government and Manokwari Regency to compensate land and buildings due to the status of residential areas (Figure 1). The concept of urban green road design, also based on low-carbon development, is created for the full section of planned road widening.

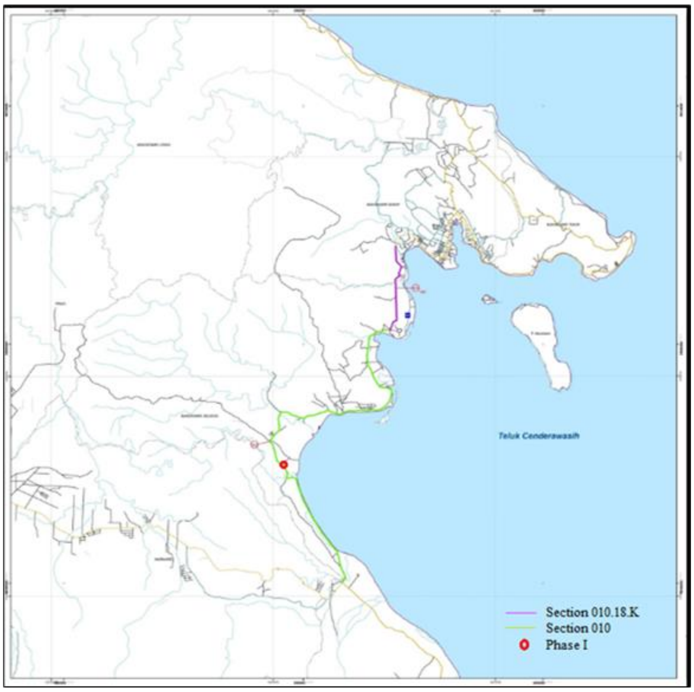

Figure 1 Capacity expansion of the Maruni - Drs Esau Sesa road in Manokwari

2.2. Method of data analysis

Construction design for increasing road capacity (widening) based on a cross-section of a two-sided widening, with work submitted to PT. Cipta Daya Dian Plans and additional design suggestions are driven by low-carbon and climate-resilient development [17,18].

The economic and financial feasibility analysis aims to invest in medium and high-traffic roads (medium/high volume roads). The analysis compares the construction costs to the project's direct benefits arising from savings in road user costs. The estimate of vehicle variable/running costs is based on basic rules for construction and building standardization methodologies regarding variable/running costs from the Department of Public Works, Ministry of Public Works and Housing, Republic of Indonesia [19]. The following formula shows the formula for determining vehicle operating costs (VOC):

Vehicle Operating Cost (VOC) = $\sum F + MO + T + M + D + IR + I + C + O$ ………….. 1

which F = fuel oil, MO = machine oil, T = tire, M = maintenance (vehicle parts + mechanic), D = depreciation, IR = interest rate, I = insurance, C =crew travel wages, and O = overhead

Furthermore, the profit of VOC/year is calculated using the following formulas:

Total VOC A = LVOC A + HVOC A…………………………………………………….. 2

Total VOC B = LVOC B + HVOC B ……………………………………………….…. 3

LVOC = LVC/day x 365 day/ 1 year x VOC/km x l ……………………………………. 4

HVOC = HVC/day x 365 day/ 1 year x VOC/km x l ………………………………….. 5

BVOC = Total VOC A - Total VOC B ………………………………………………….. 6

which Total VOC A = Total VOC without road improvements/year, LVOC A = LV operating costs without road improvements/ year, HVOC A = HV operating costs without road improvements/ year, Total VOC B = Total VOC with road improvements/year, LVOC B = LV operating costs with road improvements/ year, HVOC B = HV operating costs with road improvements/ year, VOC A = vehicle operating cost without road improvements/km (40 km/hours), VOC B = vehicle operating cost with road improvements/km (60 km/hours),

Besides the VOC benefits, the following equation must be used to compute time savings [20]:

TS = $\sum_{1}^{300} \mathbf{ST}\ [\mathbf{LV} + \mathbf{HV} + \mathbf{MC}]$ …. 7

VTS = AP x % E/P x TT x AH ……………………………. 8

TT = d x 1 hour/60 minutes ……………………………….. 9

AH = MW x WD x WH …………………………………… 10

TSi = TSo + GV …………………………………………… 11

which TS = time saving /year, MC = motorcycle, VTS = vehicle time saving / day (LV, HV, MC), AP = average passenger, %E/P = economy value/passenger, TT = travel time, AH = average hourly value, d = distance traveled (minutes), MW = minimum wage of West Papua Province, WD = working day for 1 month, WH = working hours per day, TSi = time saving next year, TSo = starting time saving, and GV = growth vehicle annually.

The economic calculations are then proceeded with the NPV, IRR, BEP, and Net B/C Ratio [21] using the formula:

NPV = $\frac{\boldsymbol{R_t}}{\boldsymbol{(1+i)^t}}$ …………………………………………………... 12

IRR = $\boldsymbol{r_a} + \frac{\boldsymbol{NPVb}}{\boldsymbol{NPVa}}(\boldsymbol{r_b} - \boldsymbol{r_a})$ ……………………………………. 13

BEP = Total TS – (CC + MC +T) … ………………………….. 14

Net B/C Ratio = $\frac{Net\ B}{Net\ C}$ ………………………………………….. 15

which NPV = net present value, R_t = change in cash on hand during t-period, i = price reduction, t = year, IRR = internal rate of return, r_a = selecting a lower discount rate, r_b = selecting a higher discount rate, NPVa = NPV at r_a, NPVb = NPV at r_b, BEP = break-even point, CC= construction cost, MC = maintenance cost, T = tax, Net B = net benefit, and Net C = net Cost.

3. Results and discussion

3.1. Design road improvements

At the initial phase of the design process, the road enhancements of Maruni - Drs Esau Sesa were 25 meters wide, with 7 meters on the left and right (divided by two lanes), 1 meter left and right as shoulders, 2.5 meters left and right as sidewalks, and 1 meter left and right outermost as a channel for drainage. Based on research findings [22], the community has several suggestions to pay attention to the drainage channel, which is too small to accommodate rain capacity and additional garbage, causing flooding on the old road and resulting in high maintenance costs. The West Papua Government then became involved in the LTS LCCR 2050 program; thus, the design was changed to include low-carbon development and climate resilience, particularly against hydrometeorological disasters. The sidewalks and channels are combined as green pedestrians and the below as drainage, with a left and right length of 3.50 m.

It is also recommended in pedestrian areas to establish fast-growing plant species with high calorific value to produce branches and twigs for biomass pellets. Table 1 highlights various plant species that are recommended for further cultivation.

On the right side of the road improvements is a beach area where the mangrove trees have been damaged, necessitating replanting because it is immediately facing the Pacific Ocean with strong currents [26]. However, in cases where the mangrove forest has entirely disappeared, technological efforts are required to plant mangroves in fast currents, and colleges must support these efforts from that; a beach barrier from coastal erosion is required, as the old road conditions were deteriorating and necessitated special attention [27]. As a result, this additional analysis is required to predict coastal erosion while also reducing the damage rate enhancements being developed.

Table 1 Tree species potential for biomass energy raw materials

Species	Regeneration method	Rotation	Growth/yield
Acacia auriculiformis [23]	generative	recommended rotations are 4-5 years (for firewood), 8-10 years (for pulp), 12-15 years for wood	15-20m^3/ha/yr can be achieved but on less fertile soils or areas with high erosion, growth reduced to 8-12m^3/ha/year; 24.2 m^3/ha/year
Acacia mangium [24]	generative	6-7 years (for pulpwood); 15-20 years (sawn wood)	35,2 m^3/ha/yr
Albizia procera [23]	generative and vegetative	firewood is arranged in a 20 year rotation	average annual growth diameter of 1-4 cm; reaches 40-60 cm in 30 years
Gliricidia sepium [25]	generative and vegetative	every 2-3 years	first harvest after 3-4 years, 8-15 m3/ha, 3.5 - 4.5 kg/tree/year, 10-20 m3/ha/year (firewood harvested every 2-3 years)
Calliandra callothyrsus [23]	generative and vegetative	every 1-2 years, the annual infusion continues for 10-20 years	35-65 m^3/ha/yr; 15-40 tdm/ha/yr with annual shoot harvest for 10-20 years; 25 t/ha/year in Indonesia

Species	Regeneration method	Rotation	Growth/yield
Leucaena leucocephala [23]	generative and vegetative	shorter rotation (3-5 years)	from 3-4 m height gain/year and 20-60 m^3/ha/yr
Sesbania grandiflora [23]	generative and vegetative	not long-lived can be harvested in short 3 year rotations	on deep loamy soil with good drainage, the yield is 4 t/ha/year. In Indonesia, 20-25 m^3/ha/yr

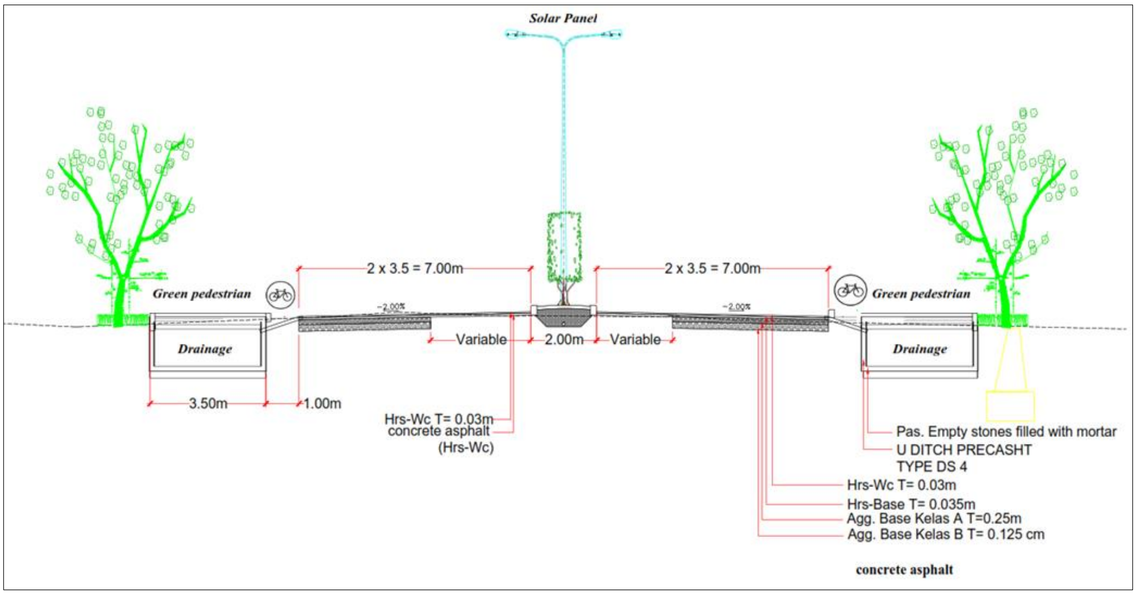

Figure 2 Design of road improvement on the Maruni-Drs. Esau Sesa Street

A further development is replacing street lights that traditionally utilize fossil fuels with solar panels with a design distance of every 50 m for a pole height of 12 m and a power of 60 Watts [28,29]. Overall, the modification design proposed for road enhancements guided by the LTS LCCR 2050 can be presented in Figure 2.

3.2. Vehicle Operating Costs

Vehicle Operating Costs (VOC) in IDR/1000 km is calculated and then converted to USD/1000 km (conversion value, 1 USD = IDR 15,000) in Manokwari Regency, West Papua Province, at vehicle speeds ranging from 1 km/hour to 60 km/hour. The average speed of vehicles moving via the Maruni-Drs Esau Sesa Street is roughly 40 km/h for cars (LV) and 30 km/h for trucks (HV), with several traffic points already congested. If the congestion can be alleviated through road improvements, the average vehicle speed (LV and HV) is expected to approach 60 km/h. The calculation of the VOC value can be recognized in Figure 3.

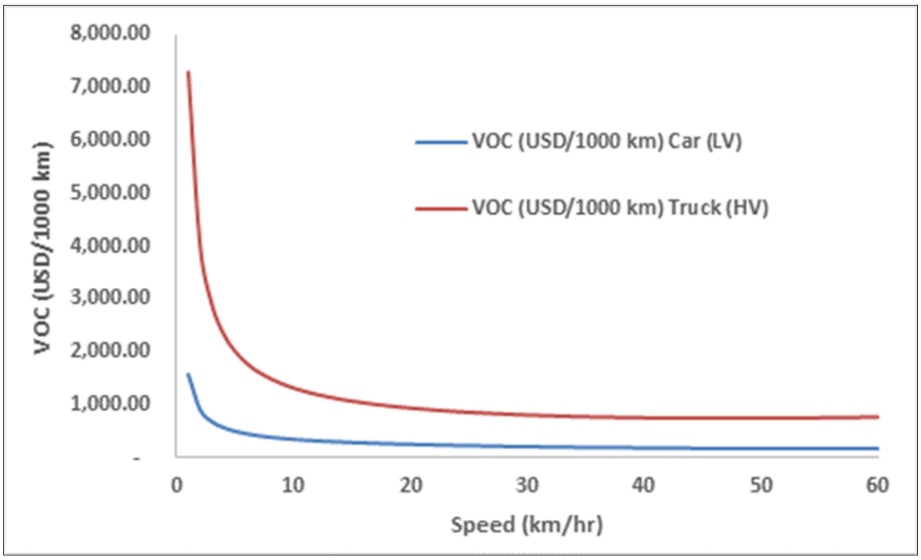

Figure 3 VOC in LV and HV

The calculations are then double-checked by comparing the VOC values before and after road enhancements with the new phase I being carried out for 6.5 km. The calculated value is presented in Table 2.

Table 2 VOC before and after road enhancements

Variable	Before	After	Benefit VOC/year
LV/day	3,039.00	3,039.00	
HV/day	570.00	570.00	
BOK LV/1000 km	174.22	157.67	
BOK HV/1000 km	801.09	763.01	
BOK LV/km	0.17	0.16	
BOK HV/km	0.80	0.76	
BOK LV/year	1,256,112.92	1,136,828.53	
BOK HV/year	1,083,327.99	1,031,843.68	
Total VOC (USD)	2,339,440.91	2,168,672.21	170,768.70

The VOC calculation begins in 2021 with the conditions before road enhancement where there is road congestion for LV with a speed of 40 km/hour and lowers to 39 km/hour 5 years later and again 2 years later until 2040. Similarly, the HV is currently around 30 km/h, but in 5 years, it will reduce to 29 km/h, and then again in 2 years to 28 km/h until 2040. Meanwhile, LV and HV will attain an average speed of 60 km/h after road improvements until 2040. The entire VOC gain due to average vehicle speed due to road enhancements can be seen in Figure 4.

The VOC benefits gained in West Papua Province (Figure 4) are not as significant as those obtained in other major cities in Indonesia because the number of LV (cars) is lower with a ratio of 1:7, and HV (trucks) is lower with a ratio of 1:4 with the City of Surabaya and many other major cities [30,31].

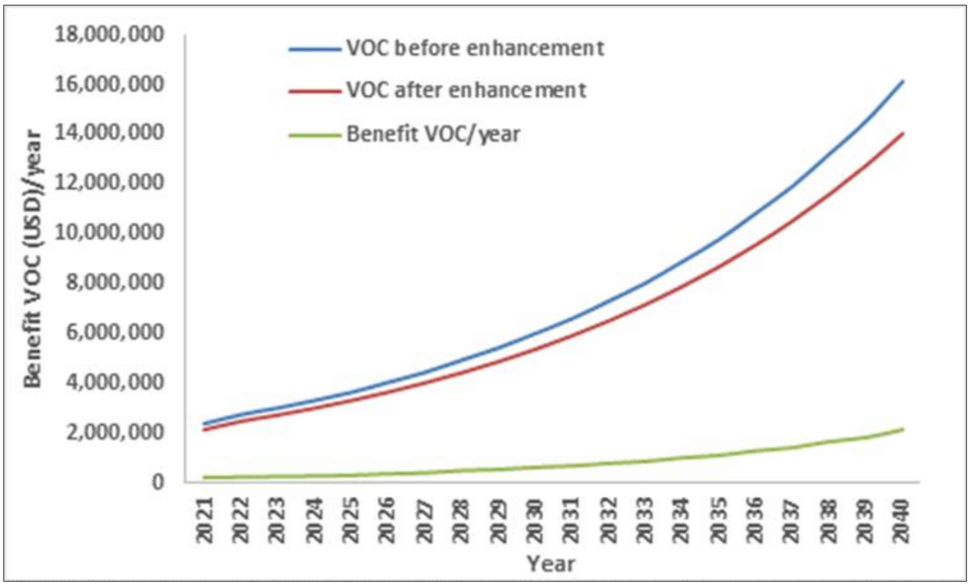

Figure 4 Benefit VOC before, after and benefit

3.3. Time savings

Several scenarios result in time savings per year from LV, HV, and MC, including time savings from the impact of road widening from the old two-way road, which has several congestion points, travel time from alternative I to the Governor's office (Marampa – Drs. Esau Sesa), and travel time from alternative II to the Governor's office (Church – Drs. Esau Sesa). Some important values to be aware of include the West Papua Province minimum wage of Rp. 3,282,000, -, 1 month is equivalent to 25 working days, 1 working day is equivalent to 8 hours, travel time for long roads is 35 minutes, road improvement is increased by 25 minutes, the long walk to the Governor's office is 16 minutes, scenario I being 8 minutes, and scenario II being 6 minutes. The other essential data variables and total time savings for several scenarios from 2021 to 2040, taking into account the growth of vehicle traffic per year by 4.8%, can be referred to in Table and Figure 5.

Table 3 Time savings from LV, HV, and MC

Variable	Vehicle		
	LV	HV	MC
Average passenger	5	2	1.5
% Economy value/passenger	60	80	80
Travel time (hours) before	0.5833	0.5833	0.5833
Travel time (hours) after	0.4167	0.4167	0.4167
Travel time (hours) Governor's office	0.2667	0.2667	0.2667
Travel time (hours) Scenario I (Marampa - Drs. Esau Sesa)	0.1333	0.1333	0.1333
Travel time (hours) Scenario II (Church - Drs. Esau Sesa)	0.1000	0.1000	0.1000
Average hourly time value	16410	16410	16410
Number of traffic vehicles per hour	3039	570	16727
Time value (before)	28,715.86	15,315.12	11,486.34
Time value (after)	20,514.14	10,940.88	8,205.66
Time value (Governor's office)	13,129.64	7,002.48	5,251.86
Time value (Scenario I)	6,562.36	3,499.92	2,624.94

Variable	Vehicle		
	LV	HV	MC
Time value (Scenario II)	4,923.00	2,625.60	1,969.20
Time savings due to traffic jams per day (before)	5,817.83	581.97	12,808.80
Time savings due to traffic jams per day (after)	4,156.16	415.75	9,150.40
Time savings due to traffic jams per day (Governor's office)	2,660.07	266.09	5,856.52
Time savings due to traffic jams per day (Scenario I)	1,329.53	133.00	2,927.16
Time savings due to traffic jams per day (Scenario II)	997.40	99.77	2,195.92
Total Time savings USD/year (before)	5,762,583.72		
Total Time savings USD/year (after)	4,116,695.76		
Total Time savings USD/year (Governor office)	2,634,803.84		
Total Time savings USD/year (Scenario I)	1,316,907.95		
Total Time savings USD/year (Scenario II)	987,927.95		
Benefit time savings/year (after)	1,645,887.96		
Benefit time savings/year (Scenario I)	1,317,895.88		
Benefit time savings/year (Scenario II)	1,646,875.89		

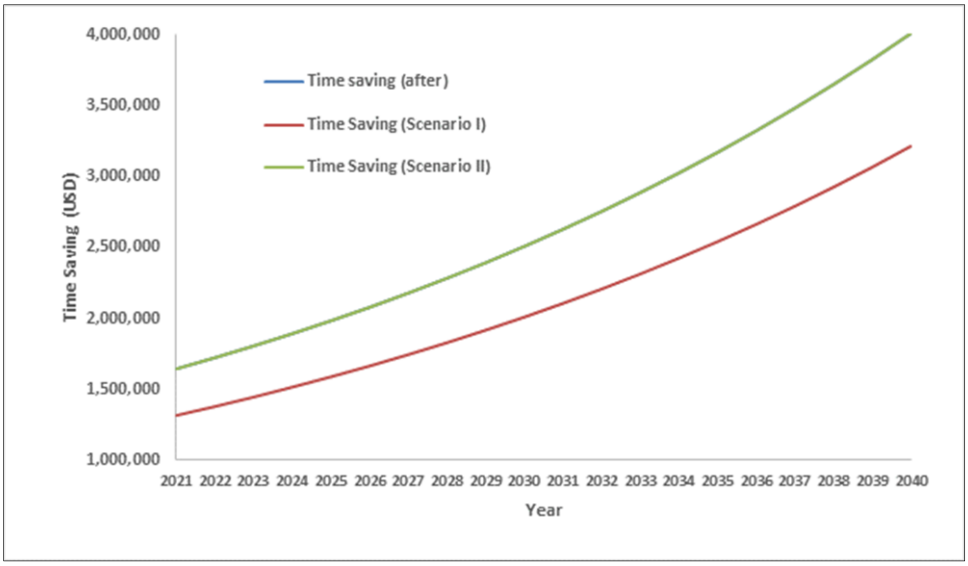

Figure 5 Benefit time saving

Figure 5 demonstrates that the total time saved for Scenario 2 nearly matches the after-road improvements scenario. Because the time decrease from the start was pretty large, perhaps 10 minutes. In the case of scenario I, the time savings is merely 8 minutes. As a result, the bigger the time savings, the greater the total profit savings and the creation of sustainable development for increased road efficiency and effectiveness [32,33].

3.4. Total saving

The savings are calculated by adding the total VOC and time-saving benefits, as shown in Figure 6. Much of this total savings is due to large time-saving gains, particularly in scenario II and after enhancements [34,35].

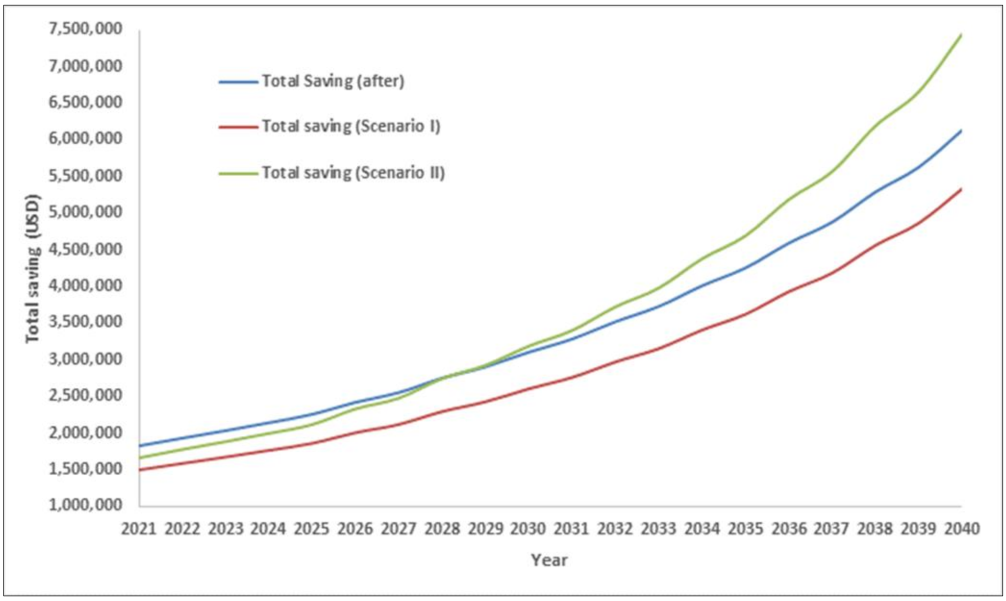

Figure 6 Total savings across numerous scenarios

3.5. Economic analysis of road improvements

3.5.1. NPV

The Net Present Value (NPV) is determined by subtracting the amount of net cash that is coming in from the amount that is going out throughout the 2021-2040 period and a discount rate of 10% (Table 4) or 15% (Table 5). Inflow is calculated as the total time saved. In contrast, the outflow is calculated as the total cost, which includes construction costs for road improvements such as solar panels, green infrastructure, drainage, erosion-resistant buildings, or mangroves, and annual maintenance, which is budgeted for road markings, plant maintenance, solar panel maintenance, and road repair.

Table 4 Discounted NPV by 10%

Year	Dis. rate (10%)	Construction Cost (USD)	Maintenance Cost (USD)	Total cost after discount (USD)	Total saving, USD (after)	Total saving, USD (Scenario I)	Total saving, USD (Scenario II)
	0.909	6,240,000	(6,240,000.00)	(4,727,273)			
2021	0.826		260,000.00	214,876	1,816,657	1,488,665	1,659,433
2022	0.751		260,000.00	195,342	1,922,200	1,578,464	1,775,774
2023	0.683		260,000.00	177,583	2,024,805	1,664,570	1,881,689
2024	0.621		260,000.00	161,440	2,133,372	1,755,846	1,994,764
2025	0.564		260,000.00	146,763	2,248,294	1,852,646	2,115,552
2026	0.513		260,000.00	133,421	2,412,639	1,998,001	2,329,954
2027	0.467		260,000.00	121,292	2,545,840	2,111,299	2,476,580
2028	0.424		260,000.00	110,265	2,742,757	2,287,357	2,744,888
2029	0.386		260,000.00	100,241	2,898,384	2,421,125	2,924,592
2030	0.350		260,000.00	91,128	3,098,473	2,598,306	3,186,905
2031	0.319		260,000.00	82,844	3,278,042	2,753,867	3,401,562
2032	0.290		260,000.00	75,313	3,514,938	2,965,602	3,723,936

Year	Dis. rate (10%)	Construction Cost (USD)	Maintenance Cost (USD)	Total cost after discount (USD)	Total saving, USD (after)	Total saving, USD (Scenario I)	Total saving, USD (Scenario II)
2033	0.263		260,000.00	68,466	3,723,391	3,147,688	3,982,158
2034	0.239		260,000.00	62,242	4,005,998	3,402,661	4,381,070
2035	0.218		260,000.00	56,584	4,249,555	3,617,257	4,693,898
2036	0.198		260,000.00	51,440	4,589,338	3,926,690	5,190,815
2037	0.180		260,000.00	46,763	4,875,866	4,181,412	5,572,454
2038	0.164		260,000.00	42,512	5,287,671	4,559,883	6,195,459
2039	0.149		260,000.00	38,647	5,627,183	4,864,461	6,664,249
2040	0.135		260,000.00	35,134	6,130,337	5,331,004	7,450,231
	Total			(2,714,976)	69,125,739	58,506,805	74,345,961

Table 5 Discounted NPV by 15%

Year	Dis. rate (10%)	Construction Cost (USD)	Maintenance Cost (USD)	Total cost after discount (USD)	Total saving, USD (after)	Total saving, USD (Scenario I)	Total saving, USD (Scenario II)
	0.870	6,240,000	(6,24.00,000.00)	(4,110,672)			
2021	0.756		260,000	196,597	1,816,657	1,488,665	1,659,433
2022	0.658		260,000	170,954	1,922,200	1,578,464	1,775,774
2023	0.572		260,000	148,656	2,024,805	1,664,570	1,881,689
2024	0.497		260,000	129,266	2,133,372	1,755,846	1,994,764
2025	0.432		260,000	112,405	2,248,294	1,852,646	2,115,552
2026	0.376		260,000	97,744	2,412,639	1,998,001	2,329,954
2027	0.327		260,000	84,994	2,545,840	2,111,299	2,476,580
2028	0.284		260,000	73,908	2,742,757	2,287,357	2,744,888
2029	0.247		260,000	64,268	2,898,384	2,421,125	2,924,592
2030	0.215		260,000	55,885	3,098,473	2,598,306	3,186,905
2031	0.187		260,000	48,596	3,278,042	2,753,867	3,401,562
2032	0.163		260,000	42,257	3,514,938	2,965,602	3,723,936
2033	0.141		260,000	36,745	3,723,391	3,147,688	3,982,158
2034	0.123		260,000	31,953	4,005,998	3,402,661	4,381,070
2035	0.107		260,000	27,785	4,249,555	3,617,257	4,693,898
2036	0.093		260,000	24,161	4,589,338	3,926,690	5,190,815
2037	0.081		260,000	21,009	4,875,866	4,181,412	5,572,454
2038	0.070		260,000	18,269	5,287,671	4,559,883	6,195,459
2039	0.061		260,000	15,886	5,627,183	4,864,461	6,664,249
2040	0.053		260,000	13,814	6,130,337	5,331,004	7,450,231
	Total			(2,695,519)	69,125,739	58,506,805	74,345,961

The NPV with a 10% discount is USD 66,410,764 for the after scenario, USD 55,791,829 for scenario I, and USD 71,630,986 for scenario II, according to Table 4. Meanwhile, the NPV with a 15% discount rate for the after scenario is USD 66.430221, USD 55,811,286 for scenario I, and USD 71,650,443 for scenario II. These findings demonstrate that the NPV exceeds zero, implying that road improvements are feasible [36,37].

3.5.2. IRR

After obtaining the NPV values from the 10% and 15% discount rates, compute the Internal Rate of Return (IRR) by using the following formulas for each scenario:

IRR scenario after = 10% + (66,430,221/66,410,764) x 5 = 15%.

IRR scenario I = 10% + (55,811,286/55,791,829) x 5 = 15%.

IRR scenario II = 10% + (71,650,443/71,630,986) x 5 = 15%.

The calculations demonstrate that the IRR in all three scenarios is 15%. This implies that it is greater than 12% of the rate of return, with a range of 10-12%. As a result, budgetary projections for road improvements are included in the feasible category [38,39].

3.5.3. BEP

The break-even point (BEP) is a measure that shows that the revenue from the activities carried out can cover the whole production cost. To find out the BEP of road enhancements investment from several scenarios can be seen in Table 6.

Table 6 BEP road enhancements

Year	Total Saving, USD (after)	Time Saving, USD (Scenario I)	Time Saving, USD (Scenario II)	Total Cost (USD)	Profit (USD) after	Profit (USD) Scenario I	Profit (USD) Scenario II
				-6,240,000.00	-6,240,000.00	-6,240,000.00	-6,240,000.00
2021	1,816,657	1,317,896	1,646,876	260,000.00	-4,865,009.01	-5,313,893.71	-5,017,811.70
2022	1,922,200	1,381,155	1,725,926	260,000.00	-3,395,028.87	-4,330,854.31	-3,724,478.36
2023	2,024,805	1,447,450	1,808,770	260,000.00	-1,832,704.57	-3,288,149.02	-2,356,585.02
2024	2,133,372	1,516,928	1,895,591	260,000.00	-172,669.35	-2,182,913.88	-910,552.80
2025	2,248,294	1,589,740	1,986,580	260,000.00	1,590,794.94	-1,012,147.45	617,368.96
2026	2,412,639	1,666,048	2,081,936	260,000.00	3,502,170.41	227,295.76	2,231,110.97
2027	2,545,840	1,746,018	2,181,868	260,000.00	5,533,426.79	1,538,712.26	3,934,792.60
2028	2,742,757	1,829,827	2,286,598	260,000.00	7,741,907.86	2,925,556.74	5,732,730.95
2029	2,898,384	1,917,659	2,396,355	260,000.00	10,090,453.15	4,391,449.76	7,629,450.33
2030	3,098,473	2,009,707	2,511,380	260,000.00	12,619,078.47	5,940,185.64	9,629,692.25
2031	3,278,042	2,106,172	2,631,926	260,000.00	15,309,316.14	7,575,740.84	11,738,425.78
2032	3,514,938	2,207,269	2,758,259	260,000.00	18,212,759.95	9,302,282.70	13,960,858.51
2033	3,723,391	2,313,218	2,890,655	260,000.00	21,303,812.07	11,124,178.56	16,302,448.02
2034	4,005,998	2,424,252	3,029,406	260,000.00	24,649,210.29	13,046,005.43	18,768,913.83
2035	4,249,555	2,540,616	3,174,818	260,000.00	28,213,809.38	15,072,559.98	21,366,249.99
2036	4,589,338	2,662,566	3,327,209	260,000.00	32,084,213.50	17,208,869.16	24,100,738.29
2037	4,875,866	2,790,369	3,486,915	260,000.00	36,212,493.13	19,460,201.17	26,978,962.03

Year	Total Saving, USD (after)	Time Saving, USD (Scenario I)	Time Saving, USD (Scenario II)	Total Cost (USD)	Profit (USD) after	Profit (USD) Scenario I	Profit (USD) Scenario II
2038	5,287,671	2,924,307	3,654,287	260,000.00	40,711,397.06	21,832,077.12	30,007,820.51
2039	5,627,183	3,064,673	3,829,693	260,000.00	45,515,862.14	24,330,283.12	33,194,544.19
2040	6,130,337	3,211,778	4,013,518	260,000.00	50,773,165.49	26,960,883.00	36,546,710.62

Based on Table 6, the BEP value in the after scenario and scenario II is attained in year 5, whereas scenario I is accomplished in year 6. This demonstrates the viability of investing in the after-road upgrades scenario and scenario II (Church - Drs Esau Sesa) for the governor's office to achieve its BEP faster than the scenario I (Marampa - Drs Esau Sesa).

BEP in less than ten years for road improvements is still in the good category, and in terms of time, advantages have been received from overall savings, particularly on distance travel time that is less than ten minutes [40,41].

3.5.4. Net B/C Ratio

The net B/C ratio is calculated by comparing the total value of savings to total cost with a 10% (Table 4) or 15% (Table 5) reduction. The following computations show the results of comparing each of these scenarios:

Net B/C ratio (10%):
Net B/C ratio scenario after = 69,125,739/2,714,976 = 25.46
Net B/C ratio scenario I = 58,506,805/2,714,976 = 21.55
Net B/C ratio scenario II = 74,345,961/2,714,976 = 27.38

Net B/C ratio (15%)
Net B/C ratio scenario after = 69,125,739/2,695,519 = 25.64
Net B/C ratio scenario I = 58,506,805/2,695,519 = 21.71
Net B/C ratio scenario II = 74,345,961/2,695,519 = 27.58

The net B/C ratio of numerous scenarios at 10% and 15% discount rates is greater than one. This demonstrates that investing in this project is still viable and rewarding. Some studies utilize the net B/C ratio as an economic indicator to determine whether or not an activity is feasible [42,43,44,45].

4. Conclusion

Based on the LTS LCCR 2050 program, design enrichment was carried out with several additions to bicycle paths, green infrastructure for pedestrians with a focus on energy source plants for biomass pellets, street lights with solar panels, drainage widened along pedestrians to anticipate extreme rainfall and flooding, and ecosystem restoration damaged mangroves or building erosion-resistant structures for damaged mangrove areas.

Compared to major cities such as Surabaya and Jakarta, VOC for before and after road improvements yielded lower earnings. This is due to the fact that the number of cars is smaller in West Papua, with a ratio of 1:7 (LV) and 1:4 (HV). It is connected to time savings that reach 10 minutes for time savings with a greater value in scenario II and after. This corresponds to the overall savings in road capacity-building initiatives in Manokwari Regency, West Papua Province.

Economic and financial analysis of road widening implementation demonstrates that the NPV value is greater than zero for discount rates of 10% and 15%, indicating that road improvement is possible. The IRR value is 15%, which suggests it is higher than the reasonable rate of return of 10-12%. BEP is produced with a reduction between total net savings and net costs, including tax 10%, resulting in a profit within 5-6 years, and it is included in the good category to continue. And the net B/C ratio, which compares total savings to expenses at 10% and 15% discount rates, is more than zero, indicating that these road upgrades are viable and can be completed.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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