



Analysis of Public Transportation (Trans Metro Dewata Bus) as a Congestion Solution

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Abstract. Traffic congestion is a prevalent problem in urban areas of Indonesia, including Jalan Gajah Mada and Denpasar, which often experience congestion due to community activities, shophouses, and shops along the road. This study explores the potential use of public transportation (Trans Metro Dewata) as an alternative to reduce congestion in the area. This study aims to evaluate the effect of public transportation use on congestion mitigation in Jalan Gajah Mada, Denpasar, by analyzing three different periods: morning, afternoon, and evening. This method aims to identify potential changes in traffic saturation levels and road service levels, assuming effective use of public transportation. The analysis was conducted based on MKJI 1997 regulations at three different periods: morning (06.00–08.00 WITA), afternoon (11.00–13.00 WITA), and evening (16.00–18.00 WITA). The performance of the road sections was evaluated using adjusted degrees of saturation and level of service. The assumption of effective use of public transportation was also considered to obtain a more accurate picture. The results show that public transit has significant potential to reduce congestion in Jalan Gajah Mada, Denpasar. The analysis shows a 4% to 24% change in road level of service, indicating a meaningful effect on congestion mitigation. The findings significantly contribute to a potential solution to the problem of traffic congestion in urban areas by using public transportation more effectively.

Keywords. Congestion, public transportation, congestion mitigation, and section performance

INTRODUCTION

In urban areas in Indonesia, congestion problems often occur due to the dense population and the movement caused by the residents. Congestion that occurs on urban roads such as Jakarta is due to several reasons, namely the high use of private vehicles and the volume of vehicles not commensurate with road capacity [1], [2]. Congestion is a decrease in the level of smoothness in existing traffic conditions and will significantly affect motorists on the road; this impacts discomfort and increases the time motorists take to reach their trip destination. [3], In addition to time losses, congestion also incurs losses in cost [4]. Other research also proves something similar [5], [6]. Besides that, excessive use of private vehicles over a long period can cause severe air pollution and impact the broader community [7]. The same problem is also experienced by one of the roads in Denpasar City, namely the Gajah Mada Road section.

On Gajah Mada Road, it is indeed one of the most congested roads because of its activities. Following its location in the middle of Denpasar City, the beginning of this road section became the meeting of two major roads, namely Sutomo Street and Thamrin Street. In addition, this street has very dense activity at certain hours because this area is one of the trading areas with various shophouses that are rarely deserted. This road section is also widely crossed by public transportation, one of which is the Trans Metro Dewata bus, which passes as many as 15-25 buses per hour; where this public transportation can be used as the best alternative to overcome congestion on the Gajah Mada Road section.

Considering that many private vehicles cross this road with only one or two passengers, which, of course, is a waste of road capacity before this public vehicle operated, other public vehicles also crossed the area in Denpasar, namely the Trans SARBAGITA Bus, which is a public vehicle that has good perception. If seen from the dimensions of performance, service, capabilities, product characteristics, and similarities with specifications, while if seen from the dimensions of the results, there needs to be a better perception [8]. Trans SARBAGITA buses are adequate in accessibility, capacity, safety, and comfort. However, they could be more effective in time because they are often stuck in traffic jams [9]. Of course, the main problem, traffic jams, still need to be resolved.

This research focuses on what would happen if some private vehicle drivers switched to public transportation, namely the Trans Metro Dewata bus. Previous research stated that the public has 72% interest in using the Trans Metro Dewata Bus. This figure is quite prominent if it is related to traffic jams. Found on the streets of Denpasar City [10]. The purpose of this research is to find out what the level of service on Gajah Mada roads would be if private vehicle drivers switched to using Trans Metro Dewata buses.

RESEARCH METHODS

This research was carried out by applying the Indonesian Road Capacity Manual (MKJI) in 1997 as a guideline for each calculation. Of course, the results obtained in this study are expected to conform to the intent of this research.

The data to be used in this study is divided into two parts, namely primary data and secondary data. The process of searching for data has several levels carried out, namely:

Preparation stage

The preparation stage is carried out by preparing all the tools and needs to facilitate and streamline the survey process in the field. At this stage, it is carefully crafted and structured so that no negligent things will significantly affect the survey process and data analysis later.

Implementation Stage

At this level, several stages were carried out to obtain the data used to analyze this research. Following what has been done in the previous preparation stage, at this implementation stage, several stages will be carried out, including:

a. Road geometric survey

This survey was carried out to obtain data that describes the situation and condition of the road to be studied, namely Gajah Mada Road, Denpasar City. The data acquired will primarily relate to road width, sidewalk width, and the number of lanes on Gajah Mada Road.

b. Calculate vehicle volume

Calculating the number of vehicles as one of the primary data from the results recorded on March 27, 2023, from the Area Traffic Control System (ATCS), which was obtained from the Denpasar City Transportation Service, the Area Traffic Control System or ATCS is an information technology-based traffic control scheme in an area [11]. The process of calculating vehicles crossing this road section is assisted by Traffic Counter software following MKJI provisions: stopped vehicles, slowed down vehicles, and vehicles in and out of the lane [12]. The data obtained will be used to analyze the capacity of road sections to determine the level of service based on the degree of saturation.



FIGURE 1. Top view from the Google Earth application on Gajah Mada Road, Denpasar City
Source: Google Earth, 2023

Calculation Analysis

At this stage, the analysis is carried out from primary data obtained from the process that has been carried out, and secondary data is also needed, namely population quantity data in Denpasar City and the geometric conditions of the road sections as supporting data for this research. The analysis used MKJI, 1997 as a reference and several books [13], [14], and government regulations [15] as an additional reference.

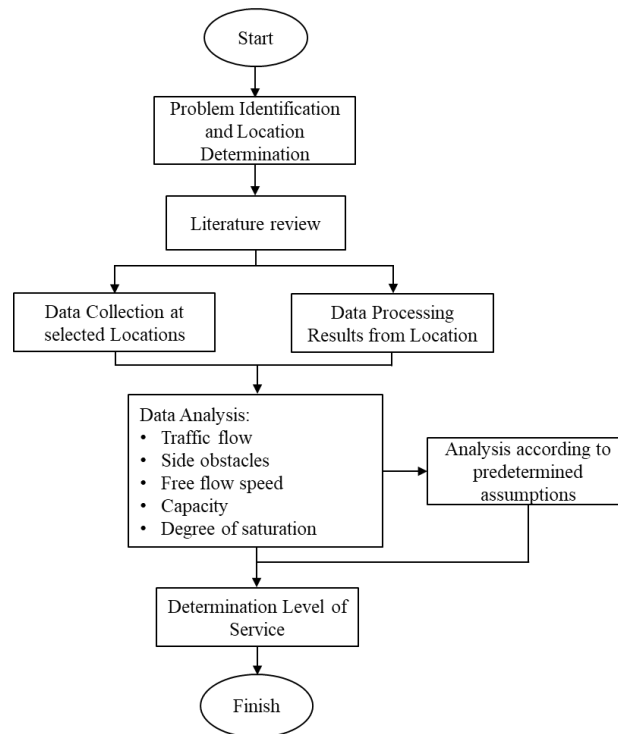


FIGURE 2. Research flow diagram

In this research, an evaluation will be carried out between the performance of the Gajah Mada road section in its actual condition, which will be compared with the results of the review of the performance of the road section resulting from the application of the assumption that private vehicle drivers will switch to public transport using the Trans

Metro Dewata bus assuming the bus can be filled to its maximum capacity. which are owned. Based on observations, the seating capacity of the Trans Metro Dewata bus is 20 passenger seats. Still, if you count standing passengers, this bus can accommodate up to 40 or 200% of the seating capacity. [16].

RESULTS AND DISCUSSION

Research result

The results of a road geometry survey on the Gajah Mada road, Denpasar City, showed that the lane width is 8 meters, the road shoulder is 0.5 meters, with a flat alignment type without a road median, with a supported two-lane one-way (2/1 UD) road type. With rigid pavement in the form of block paving.

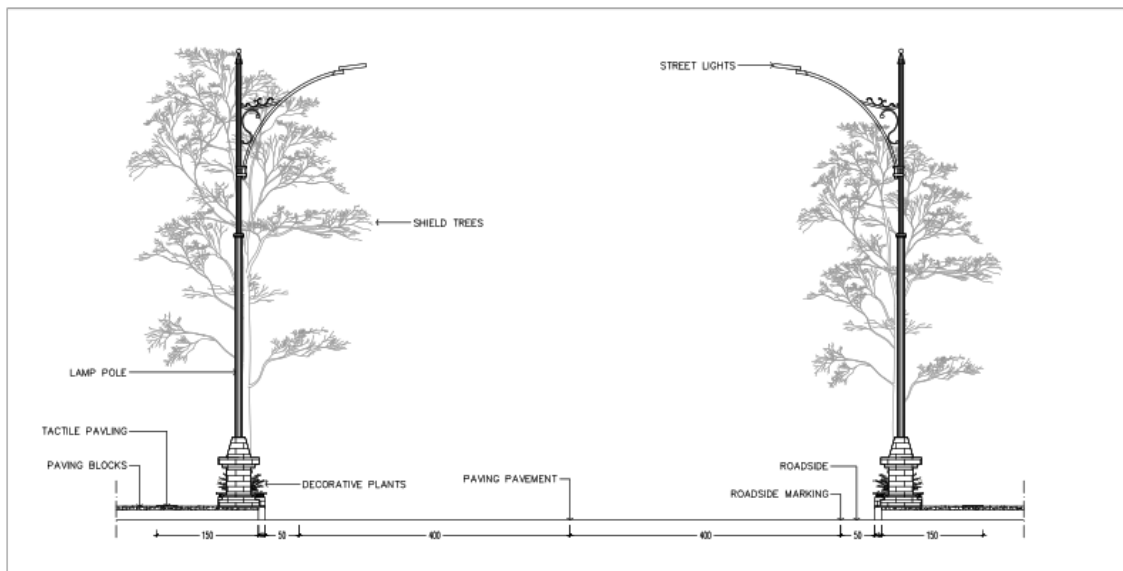


FIGURE 3. Front view from Gajah Mada Road
Source: Analysis Results, 2023

In the analysis carried out based on the description in the research method, to obtain the service level of the Gajah Mada road section in each period, the pcu/hour is obtained by multiplying the traffic flow (vehicles/hour) per lane by the emp, using emp for LV = 1.00 for HV = 1.20 and MC = 0.25 by the provisions contained in the MKJI, shown in Table 1

TABLE 1. Traffic flow and peak hours on the Gajah Mada road

Period	Peak Hours	Traffic Flow (Q)	
		Vehicles/hour	Pcu/hour
Morning	07.00 – 08.00	4.144	1.572
Noon	11.00 – 12.00	2.782	1.350
Afternoon	17.00 – 18.00	3.403	1.367

Source: Analysis Results, 2023

Based on the one-way, two-lane road (2-1) type, the free-flow speed for urban roads (FVO) is used at LV = 57, HV = 50, and MC = 47. Then, for the adjustment of traffic lane width (FVW) based on the table (MKJI, 1997), the amount used is 4,00. The adjustment factor for the effect of side barriers and road shoulder width (FFV_{SF}) on type (2/1) with moderate side resistance levels in the morning period, high in the noon and afternoon periods, with an effective shoulder width of 0.50 meters is 0.91 for the morning period and 0.82 for the noon and afternoon periods.

The population of Denpasar in 2022 is 726,808 people [17], where the city size adjustment factor (FFV_{CS}) 0.95 is used, and the free flow velocity is obtained, as shown in Table 2.

TABLE 2. Free flow speed

Period	FV	FV _{HV}	FV _{MC}
Morning	52.73	46.26	43.48
Noon	47.52	41.68	39.18
Afternoon	47.52	41.68	39.18

Source: Analysis Results, 2023

Based on the provisions contained in (MKJI, 1997), the essential capacity (C_0) with a type of two-lane one-way road (2/1) is 1.650 pcu/hour, FC_W with an effective traffic lane width of 4 meters is used at 1.08. FC_{SP} is used at 1.00, the Side resistance adjustment factor or FCSF is used at 0.82, and FCCS is used at 0.94, so the capacity (C) in each period is 1.374. The result of the degree of saturation of the equation from MKJI is used to understand the service level of a matching road section [18]. Detailed analysis results are in Table 3.

TABLE 3. Degree of saturation and level of service

Period	Q	C	DS	LoS
Morning	1.572	1.374	1,14	F
Noon	1.219	1.374	0,89	E
Afternoon	1.367	1.374	0,99	E

Source: Analysis Results, 2023

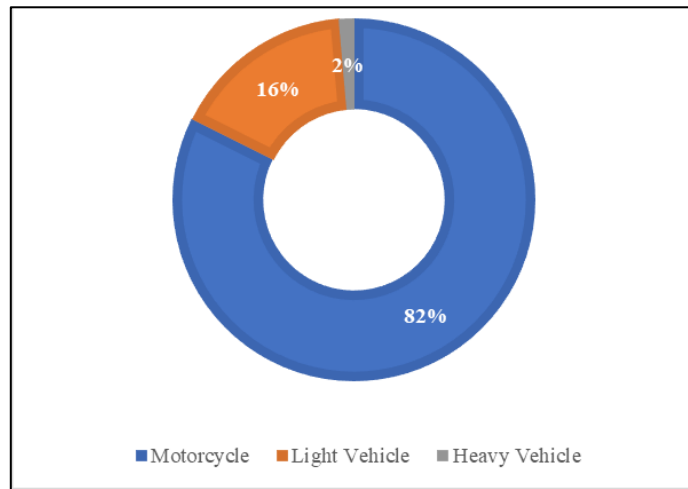


FIGURE 4. Comparison ratio of vehicle types (unit) morning period

Source: Analysis Results, 2023

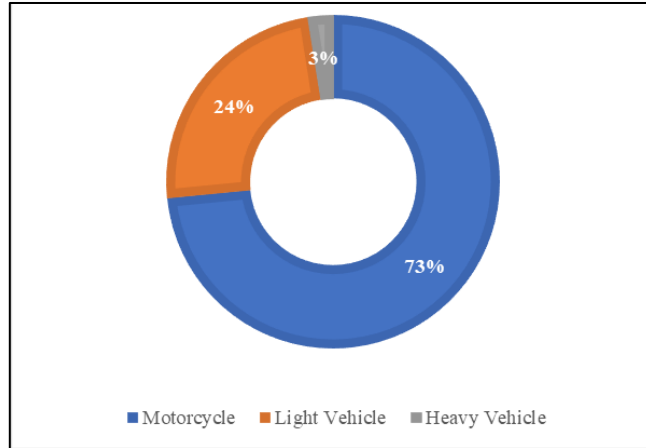


FIGURE 5. Comparison ratio of vehicle types (unit) of the noon period
Source: Analysis Results, 2023

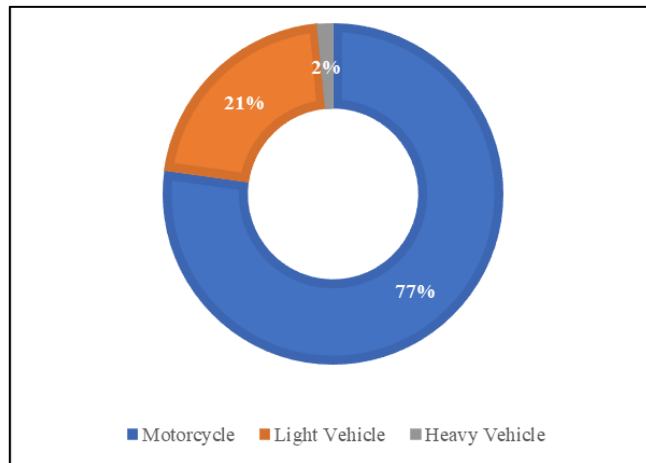


FIGURE 6. Comparison ratio of vehicle types (unit) of the afternoon period
Source: Analysis Results, 2023

After obtaining the degree of saturation, the level of service on the Gajah Mada road section was also obtained, with a level of service (LOS) of E in the afternoon and evening and F in the morning. Based on this, it can be interpreted that this section of Gajah Mada road is congested. Then, we will continue applying assumptions to the congestion conditions that occur. The analysis carried out remains the same as before so that the results in Table 4 are obtained:

TABLE 4. The number of buses plying Gajah Mada Road

Period	Hour	Number of Buses
Morning	06.00 – 07.00	17
	07.00 – 08.00	17
Noon	11.00 – 12.00	22
	12.00 – 13.00	21
Afternoon	16.00 – 17.00	17
	17.00 – 18.00	22

Source: Analysis Results, 2023

The number of Trans Metro Dewata buses used for analysis is only those that correspond to the peak hours in each period determined in the previous study based on the following assumptions:

- a) Assumption 1: One bus with a maximum capacity of 40 people carries 30 people, filled with 50% motorcycle (MC) vehicle riders and 50% light vehicle (LV) riders, with each type of vehicle assumed to be driven by one person.
- b) Assumption 2: One bus with a maximum capacity of 40 people carries 30 people, filled with 75% motorcycle (MC) vehicle riders and 25% light vehicle (LV) riders, with each type of vehicle assumed to be driven by one person.
- c) Assumption 3: One bus with a maximum capacity of 40 people carries 30 people, filled with 25% motorcycle (MC) vehicle riders and 75% light vehicle (LV) riders, with each type of vehicle assumed to be driven by one person.

The results obtained are shown in Tables 5 to 7 below.

TABLE 5. Traffic flow results (Q) from the use of the assumptions applied

Period	Assumption 1	Assumption 2	Assumption 3
Morning	1,320	1,253	1,388
Noon	994	931	1,135
Afternoon	1,143	1,079	1,215

Source: Analysis Results, 2023

TABLE 6. Capacity results from the use of the assumptions applied

Period	Assumption 1	Assumption 2	Assumption 3
Morning	1,374	1,374	1,374
Noon	1,374	1,374	1,374
Afternoon	1,374	1,374	1,374

Source: Analysis Results, 2023

TABLE 7. Results of the degree of saturation and level of service from the use of the assumptions applied

Period	Assumption 1		Assumption 2		Assumption 3	
	DS	LoS	DS	LoS	DS	LoS
Morning	0.96	E	0.91	E	1.01	F
Noon	0.72	D	0.68	C	0.83	D
Afternoon	0.83	D	0.79	D	0.88	E

Source: Analysis Results, 2023

The application of this assumption provides a reduction in the degree of saturation by 7% to 24%, which results in several periods experiencing a decrease in the level of service (LoS) to E with the flow condition reaching an unstable condition with the quantity of traffic approaching the road capacity, traffic density high levels where drivers start to experience short-duration traffic jams. Even assuming that the 1st and 2nd afternoon periods experience a decrease until the level of service becomes category D with the flow condition reaching non-stable conditions with high traffic volumes, traffic density is classified as moderate. Still, fluctuations in capacity can result in a speed reduction. Drivers are limited in moving the vehicle. However, in the morning period, which incidentally has a high level of motorcyclists with a ratio reaching 82%, the assumptions' effectiveness is reduced.

Based on the analysis results obtained from the degree of saturation, we present the results in visual form in the form of a degree of saturation comparison diagram in Figure 7. Then, to determine the level of service in the use of assumptions that have been made, we also present the results obtained in the form of a LoS comparison diagram in Figure 8 below.

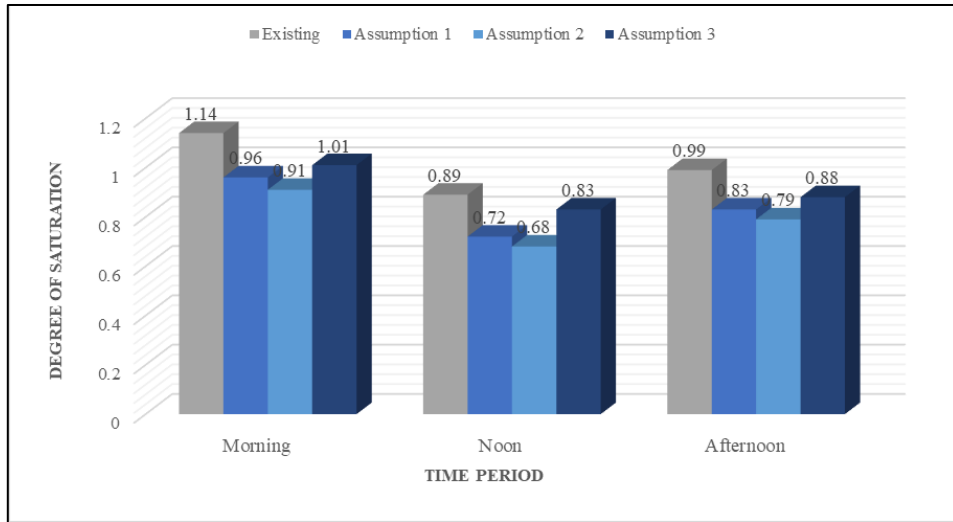


FIGURE 7. Comparison diagram of the results of the degree of saturation obtained
Source: Analysis Results, 2023

It can be seen that in each period analyzed and the application of each assumption has various results; in the morning period, the decrease in the degree of saturation obtained is enough to make a change, but the decrease is not felt sufficient because the degree of saturation is still close to 1.00. Then, in each period, it can be seen that the most pronounced is the application of the 2nd assumption, which gives the most significant decrease in the degree of saturation.

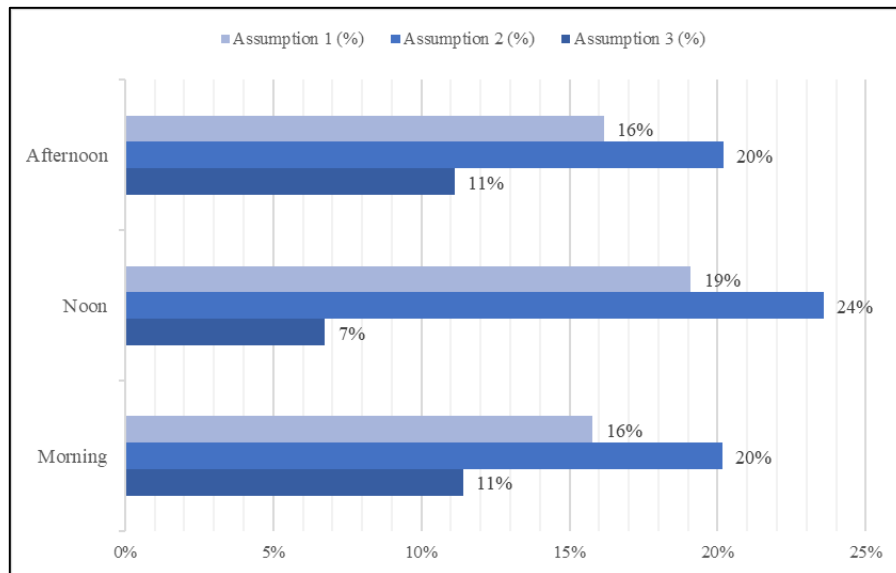


FIGURE 8. The ratio of the level of road service (LoS) between each assumption used
Source: Analysis Results, 2023

In Figure 8 above, the afternoon period shows the most significant peak increase with assumption 2. For the morning and afternoon periods, the increase that occurs is relatively similar between each assumption applied to the analysis, but of course, the degree of saturation in Figure 7 shows that the afternoon period has a lower degree of saturation than the morning period.

Discussion

Based on the initial aim of the research, which was to find out what the level of service on the Gajah Mada road would be if private vehicle drivers wanted to switch to using public transportation, the comparison results obtained were 7% to 24% as received in the previous analysis, of course, based on the assumptions applied. It has quite an impact even though it cannot significantly solve the congestion problem because the assumed capacity is not considered to be filled. After further observation, the reality is that the Trans Metro Dewata bus is a public vehicle that currently carries a small number of passengers. Public transport performance has a low level of similarity compared to expectations for each variable or service attribute [19]. This identified that transport service users were dissatisfied with the performance of public transport services at that time (Trans Sarbagita Bus). In contrast, for the public, the fare setting was still relatively high [20].

It could be that this is caused by inadequate facilities such as uncomfortable passenger pick-up places or bus routes that are combined with other private vehicles so that it is no different from riding a private vehicle, plus access to destination locations which are pretty far from the bus pick-up point often makes people -People who take public transportation think twice about using it and tend to choose private vehicles that reach their destination straight away without having to wait any longer and are considered to be able to save much time.

However, this study will only discuss these problems if they are within the scope of its objectives. Apart from these problems from the results shown in the data analyzed, this assumption method has the opportunity to reduce congestion formed on the Gajah Mada road section, seen in Figure 8 the assumption that has the highest average ratio of road service level comparison with a value of 7% to 24% is the second assumption where this assumption can reduce light vehicles (LV) by 75% and motorcycles (MC) by 25% from the specified bus capacity. The first assumption is the middle value of all established assumptions by subtracting 50% of each vehicle type from the specified bus capacity. Finally, the assumption with the lowest influence in reducing the degree of saturation is the third assumption, which can reduce light vehicles (LV) by 25% and motorcycles (MC) by 75% from the specified bus capacity.

Of course, this reduction in vehicles can reduce the congestion that occurs in Denpasar City so that the Trans Metro Dewata buses can operate as they should, namely decreasing the level of congestion, reducing air pollution (environmentally friendly), and, of course, reducing the level of frequent traffic accidents on the road. Experienced by private vehicle users [21], it can increase people's interest in using public transportation again and then reduce the use of private vehicles, which is also expected to reduce traffic jams and air pollution in Bali [22].

CONCLUSION

The conclusion that can be drawn by applying the assumptions in this analysis can influence the level of service on the Gajah Mada road section, decreasing the degree of saturation by reducing or moving the number of vehicles passing. The sequence of assumptions that have the most influence on the level of service of the Gajah Mada road section is the second assumption, with the transfer of light vehicles (LV) by 75% and motorbikes (MC) by 25% of the 30-person capacity of the trans metro dewata bus from the total capacity of 40 people, having an adequate level of traffic jam reduction of up to 4% to 24%. Furthermore, the first assumption with the transfer of light vehicles (LV) by 50% and motorcycles (MC) by 50% of the 30-person capacity of the trans metro Dewata bus has an adequate level of traffic reduction of up to 11% to 20%. The last is the third assumption, with the transfer of light vehicles (LV) by 25% and motorcycles (MC) by 75% of the 30-person capacity of the trans metro Dewata bus, having an adequate traffic reduction of up to 11% to 20%. The most influential factor on the level of service of the Gajah Mada road section analysis is a 4% to 24% change in road level of service, indicating a meaningful effect on congestion mitigation.

The assumptions applied in this study will be implemented if there are regulations that require some elements of society to use public transportation when carrying out personal activities to reduce the volume of passing vehicles, such as among students, civil servants, government agencies, and other types of individual activities. However, supporting facilities and infrastructure must be completed first because people will choose a safe way to travel and carry out their respective activities.

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