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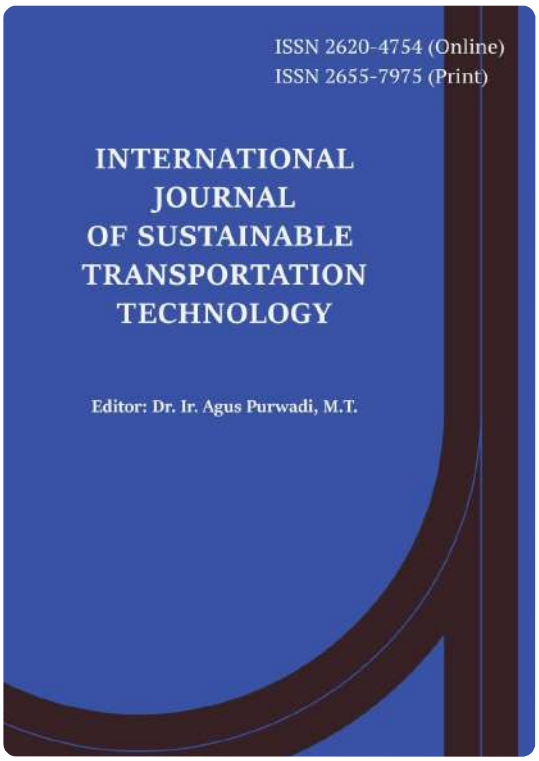

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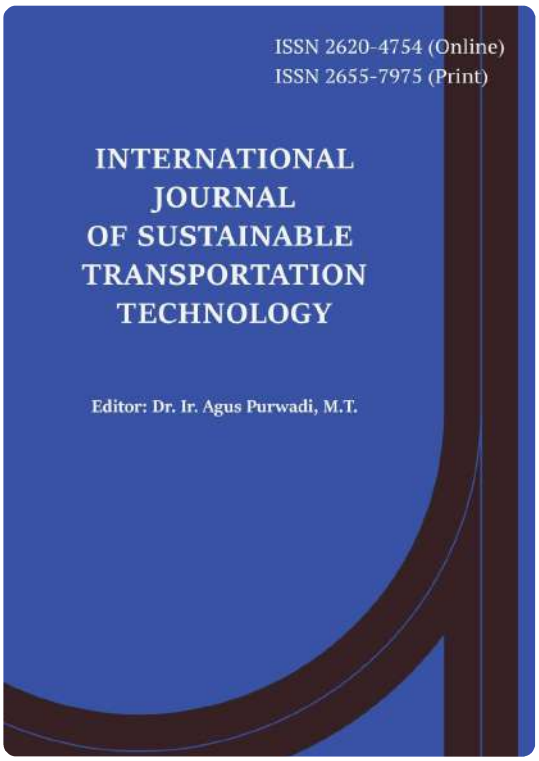

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Improving the Accessibility of the West Java Southern Area through Collector Road Widening

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Abstract

This study assesses the impact of the road segment widening in the southern area of West Java Island. The resulting network performance is measured by volume capacity ratio, network average speed, aggregate travel distance and time. The network 4-step modeling approach was used for the analysis and data on traffic counts and average speed are used to validate the model. The study proceeds two scenarios for the analysis, namely the do-nothing scenario, in which no road widening occurs, and the do-something scenario where the road widening is carried out. The result shows that widening the road segments will contribute to improving accessibility in the area, which is reflected by lower volume capacity ratio and higher average network speed. This study also triggers a research question on alternative transport modes to improve accessibility in the southern area of West Java.

Keywords

Accessibility; Traffic network modeling; West java

1 Introduction

Accessibility is an important factor in supporting economic growth. Accessibility, which can be defined as the ease of movement, will enable people to move from one place to another to fulfill their needs. Examples of these are people moving from their home to office, school, market as well as tertiary activities such as tourism. Such activities will keep the economy running which will ultimately benefit society.

The case of enhancing accessibility is even stronger for areas that have a growing population as well as many economic potentials, i.e., industry, tourism, trade, service, etc. Such trend will eventually lead to congestion and hence, higher energy consumption, air pollution and emission [1], especially because almost all vehicles in Indonesia are still powered by fossil fuel [2]. This impact is harmful for human health as it can cause lung related diseases, eye irritation, the risk of premature death, etc. [3], [4].

The growing population and economic activities are also the case for the southern area of West Java. This area is a part of West Java province which consists of 6 regencies. Its broad area causes the southern area of West Java as the place where many economic sectors are located. This makes the area contributes significantly to the economic growth in both province and national level.

However, due to the increasing population in the future, this area will have more travel demand. As a result, the road network will contain more traffic and have deteriorating performance, some of which are in terms of reduced average speed, increased volume capacity ratio and other traffic indicators.

Therefore, it is important to maintain the road network performance to preserve accessibility, and hence support the economy. This study explores national and provincial road performance in the southern area of West Java and discuss the possible network performance improvement by widening the existing road segments in the study area. The road widening will be carried out on road segments that connect the eastern and the western side of the area. The network performance is then evaluated in terms of volume capacity ratio, network average speed, aggregate trip length, and travel time, which are all measured during peak hour.

2 Literature Review

According to [5], accessibility is defined as the ease of accessing opportunities, including goods, services, and activities. [6] and [7] also stated that accessibility is a form of interaction and exchange potential. Thus, accessibility can be interpreted, one of which, as the 'time' and 'money' that must be devoted to transportation to be able to travel from one place to

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another. The time spent during travel itself contains values called "travel time value", which is typically monetized in its calculation [8]. Several factors that influence accessibility according to [5] are: i) mobility, ii) proximity, iii) transportation system connectivity, iv) affordability, v) convenience and vi) social acceptability. One of the factors that influences accessibility is mobility. Mobility, according to [5], is the ease of physical movement of transport modes, which is reflected by availability, speed, comfort, etc. Previous studies have carried out analyses related to mobility to make an area or cities more accessible. For instance, [9] carried out a study on traffic management policy, namely odd-even plate number and car-free day policy. The study identified the impact of the policies on road network volume capacity ratio, which influences traffic speed, and hence accessibility. A study by [10] also analyzed the impact of terminal development as well as new inner ring road development in Bandung City and its impact in terms of traffic volume, average speed and volume capacity ratio, which are indicators that reflect accessibility. One of the measures that can also be taken to improve accessibility is also through the operation of public transport as a study conducted by [11] which attempts to identify public transport strategies to reduce congestion and improve accessibility in Palembang City, Indonesia.

These studies imply that improving accessibility will also result in economic and environmental benefits. Improving volume capacity ratio on the road will result in reduced congestion, and hence reduced fuel burn, emission, and travel time loss. Moreover, a decrease in travel time loss will also lower the loss of productivity caused by the tiredness of travel. This is in line with [12] and [13], which stated that improved transport performance, including accessibility, will create benefits such as user benefit, productivity effects, investment, and employment. Hence, improving accessibility is important in supporting economic growth of an area and reducing environmental problem. This study attempts to explore the impact of road segments widening in the southern area of West Java that connects several municipalities. Moreover, the area also has tourism potential. As mentioned by [14], accessible tourism, which is enabled by the transport sector, has a significant economic benefit in the tourism sector and beyond. [14] further mentioned that traffic is a prerequisite for tourism. Therefore, improving accessibility in the southern area of West Java will contribute to supporting tourism as well as intercity access which will ultimately support the area's economy.

3 Study Area

The study area for this research is the southern area of West Java. The map of this area as well as the name of the activity centers (zones) can be seen in Figure 1. The activity centers are later used as a basis to develop the network model. The area consists of 6 regencies, namely Sukabumi, Cianjur, Garut, Tasikmalaya, Pangandaran, and Ciamis, in which each regency has its unique economic commodities. For instance, Sukabumi is a place for industry and nature tourism whilst Pangandaran has a nature (seaside) tourism which is well known in Indonesia. Improving accessibility in this area thus will significantly bolster the economic growth in this area, which will also contribute to the national economy.

4 Methodology

This study employs the 4-step network modeling approach as explained in [9] to analyze road network performance in the southern area of West Java, without and with road widening. Inputs that are required are i) the road network data and ii) the origin-destination matrix (O-D matrix). The road network data that were obtained by a primary survey as well as from the Integrated Road Management System (IRMS) year 2017 data. While for the O-D matrix, the data were derived from national origin-destination data and primary survey during peak hours. The O-D matrix for this study consists of 64 zones in which each zone represents an activity center.

Through this approach, road network performance in terms of travel distance, travel time, network average speed, and total traffic flow is generated. The base year for the network is the year 2019 and the road network performance is analyzed until the year 2039. To ensure that the network represents real-world situations, two sets of real-world data were used for validation, namely i) traffic counts and ii) travel time. The study then plots the modeled and observed traffic flow and travel time data and use the linear regression method to obtain the R^2 value. As the network performance is estimated until the year 2039, there will be a change in traffic flows, whether an increase or decrease. Hence, this study considers this change by updating the origin-destination matrix data, by double-constrained method, and by considering economic growth.

Two scenarios are then developed for this study, namely do-nothing and do-something. The do-nothing scenario consists of existing roads while the do-something scenario includes the widening of road segments on the existing network that function as collector road. Besides, the road widening for the do-something scenario is implemented in stages that finish in 2035.

After the data and network preparation has been completed, the next step is traffic assignment. To carry out this phase, two pieces of information need to be prepared, namely travel time and travel cost function. This is because the result of the traffic assignment depends highly on travel generalized cost. The calculation of travel time and travel cost is carried out by equation (1) and (2). The travel time equation refers to the method by [15]. The network model is then validated by using real-world traffic counts and travel time data and then used for traffic simulation.

Figure 1 Map of the southern area of West Java

$$t_{cur} = t_0 \left(1 + \frac{q}{q_{max}}^2\right) \quad (1)$$

$$f(x) = l * VoT + l * VoC + l * Toll\_Fare \quad (2)$$

Where:

t_{cur}	: travel time during assignment (hr)
t_o	: free-flow travel time (hr)
q	: traffic flow (veh/hr)
q_{max}	: maximum traffic flow (veh/hr)
$f(x)$	: travel cost function
l	: road length (km)
VoT	: time value (IDR/hr)
VoC	: vehicle operational cost (IDR/km)
$Toll\_Fare$	: toll road fare (IDR/km)

5 Network Validation

The network is validated by comparing the modeled and observed traffic flow and travel time by linear regression approach. The results show high R^2 on both traffic flow and travel time validation, namely at 0.87 and 0.98 respectively, as shown in Figure 2 and Figure 3. The network is ready to be used for simulation.

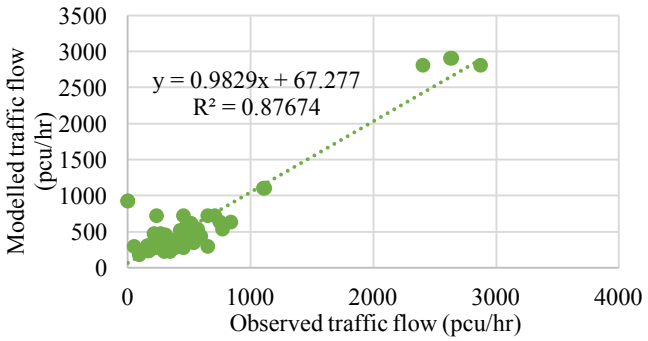

Figure 2 Traffic flow validation (pcu/hr)

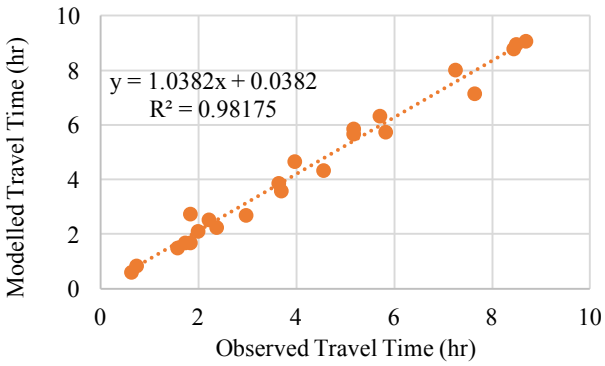

Figure 3 Travel time validation (hr)

6 Results and Analysis

The network performance is measured by volume capacity ratio (VCR), average network speed (km/hr), aggregate trip length (pcu.km) and travel time (pcu.hr) during peak hour. In Figure 4, only a small portion of roads in the network that has VCR greater than 0.85. This means that the network is still in good condition. However, by the year 2039, a significant portion of the road segment has VCR more than 0.85 due to population and hence traffic increase. This can be seen in Figure 5 (left).

This strengthens the case that road widening is necessary, namely, to reduce traffic along with enhancing the economy of the study area. The widening of collector road in the do something scenario is expected to be increasing the travel time in the southern area of West Java. Figure 5 (right) shows that there is an improvement in the network model in terms of VCR through not apparent. To observe the improvement in more detail, the network average speed shows a clearer result as presented in Figure 6.

Figure 4 Road network performance year 2019 for "do-nothing" scenario

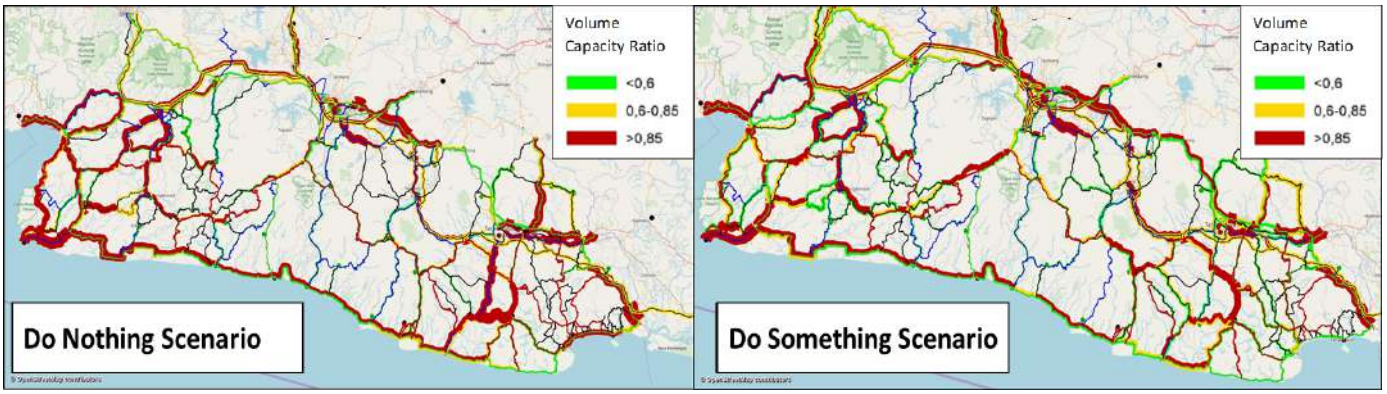

Figure 5 Comparing road network performance year 2039 for the "do-nothing" scenario and "do-something" scenario

The road widening continuously improves network average speed until the year 2035 and slowly decreases until 2039 but still better than the network average speed for the "do-nothing" scenario. Figure 7 and Figure 8 also show that road widening is expected to reduce the trip length and travel time. The road widening will also provide road spaces for drivers to reach their destination faster than road width on the do-nothing scenario. This strengthens the case that the road widening improves road network performance, even though, another measure is needed to maintain the network performance after 2035. This shows the inherent nature of the necessity of continuously seeking for solution, including in the transport sector.

Thus, according to the analysis, it is recommended that the road widening of the collector road is carried out to accommodate traffic and economic growth in the Southern Area of West Java. However, as continuous road expansion is not an efficient use of space, strategies should be formulated to develop public passenger transport or railway freight transport to accommodate people and goods movement. This, then, is an opportunity for further studies focusing on transport or accessibility improvement in the southern area of West Java.

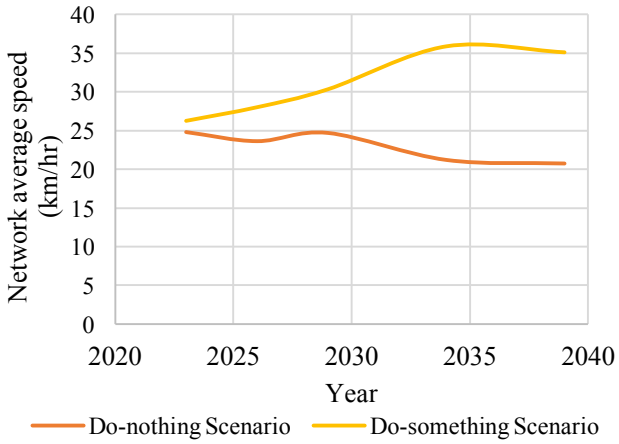

Figure 6 Network average speed for "do-nothing" and "do-something" scenario

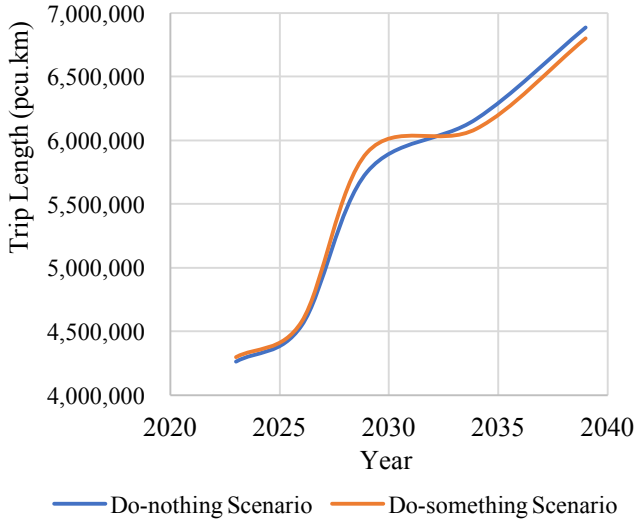

Figure 7 Aggregate trip length for "do-nothing" and "do-something" scenario

7 Conclusion

This study explores the impact of the widening of collector road to improve accessibility in the southern area of West Java. The study utilizes the 4-step network modeling approach which then validated by using traffic counts and travel time data.

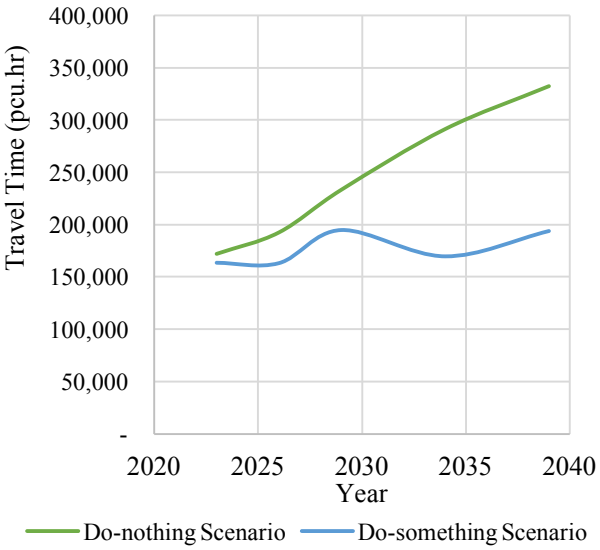

Figure 8 Aggregate travel time for "do-nothing" and "do-something" scenario

The study then develops two scenarios, namely the do-nothing and do-something scenario. In the do-nothing scenario, there is no road widening in the study area, while on the do-something scenario, collector road widening that connects the eastern and western part of the study area is carried out. The results of the two scenarios are then compared to see the impact of the road widening in terms of volume capacity ratio, network average speed, aggregate trip length and travel time. The analysis shows that the road widening will lower the volume capacity ratio in different parts of the network. This is because now the network has more capacity to accommodate vehicle travel. The network average speed comparison also shows a significant difference between the do-nothing and do something scenario, with the do-something scenario has significantly higher average speed after the widening road construction has finished in 2035. Similar case also occurs to the aggregate trip length and travel time where the do-nothing scenario shows better performance. Thus, road widening is expected to improve accessibility in the southern area of West Java.

However, it is only a matter of time that the road network will be saturated again, as a result of increased population and thus travel demand. When this happens, two options can be taken, namely building more roads or widening the current road segments or operating public transport, which is deemed more sustainable in numerous transportation studies. Therefore, opportunities exist to explore the appropriate transport mode that should be prioritized for the southern area of west java in the future. This could be determined based on land availability, travel cost, public preference, etc. Mode options that can be explored can be rail-based transport, buses and other types of modes.

Acknowledgment

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By Andrean Maulana

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Figure 1 Map of the southern area of West Java

$$t_{\#\$} = t_0 \left(1 + \alpha \left(\frac{v}{c}\right)^{\beta}\right) \quad (1)$$

$$C = f(t_{\#\$}, d, \ldots) \quad (2)$$

Where:

$t_{\#\$}$: travel time during assignment (hr)
t_0 : free-flow travel time (hr)
v : traffic flow (veh/hr)
c : maximum traffic flow (veh/hr)
C : travel cost function
d : road length (km)
t : time value (IDR/hr)
toll road fare (IDR/km)
: vehicle operational cost (IDR/km)

5 Network Validation

The network is validated by comparing the modeled and observed traffic flow and travel time by linear regression approach. The results show high R^2 on both traffic flow and travel time validation, namely at 0.87 and 0.98 respectively, as shown in Figure 2 and Figure 3. The network is ready to be used for simulation.

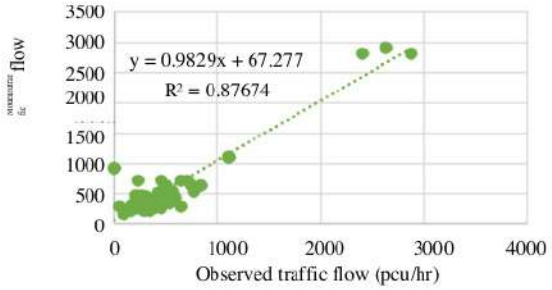

Figure 2 Traffic flow validation (pcu/hr)

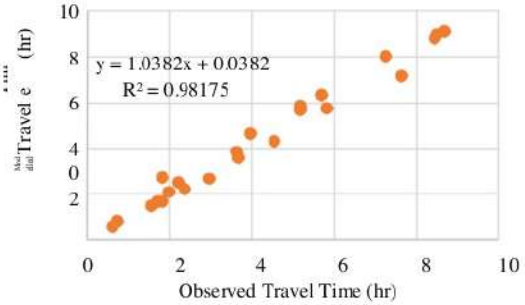

Figure 3 Travel time validation (hr)

6 Results and Analysis

The network performance is measured by volume capacity ratio (VCR), average network speed (km/hr), aggregate trip length (pcu.km) and travel time (pcu.hr) during peak hour. In Figure 4, only a small portion of roads in the network that has VCR greater than 0.85. This means that the network is still in good condition. However, by the year 2039, a significant portion of the road segment has VCR more than 0.85 due to population and hence traffic increase. This can be seen in Figure 5 (left).

This strengthens the case that road widening is necessary, namely, to reduce traffic along with enhancing the economy of the study area. The widening of collector road in the do something scenario is expected to be increasing the travel time in the southern area of West Java. Figure 5 (right) shows that there is an improvement in the network model in terms of VCR through not apparent. To observe the improvement in more detail, the network average speed shows a clearer result as presented in Figure 6.

Figure 4 Road network performance year 2019 for "do-nothing" scenario

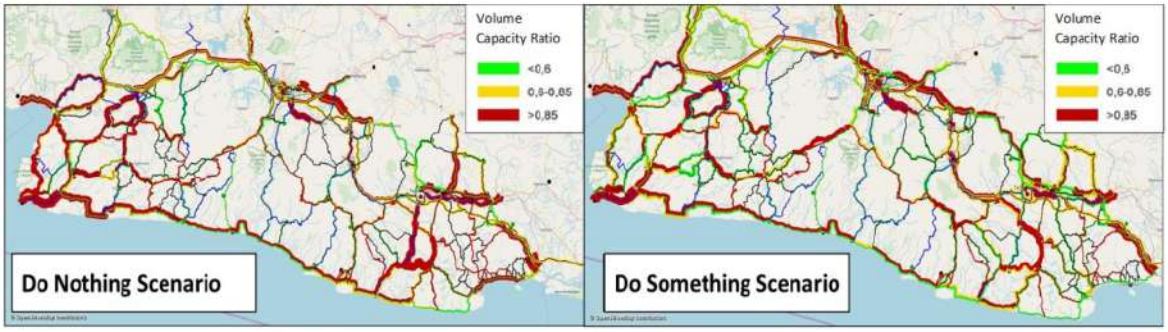

Figure 5 Comparing road network performance year 2039 for the "do-nothing" scenario and "do-something" scenario

The road widening continuously improves network average speed until the year 2035 and slowly decreases until 2039 but still better than the network average speed for the "do-nothing" scenario. Figure 7 and Figure 8 also show that road widening is expected to reduce the trip length and travel time. The road widening will also provide road spaces for drivers to reach their destination faster than road width on the do-nothing scenario. This strengthens the case that the road widening improves road network performance, even though, another measure is needed to maintain the network performance after 2035. This shows the inherent nature of the necessity of continuously seeking for solution, including in the transport sector.

Thus, according to the analysis, it is recommended that the road widening of the collector road is carried out to accommodate traffic and economic growth in the Southern Area of West Java. However, as continuous road expansion is not an efficient use of space, strategies should be formulated to develop public passenger transport or railway freight transport to accommodate people and goods movement. This, then, is an opportunity for further studies focusing on transport or accessibility improvement in the southern area of West Java.

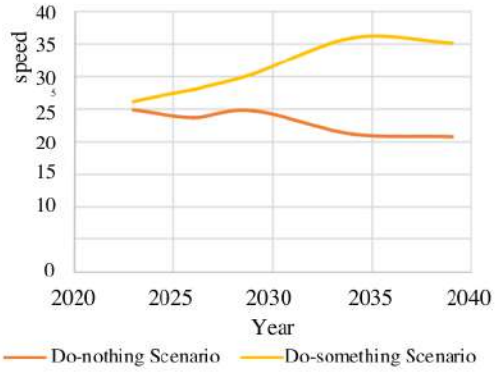

Figure 6 Network average speed for "do-nothing" and "do-something" scenario

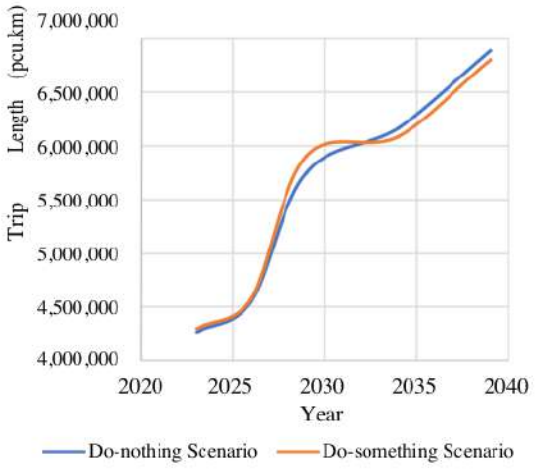

Figure 7 Aggregate trip length for "do-nothing" and "do-something" scenario

7 Conclusion

This study explores the impact of the widening of collector road to improve accessibility in the southern area of West Java. The study utilizes the 4-step network modeling approach which then validated by using traffic counts and travel time data.

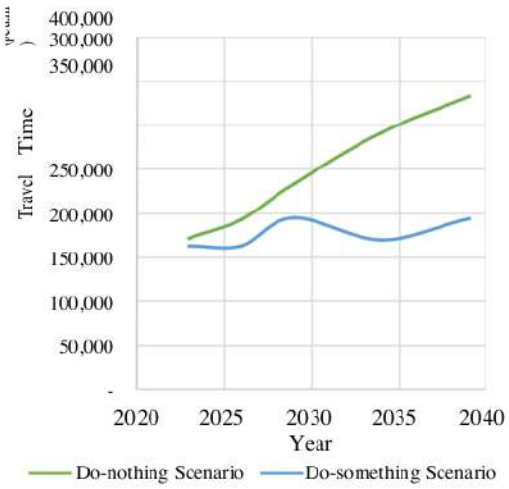

Figure 8 Aggregate travel time for "do-nothing" and "do-something" scenario

The study then develops two scenarios, namely the do-nothing and do-something scenario. In the do-nothing scenario, there is no road widening in the study area, while on the do-something scenario, collector road widening that connects the eastern and western part of the study area is carried out. The results of the two scenarios are then compared to see the impact of the road widening in terms of volume capacity ratio, network average speed, aggregate trip length and travel time. The analysis shows that the road widening will lower the volume capacity ratio in different parts of the network. This is because now the network has more capacity to accommodate vehicle travel. The network average speed comparison also shows a significant difference between the do-nothing and do something scenario, with the do-something scenario has significantly higher average speed after the widening road construction has finished in 2035. Similar case also occurs to the aggregate trip length and travel time where the do-nothing scenario shows better performance. Thus, road widening is expected to improve accessibility in the southern area of West Java.

However, it is only a matter of time that the road network will be saturated again, as a result of increased population and thus travel demand. When this happens, two options can be taken, namely building more roads or widening the current road segments or operating public transport, which is deemed more sustainable in numerous transportation studies. Therefore, opportunities exist to explore the appropriate transport mode that should be prioritized for the southern area of west java in the future. This could be determined based on land availability, travel cost, public preference, etc. Mode options that can be explored can be rail-based transport, buses and other types of modes.

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References

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