Transport Benefit Assessment due to Increasing Capacity Transportation Infrastructure

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Abstract. The West Java Provincial Government plans to improve the transportation infrastructure capacity with road widening program in the southern part area. Current situation is travel time for trip in southern part Java is long, below the target of road functional as a collector road (40 km/h). The traffic volume is low (no congested), since it was a rural area. The transportation infrastructure feasibility can be assessed from cost-benefit analysis. Increasing the capacity of transportation infrastructure has an impact on road side user parameter, i.e the travel time, travel cost and gas emission, which will save the value of time, vehicle operational costs and gas emission cost. The transportation network model tool was used to assess benefits. The percentage of vehicle operating cost savings contributed the most in terms of benefits (78%). Economic feasibility measurement is carried out using the IRR indicator. with a value of 8.68%, which requires additional benefits so that it can be feasible based on the size of the Asian Development Bank study.

1 Introduction

The development of the South West Java region which is intensively carried out by the Central Government through various programs that are proclaimed to be able to accelerate economic equality. Attention to the southern part of West Java is necessary because development is rarely touched. There is a lot of potential in the southern part of West Java Province, as rural areas, such as the tourism, fisheries and agriculture sectors [1]. The development of the southern part of West Java can be a solution in overcoming economic inequality, and development with the northern part of West Java. The attention given is related to increasing the capacity of transportation infrastructure that connects between districts in the south of West Java.

Transportation is a driver of regional economic progress, such as an increase in GDP and an increase in people's income, which has been widely studied [2]–[5]. Investment in the transportation sector, especially roads, will increase GDP growth in China [6]. In the context of road users, the measurement of the benefits of increasing transportation capacity has also been widely studied [7]–[9], with a measure of saving the value of time and vehicle operating costs.
The decision to increase the capacity of transportation infrastructure certainly needs to be supported by the benefits of transportation that can be felt by all road users. Investments in increasing the capacity of transportation infrastructure certainly need to be calculated in detail and efficiently. This research is aimed at assessing the feasibility of transportation infrastructure by considering the benefits and costs of the investment. The contribution of this research is the use of transportation models in measuring the benefits of transportation, especially for rural/inter-city areas.

2 Scope and Study Methodology

Economic analysis requires data on the benefits and costs of investment, with methodological stages as in Figure 1. The calculation of investment costs comes from a detailed engineering design study that has been carried out. The transportation benefits assessed are vehicle operating cost savings, time value and pollution reduction [10]. Demand estimation needs to be done to get traffic parameters, in order to calculate the benefits of transportation, with the transportation model being used based on zones and road networks.

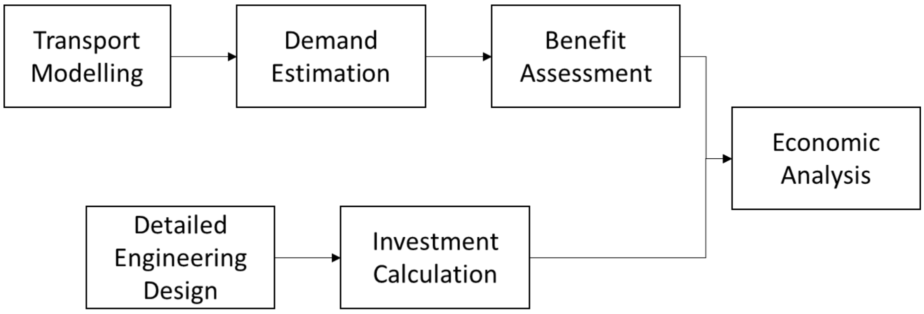


Fig. 1. Workflow Methodology

Transportation modelling is carried out based on the four-stage concept [11], which requires input data for the road network and the origin of the movement. The scope of road network is developed based on road functions and spatial characteristics. Data from the origin of the destination of the trip is obtained with the Demand Matrix Estimation feature from processed data from the origin of the National Transportation Destination in 2018 and a traffic flow calculation survey. Data on Origin of National Transportation Destinations in 2018 is based on administrative area to city/district level. There are 66 zones that are reviewed according to the function of the activity centre. The origin and destination data that will be formed in the zoning of this activity area are a combination of sub-districts. For the purposes of estimating movement to regional zoning (combined sub-districts), a relationship between the number of movements and travel time is needed, as a function of resistance, so that a more detailed movement estimate can be made.

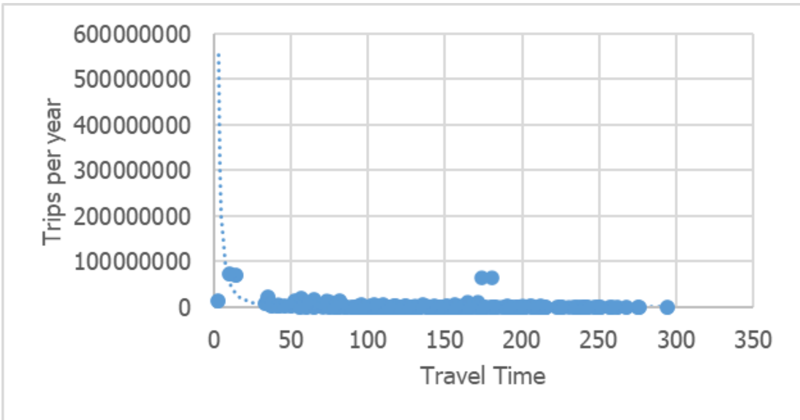


Fig. 2. Travel Time and Estimated Trips Model

Validation is done by comparing the results of traffic loading with the results of the travel time survey. The coefficient of determination (R^2) above 0.6 [12] is a good model reliability. To achieve this, it is necessary to calibrate the parameters of the model, including the prior OD matrix that has been built. From this series of processes, the results of the comparison of travel time are obtained, with a coefficient of determination (R^2) above 0.85 (see Fig 3).

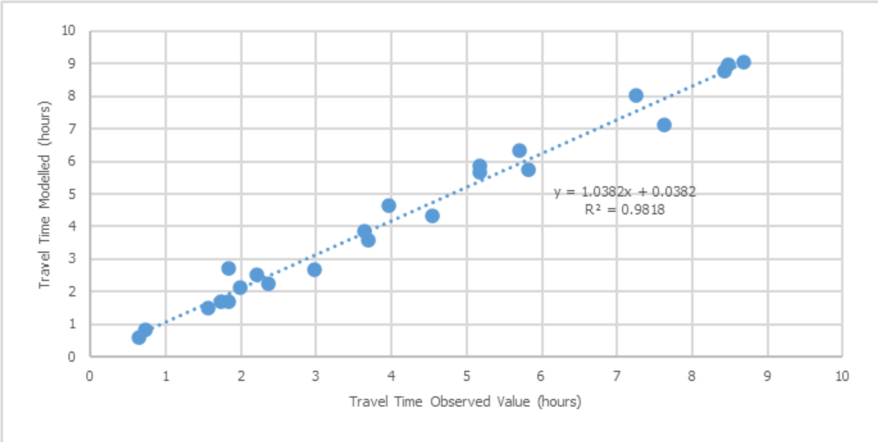


Fig. 3. Traffic Validation Result

In calculating Vehicle Operational Costs (VOC), the formula from Pacific Consultant International (PCI) [13] is used. Time value or time value savings is defined as the amount of money a person is willing to spend to save one unit of travel time [14]. Hensher identified that there are opportunity costs and marginal (relative) disutility associated with one unit of travel time. Air pollution savings are calculated from the cost of pollution with changes in traffic volume [15].

3 Result and Discussion

3.1 Traffic Demand Estimation

The traffic model used is zone-based in the form of the southern part of West Java (57 internal zones and 9 external zones, see Figure 4 and Table 1) and the road network (arterial road, collector road and local road). The discussion on calibration and model validation has been carried out by Maulana (2020) [16]. With a coefficient of determination (R^2) 0.87, the model is believed to be valid [12].

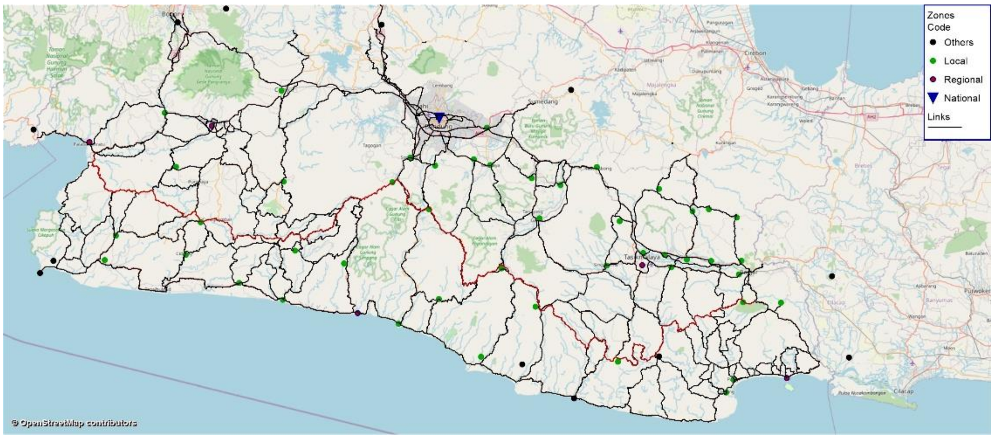


Fig. 4. Zone Model Configuration

Table 1. Zone Name List

Code	Zone Name	Area Name	Code	Zone Nae	Area Name
3201	Soreang	Bandung	3231	Cibatu	Garut
3202	Majalaya	Bandung	3232	Rancabuaya	Garut
3203	Cileunyi	Bandung	3233	Cikajang	Garut
3204	Banjaran	Bandung	3234	Garut	Garut
3205	Pangalengan	Bandung	3235	Kadungora	Garut
3206	Ciwidey	Bandung	3236	Singajaya	Garut
3207	Ciparay	Bandung	3237	Plabuhanratu	Sukabumi
3208	Ciamis	Ciamis	3238	Sagaranten	Sukabumi
3209	Cijeungjing	Ciamis	3239	Surade	Sukabumi
3210	Cisaga	Ciamis	3240	Cidolog	Sukabumi
3211	Jatinagara	Ciamis	3241	Cibadak	Sukabumi
3212	Kawali	Ciamis	3242	Jampangtengah	Sukabumi
3213	Pamarican	Ciamis	3243	Jampangkulon	Sukabumi
3214	Pangandaran	Pangandaran	3244	Karangnunggal	Tasikmalaya
3215	Panjalu	Ciamis	3245	Manonjaya	Tasikmalaya
3216	Rancah	Ciamis	3246	Singaparna	Tasikmalaya
3217	Parigi	Pangandaran	3247	Cipedes	Tasikmalaya
3218	Banjarsari	Pangandaran	3248	Cikoneng	Tasikmalaya
3219	Banjar	Pangandaran	3249	Ciawi	Tasikmalaya
3220	Cijulang	Pangandaran	3250	Cipatujah	Tasikmalaya
3221	Naringgul	Cianjur	3251	Ujung Genteng	Sukabumi
3222	Agrabinta	Cianjur	3252	Cikatomas	Tasikmalaya
3223	Cidaun	Cianjur	3253	Mekarmukti	Tasikmalaya
3224	Cianjur	Cianjur	3254	Ciracap	Sukabumi
3225	Sindangbarang	Cianjur	8006	Kota Bandung	Kota Bandung
3226	Sukanegara	Cianjur	8009	Kota Sukabumi	Kota Sukabumi
3227	Cibinong	Cianjur	8010	Kota Tasikmalaya	Kota Tasikmalaya
3228	Malangbong	Garut	9001	Eksternal Barat	Banten
3229	Pameungpeuk	Garut	9002	Eksternal Utara	Dki Jakarta
3230	Bungbulang	Garut	9003	Eksternal Timur	Jawa Tengah
9007	Eksternal Utara 3	Sumedang	9004	Eksternal Utara	Bogor
9008	Eksternal Timur2	Cilacap	9005	Eksternal Utara	Karawang, Subang

Based on the generation and attraction analysis, the total generation value is 3.397 pcu/h and the total pull is 4.197 pcu/h. The largest generation and attraction values came from Cianjur Regency with a value of 1,496 pcu/h and 2,793 pcu/h. The smallest generation value is in Pangandaran Regency, namely Parigi with a value of 72 pcu/h and the smallest value is in Bandung Regency, namely Pangalengan with a value of 57 pcu/h. The largest internal movement occurred between Soreang and Bandung City with a value of 1,033 pcu/h. The movement between the City of Tasikmalaya and Manonjaya became the largest with a value of 325 pcu/h. The generation/attraction of the movement and the distribution of the movement can be seen in Figure 5 and Figure 6.

Fig. 5. Production/Attraction in South Area West Java Province

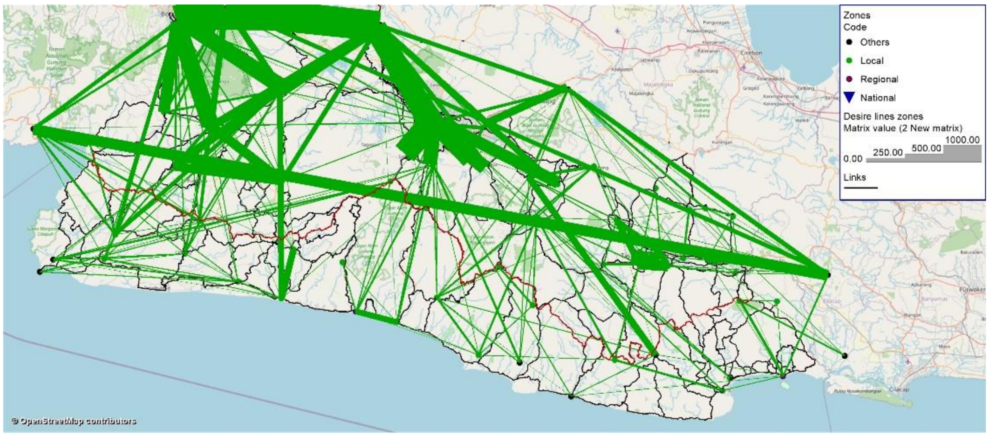


Fig. 6. Desired Lines Movement in South Area West Java Province

The demand projection produces parameters in the form of network speed, distance travelled and hours travelled. The results of the link-based model so that the data is large and unique. Table 2 shows the values for all within one road network scope. The Do Something condition is when the road widening has been done.

Table 2. Network Performances in Each Conditions/Scenarios

Condition	Network Speed (km/jam)	Distance Travelled (veh.km/hour)	Hours Travelled (veh.hour/hour)
2023 Do Nothing	34.25	517,926	15,123
2023 Do Something	34.60	476,389	13,768
2028 Do Nothing	33.00	588,852	17,847
2028 Do Something	33.50	535,338	15,978
2033 Do Nothing	31.74	660,291	20,803
2033 Do Something	32.46	596,097	18,363
2038 Do Nothing	30.68	722,577	23,551
2038 Do Something	31.55	649,263	20,576
2043 Do Nothing	29.74	782,262	26,301
2043 Do Something	30.68	700,737	22,842

3.2 Cost Estimation

The estimated cost of the proposed investment is an increase in infrastructure capacity which will be assessed in the form of road widening (length 370 km) in the southern region of West Java, namely Sukabumi, Cianjur, Bandung, Garut, Tasikmalaya and Pangandaran. (See the red trace in Figure 7). The results of the initial cost estimation and maintenance cost can be seen in Table 3.

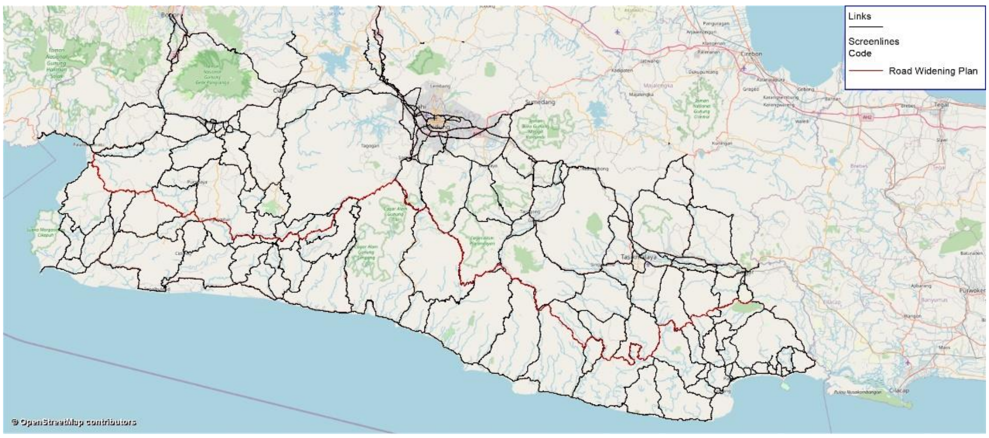


Fig. 7. Network Development: Road Widening in South Area West Java

Table 3. Investment Cost Estimation

Initial Cost (million Rp)	Maintenance Cost per year (million Rp)	Maintenance Cost per 5 year (million Rp)
4,378,715	2,922	790,884

3.3 Benefit Estimation

Estimated vehicle operating cost benefits are based on the PCI model (see Figure 8). The speed value is calculated based on the link so it is varied and unique. The estimation of the time saving benefits is based on the calculation of the time value with the income per area approach (see Table 4). Estimated pollution reduction is calculated referring to the Ministry of Environment and Forestry Regulation No. 12 of 2010. The controlled exhaust gases include CO (Carbon Monixide), NO2 (Nitrogen Oxides), SO2 (Sulfur Oxides) and PM10 [17] (see Table 5). Figure 9 shows the projected results for 20 years, starting in 2023. The savings in vehicle operating costs are the largest with a percentage of 78% compared to the savings in time value and air pollution.

Table 4. Average Income in Scope Area

No	Area Name	Average Income per Capita (Million Rp)
1	Pangandaran	1.86
2	Ciamis	1.88
3	Garut	1.96
4	Tasikmalaya	2.25
5	Cianjur	2.53
6	Sukabumi	3.13
7	Bandung	3.24

Table 5. Emission Gas Unit

No	Parameter	Emission Factor (g/km)	Unit (Rp/kg)
1	CO	40	1.86
2	NO_2	2	1.88
3	SO_2	0.026	1.96
4	PM_{10}	0.01	2.25

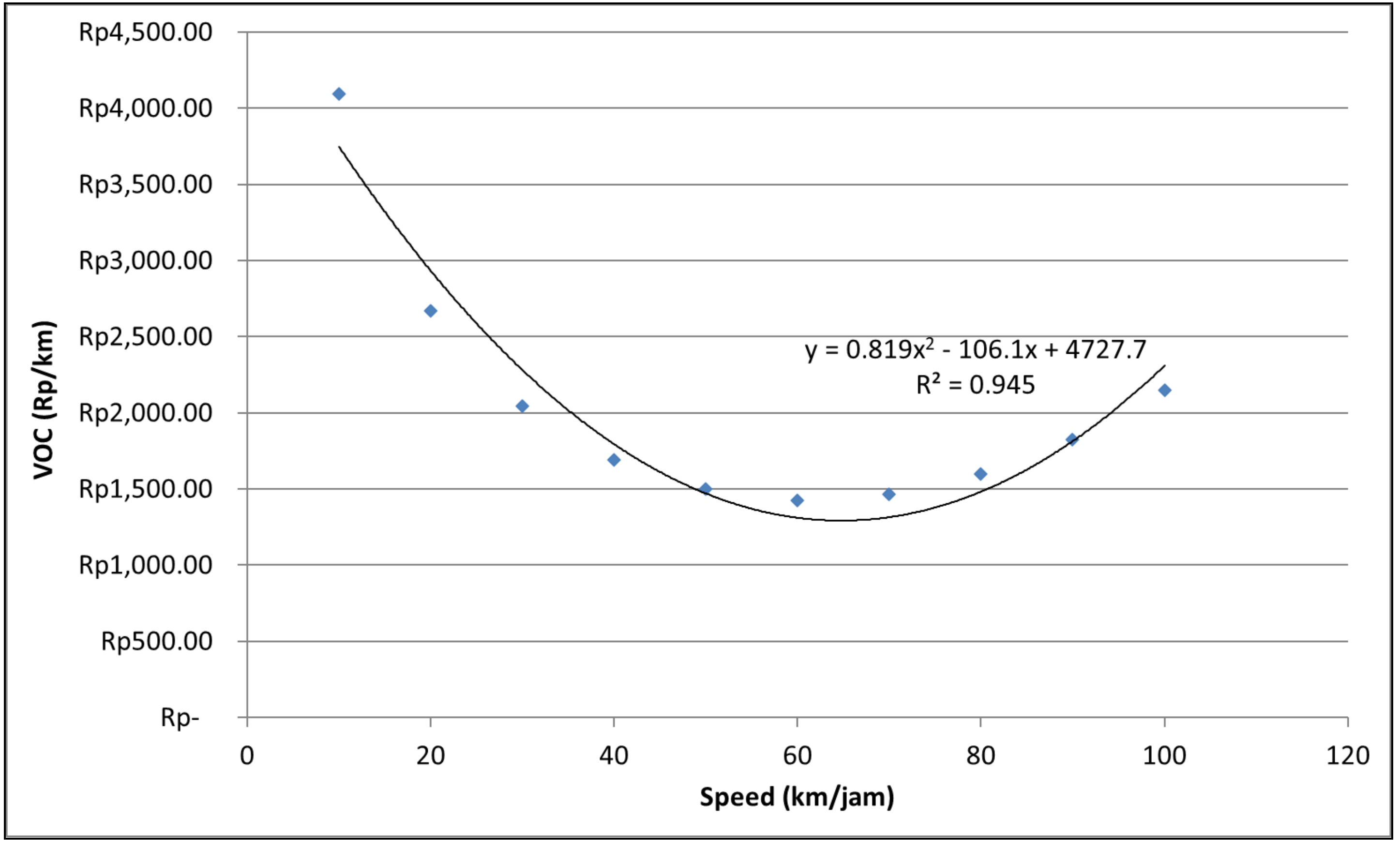
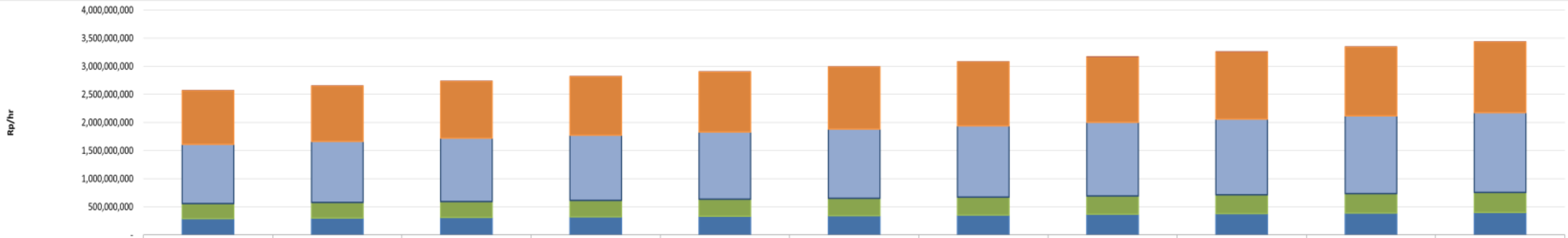
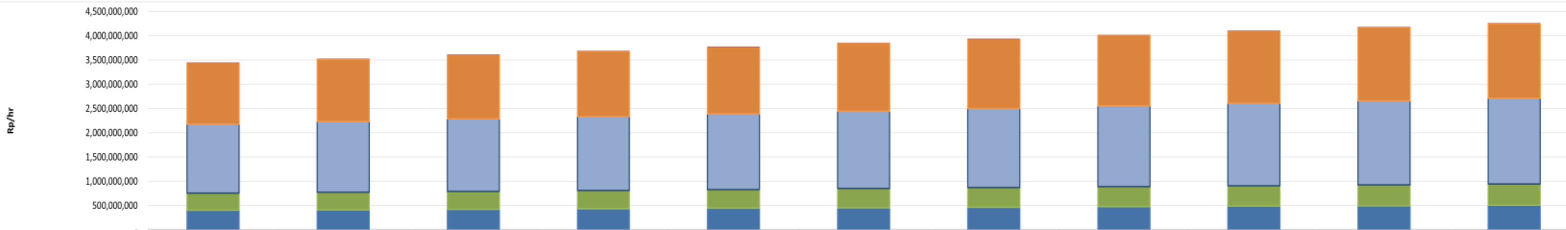


Fig. 8. Vehicle Operation Cost Unit for Particular Speed



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Ga Emission Savings Do Something	1,329,467	1,362,370	1,395,272	1,428,174	1,461,076	1,493,978	1,527,891	1,561,803	1,595,715	1,629,628	1,663,540
Gas Emission Savings Do Nothing	1,445,386	1,484,973	1,524,560	1,564,147	1,603,734	1,643,322	1,683,195	1,723,067	1,762,940	1,802,813	1,842,686
VOC Savings Do Something	958,587,721	987,633,293	1,016,678,864	1,045,724,436	1,074,770,007	1,103,815,578	1,134,700,173	1,165,584,768	1,196,469,363	1,227,353,957	1,258,238,552
VOC Savings Do Nothing	1,053,328,002	1,089,151,179	1,124,974,356	1,160,797,534	1,196,620,711	1,232,443,889	1,270,439,796	1,308,435,703	1,346,431,611	1,384,427,518	1,422,423,425
Time Savings Do Something	265,229,498	273,746,520	282,263,541	290,780,563	299,297,584	307,814,605	317,001,578	326,188,551	335,375,524	344,562,497	353,749,469
Time Savings Do Nothing	291,331,903	301,825,760	312,319,618	322,813,475	333,307,333	343,801,190	355,192,087	366,582,984	377,973,881	389,364,778	400,755,675



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Gas Emission Savings Do Something	1,663,540	1,693,214	1,722,888	1,752,562	1,782,236	1,811,910	1,841,584	1,871,258	1,900,932	1,930,606	1,955,562
Gas Emission Savings Do Nothing	1,842,686	1,877,451	1,912,216	1,946,981	1,981,745	2,016,510	2,051,275	2,086,040	2,120,805	2,155,569	2,183,073
VOC Savings Do Something	1,258,238,552	1,286,384,377	1,314,530,203	1,342,676,028	1,370,821,853	1,398,967,679	1,427,113,504	1,455,259,330	1,483,405,155	1,511,550,980	1,540,470,682
VOC Savings Do Nothing	1,422,423,425	1,457,021,489	1,491,619,553	1,526,217,618	1,560,815,682	1,595,413,746	1,630,011,810	1,664,609,874	1,699,207,939	1,733,806,003	1,765,496,836
Time Savings Do Something	353,749,469	362,276,021	370,802,572	379,329,123	387,855,674	396,382,225	404,908,776	413,435,327	421,961,878	430,488,429	440,035,394
Time Savings Do Nothing	400,755,675	411,341,627	421,927,579	432,513,530	443,099,482	453,685,434	464,271,385	474,857,337	485,443,289	496,029,240	506,669,686

Fig. 9. Transport Benefit in Do Nothing and Do Something Conditions/Scenarios

3.4 Measure of Effectiveness

The feasibility assessment was carried out with the parameters of NPV, BCR and IRR [18]. The time review was carried out for 20 years. Cashflow can be seen in Figure 10. The measurement is carried out at a rate of return of 3%, so that a comparison of the results with Henke (2020) can be made, which has the same case. Table 6 shows an NPV value of 4.039 billion IDR and a BCR of 1.63, which is similar to the results shown by Henke. The Asian Development Bank [19] recommends the economic feasibility limit with an IRR value of 9%, so that there needs to be an additional benefit value to increase the current IRR value (8.68%).

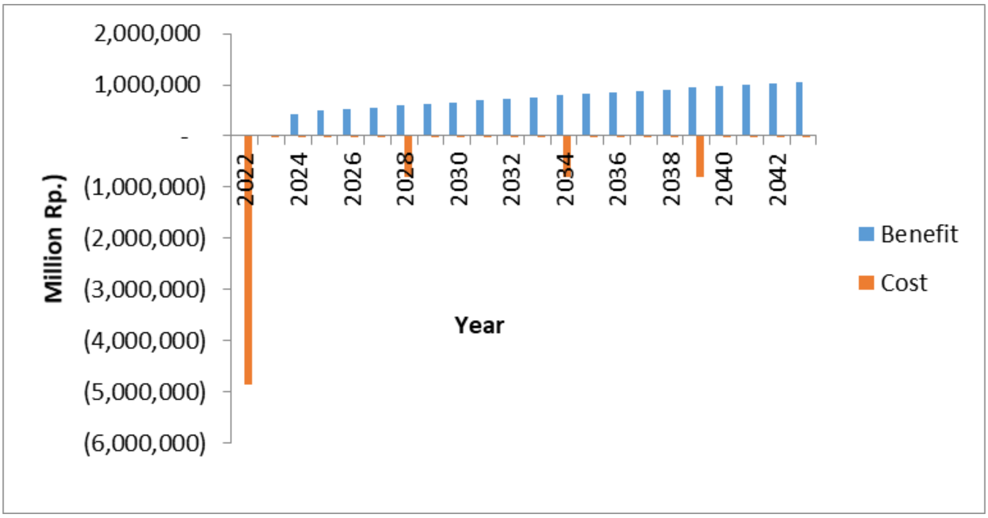


Fig. 10. Cashflow Benefit and Cost from 2022 to 2043

Table 6. The Measure of Effectiveness (MOE) for Feasibility Assessment

Indicator	Value	Unit
Rate of Return	3	%
NPV	4,039	Billion Rp
BCR	1.63	
IRR	8.68	%

4 Conclusion

The southern part of West Java Province has characteristics of low movement and poor traffic conditions with low-speed values. The traffic model is formed as a tool for projecting movement and traffic conditions, which is based on the road network and regional zoning. The benefits of transportation can be calculated using the traffic model, in the form of savings in vehicle operating costs, time value and reduction of gas emissions (CO, NO2, SO2 and PM10). The percentage savings in vehicle operating costs is 78% compared to time value savings and air pollution.

Economic feasibility assessment with an IRR indicator of 8.68%, which requires additional benefits so that it can be feasible based on the size of the Asian Development Bank study.

5 Further Research

The added value of transportation benefits can be seen from the side of business actors, as done by Zukhruf (2014) [20]. The cases reviewed in the cocoa supply chain, get additional benefits after supply chain optimization is carried out by more than 20 billion IDR per year. The development of the traffic model that has been used can be developed by adding a supply chain network, so that the transportation benefits can be calculated from the side of the business actor.

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