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# TRANSPORTATION MANAGEMENT THROUGH ONE-WAY ROUTE FOR CONGESTION ANTICIPATION IN BANDUNG

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## Abstract

This study aims to determine the effectiveness of transportation management through the application of one-way routes based on the level of service on the road sections in overcoming congestion. The method used a quantitative descriptive method with data collection using traffic counting, which is supported by various data from literature review relating to the object of this study. This study discusses the volume of vehicles that cross Sukajadi Road at certain hours to determine the time of peak vehicle volume in the morning and afternoon as well as the service level of the Sukajadi Road section based on the road capacity of 5,343.36 pcu / hour. The results of this study indicate that the application of transportation management by one-way lane has not been maximized to overcome the congestion, due to the class of road services that still have the characteristics of vehicle flow that is obstructed at certain hours, especially in the morning and afternoon. The impact of implementing transportation management in natural environment made the air quality effectively maintained with the average of PM10 by 98.

Keywords**:** Congestion; One-way route, Transportation; Transportation management

## 1. Introduction

Transportation management becomes the main issue of urban problems, due to the high of $CO_2$ emissions, one of which caused by transportation industry. Therefore, it is necessary to have a sustainable transportation policy, such as changing people's behaviour in using private transportation modes [1]. Another challenge in managing transportation in urban areas is the habit of parking on roadsides as one of the causes of congestion. Therefore, transportation management is needed in implementing relevant parking policies, such as open parking permits [2]. This is supported by previous research indicated that the best alternative for making a Transportation Demand Management (TDM) policy is to increase public transport capacity [3]. As for things to consider in increasing the capacity of public transportation is environmental sustainability, an evaluation of the environmental performance of the urban transportation system is needed [4]. The possible way to make public transportation as an attractive alternative to private transport is to implement the concept of Mobility as a Service (MaaS). This concept includes the application of a smart ticket system, providing Software as a Service (SaaS) by involving a lot of collaboration in the private sector into the provision of public transport routes in serving short and long-distance routes [5]. The example is the private sector which engaged in taxi/rideshare/bike share operators and cross-regional transportation providers in one city [6]. With rapid economic development, every city needs efficient transportation management. This affected the amount of city's air pollution [7]. The level of vehicle density significantly affects air pollution in an area, the higher the vehicle density then the air pollution will be increased [8]. The study also analyses the air pollution that occurs on the Sukajadi road, where it uses one-way traffic management to overcome congestion.

In Europe, 25% of the total greenhouse gas emissions that occur due to transportation because most of the vehicles use fossil fuels. Therefore, the Electric Mobility policy began to be implemented, then it is followed by policy to use public transportation [9]. Other research conducted in Perugia, Italy, found that using sustainable urban transportation can improve environmental and social sustainability. One of the example is the use of urban Light Rail Transit (LRT) which shows a reduction in $CO_2$ emissions and positively impacts the economic sustainability of transportation modes through urban LRT ticket sales [10]. The research conducted in three cities in Sweden, namely Stockholm, Göteborg, and Malmö shows that the integration of eco-social policies only focuses on environmental development, transportation planning, and green city planning. Therefore, it is essential to balance the equality of ecological fields and the relationship between socio-economic factors. In contrary, Masdar City began to build the concept of a sustainable carbon-free city that started from changing the city development approach. It still pays attention to commercial interests but remained focused on sustainable urban design and waste management [11]. Likewise, in Beijing, the government began to implement environmental education for its people, due to the research conducted on the citizens' knowledge about the importance of ecology shows the average environmental literacy score of Beijing citizens is 3.77 out of 5 [12]. Based on previous research, this study was conducted to determine the effectiveness of the implementation of transportation management using one-way routes based on the level of service in the segment specified path, using quantitative descriptive analysis method by collecting data using traffic counting and literature review.

## 2. Research Method

The method used in this research was a quantitative descriptive method, namely by describing the analysis results of the calculations performed [13, 14]. Data collection was obtained by traffic counting on Sukajadi road in the morning (6.23 - 8.15 a.m.) and afternoon (4.23 - 6.15 p.m.) (Figs. 1. and 2.). It also performs the calculation of air pollution quality during this period. Besides, it is supported by literature review related to the object of this study.

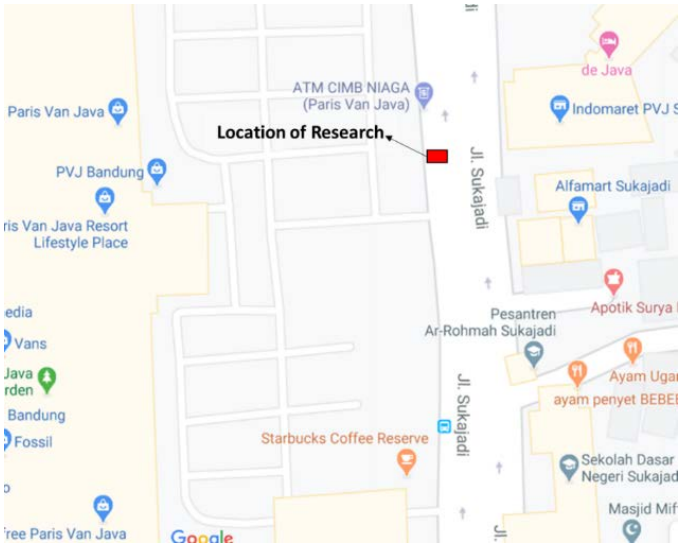


**Fig. 1. Location of Research, Sukajadi road.**

**Fig. 2. Traffic conditions on Sukajadi road in the morning and afternoon.**

The service levels on Sukajadi road was determined according to the provisions of the Indonesian Road Capacity Manual (MKJI) [15-17]. The calculation based on the following formula:

$$\text{Level of Service (LoS)} = \frac{V}{C} \quad (1)$$

where: $V$ is the vehicle volume (pcu), and C is the capacity (pcu/h)

$$\text{Capacity } (C) \text{ is the } C_0 \times FCw \times FCsp \times FCsf \times FCcs \quad (2)$$

where: $C_0$ is the basic capacity (pcu / h), $FCw$ is the road width adjustment factor; $FCsp$ is the Separated Way Adjustment Factor, $FCsf$ is the Side Friction Adjustment Factor, $FCcs$ = City Size Adjustment Factor.

## 3. Results and Discussion

### 3.1. Vehicle volume

The volume of vehicles on Sukajadi road in the morning (6.23 - 8.15 a.m.) is 16,093 vehicles consisting of 8,896 vehicles on the road section in front of the Sukajadi Sector Police Station and 7,197 in front of Paris Van Java (PVJ) shopping center, with the highest volume at 6.54 - 7.09 a.m. for the road section in front of the Sukajadi Sector Police Station with the volume of 1,195 motorcycles, 314 cars, and 19 trucks or buses. As for the road section in front of the Paris Van Java (PVJ) shopping center, the vehicle peaked at the same time, namely 6.54 - 7.09 a.m., consisting of 965 motorcycles, 261 cars, and 7 trucks or buses (See Fig. 3.).

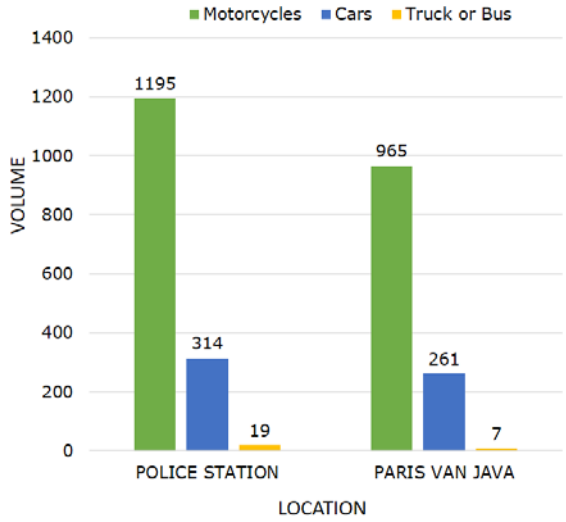


**Fig. 3. Comparison of peak vehicle volume based on vehicle type in the morning.**

As for the volume of vehicles before 6.54 - 7.09 a.m., the average vehicle volume for motorcycles is between 151-889 motorcycles, 62 - 330 cars, and 0 -12 trucks or buses that cross the road in front of the Sukajadi Sector Police Station and the Paris Van Java (PVJ) shopping center. However, the decrease in peak vehicle volume occurred after 6.54 - 7.09 a.m. (See Table 1).

**Table 1. Traffic counting at 6.15 - 6.30 a.m.**

| Time (AM) | Sukajadi Sector Police Station | | | Paris Van Java (PVJ) | | |
|---|---|---|---|---|---|---|
| | Motorcycles | Car | Truck / Bus | Motorcycles | Car | Truck / Bus |
| **6.15 - 6.30** | 398 | 216 | 12 | 151 | 62 | 0 |
| **6.30 - 6.45** | 889 | 330 | 10 | 431 | 209 | 6 |
| **6.45 - 7.00** | 1195 | 314 | 19 | 965 | 261 | 7 |
| **7.00 - 7.15** | 1076 | 259 | 12 | 880 | 243 | 4 |
| **7.15 - 7.30** | 985 | 333 | 14 | 856 | 342 | 5 |
| **7.30 - 7.45** | 1005 | 293 | 20 | 632 | 315 | 23 |
| **7.45 - 8.00** | 584 | 274 | 6 | 622 | 288 | 48 |
| **8.00 - 8.15** | 470 | 180 | 2 | 610 | 198 | 39 |
| **Total** | 6602 | 2199 | 95 | 5147 | 1918 | 132 |

The volume of vehicles at 4.23-6.15 p.m. is 47,745 vehicles, consisting of 38,793 vehicles on the road section in front of the Sukajadi Sector Police Station and 8,952 vehicles on the road in front of the Paris Van Java shopping center (PVJ), with a peak volume of vehicles at 5.55-6.10 p.m. (Sukajadi Sector Police Station bus stop) with a volume of 7,089 vehicles, and at 4.23-4.38 p.m. (in front of the Paris Van Java shopping center) with a volume of 1,254 vehicles (See Fig. 4).

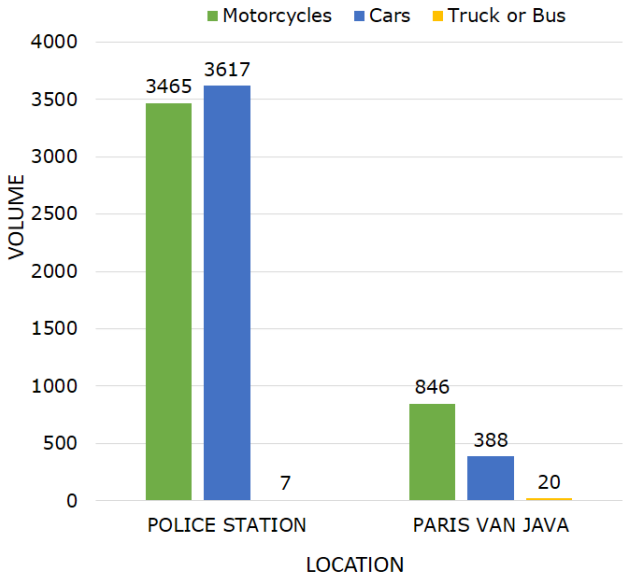


**Fig. 4. Comparison of peak vehicle volume based on vehicle type in the afternoon.**

Generally, the volume of vehicles on Sukajadi road between 4:23 - 6:15 p.m. was dominated by motorcycles and cars. On the road section in front of the Sukajadi Sector Police Station bus stop at 4:23 - 6:15 p.m. 41,183 vehicles were passing, namely 20,874 motorcycles, 20,919 cars, and 90 trucks or buses. As for the volume of vehicles passing in front of the Paris Van Java (PVJ) shopping centre at 4:23 - 6:15 p.m. as many as 8,952 vehicles consisting of 5,784 motorcycles, 3,050 cars, and 118 trucks and buses (See Table 2).

**Table 2. Traffic counting at 4:15 - 6:15 p.m.**

| Time (PM) | Sukajadi Sector Police Station | | | Paris Van Java (PVJ) | | |
|---|---|---|---|---|---|---|
| | Motorcycles | Car | Truck / Bus | Motorcycles | Car | Truck / Bus |
| **4.15 - 4.30** | 923 | 1017 | 17 | 846 | 388 | 20 |
| **4.30 - 4.45** | 1324 | 1245 | 5 | 787 | 366 | 11 |
| **4.45 - 5.00** | 1759 | 1779 | 21 | 861 | 348 | 32 |
| **5.00 - 5.15** | 3022 | 2821 | 9 | 804 | 378 | 12 |
| **5.15 - 5.30** | 3480 | 3537 | 13 | 768 | 441 | 8 |
| **5.30 - 5.45** | 3468 | 3481 | 10 | 667 | 387 | 16 |
| **5.45 - 6.00** | 3465 | 3617 | 7 | 541 | 388 | 11 |
| **6.00 - 6.15** | 3433 | 3422 | 8 | 510 | 354 | 8 |
| **Total** | 20874 | 20919 | 90 | 5784 | 3050 | 118 |

### 3.2. Air pollution measurement

The measurement of air pollution on Sukajadi road is done in two places, namely Paris Van Java Shopping Center (PVJ) and the in front of the Sukajadi Sector Police Station. The data were taken in the morning (6.23- 8.35 a.m.) and afternoon (16.23 - 18.35 p.m.). The data on air pollution level measurement on the Sukajadi Road section can be seen in Tables 3 and 4. Table 3 and 4 showed that the air pollution rate is increasing when entering after-work hours due to high-density vehicles passing through. The following is the Air Pollution Index based on the State Minister for the Environment.

**Table 3. Air pollution measurement at 6.23- 8.35 a.m.**

| Places | Time (AM) | $CO_2$ | CO | Air Quality Motor | | | | | Temp. ( °C) | RH (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ppm | ppm | PM 2.5 | PM 1 | PM 10 | HCHO | TVQC | | |
| Sukajadi Sector Police Station | 6.30 | 623 | 2 | 39 | 24 | 51 | 0.039 | 1.433 | 25.9 | 82 |
| | 6.45 | 591 | 5 | 25 | 15 | 32 | 0.036 | 0.694 | 26.3 | 78.7 |
| | 7.00 | 607 | 6 | 43 | 24 | 53 | 0.037 | 1.472 | 27.0 | 74.2 |
| | 7.15 | 577 | 2 | 39 | 22 | 48 | 0.029 | 0.408 | 27.3 | 73.4 |
| | 7.30 | 584 | 0 | 47 | 59 | 27 | 0.027 | 0.192 | 26.7 | 75.7 |
| | 8.30 | 580 | 3 | 37 | 20 | 46 | 0.02 | 0.707 | 26.4 | 79.8 |
| Paris Van Java | 6.30 | 515 | 7 | 48 | 30 | 63 | 0.021 | 0.084 | 22.7 | 86.0 |
| | 6.45 | 562 | 13 | 60 | 35 | 76 | 0.056 | 2.466 | 22.0 | 88.4 |
| | 7.00 | 543 | 10 | 57 | 34 | 73 | 0.045 | 0.967 | 22.0 | 87.6 |
| | 7.15 | 499 | 8 | 48 | 28 | 61 | 0.035 | 0.606 | 23.4 | 85.2 |
| | 7.30 | 524 | 7 | 64 | 41 | 85 | 0.033 | 1.410 | 23.6 | 85.4 |
| | 8.30 | 509 | 6 | 74 | 97 | 47 | 0.018 | 4.560 | 25.2 | 80.8 |

**Table 4. Air pollution measurement in the afternoon.**

| Places | Time (PM) | $CO_2$ | CO | Air Quality Motor | | | | | Temp. ( °C) | RH (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ppm | ppm | PM 2.5 | PM 1 | PM 10 | HCHO | TVQC | | |
| Sukajadi Sector Police Station | 4.30 | 639 | 3 | 30 | 24 | 39 | 0.013 | 0.676 | 26.6 | 82 |
| | 4.45 | 674 | 0 | 37 | 15 | 46 | 0.007 | 0.074 | 26.0 | 78.7 |
| | 5.00 | 648 | 6 | 34 | 24 | 44 | 0.016 | 0.008 | 26.0 | 74.2 |
| | 5.15 | 640 | 6 | 47 | 22 | 61 | 0.013 | 0.607 | 25.8 | 73.4 |
| | 5.30 | 634 | 6 | 40 | 59 | 52 | 0.010 | 0.802 | 25.7 | 75.7 |
| | 6.30 | 636 | 0 | 57 | 20 | 71 | 0.012 | 0.357 | 25.0 | 79.8 |
| Paris Van Java | 4.30 | 565 | 0 | 28 | 18 | 37 | 0.024 | 0.343 | 28.4 | 86.0 |
| | 4.45 | 536 | 0 | 30 | 18 | 38 | 0.027 | 0.282 | 30.5 | 88.4 |
| | 5.00 | 538 | 0 | 29 | 16 | 36 | 0.036 | 0.008 | 28.1 | 87.6 |
| | 5.15 | 555 | 0 | 51 | 33 | 68 | 0.021 | 0.496 | 28.0 | 85.2 |
| | 5.30 | 542 | 0 | 51 | 30 | 65 | 0.035 | 0.174 | 28.1 | 85.4 |
| | 6.30 | 609 | 2 | 75 | 47 | 98 | 0.025 | 6.182 | 29.9 | 80.8 |

The environment of Sukajadi road is still relatively healthy. We used PM10 as a benchmark for air quality. From the results of data collection in Table 3 and 4, the highest number was found at 6:30 p.m., by 98, this means that it reached medium category, so it is still safe [18]. This is also supported by many trees in the area of Sukajadi road so the air pollution can be minimized.

## 3.3. Service levels of road section

The condition of the road section service level can be determined based on the ratio of volume to capacity at an intersection [19]. The service level of the road segment consists of 6 categories and can be determined based on formula (1), by knowing the basic capacity of the road according to the road type, road width adjustment factor, separated way adjustment factor, side friction adjustment factor, and city size adjustment factor (*FCcs*).

### a. Road capacity by road type ($C_0$)

There is a gap between the availability of city transportation facilities and the travel demand. Besides, population growth, family income growth, and urban expansion are identified as the main causes of overcapacity in roads [19]. Based on MKJI, Sukajadi road has a basic road capacity of 6600 pcu / h for four lanes, to the kind of four-lane road divided (4/2 D) [10].

### b. Road width adjustment factor (*FCw*)

The capacity for road width adjustment factor (*FCw*) can be determined based on the width of the effective traffic lane (Wc) by taking into account the type of road under study. Sukajadi road has an effective traffic lane width (Wc) is 3.00 per lane meters with the kind of road divided into four lanes (4/2 D). It has a width capacity of traffic lanes (*FCw*) by 0.92.

### c. Separated way adjustment factor (*FCsp*)

Separated way adjustment factor (*FCsp*) is the adjustment factor for basic capacity due to traffic separation, which is seen based on the direction separation factors consisting of 50-50%, 55-45%, 60-40%, 65-35%, and 70-30% respectively based on MKJI. Sukajadi road which has a four-lane divided road type (4/2 D) with a percentage of the direction separator factor by 50-50% with directional separator capacity (*FCsp*) by 1.00 (See Table 5) [10].

**Table 5. Separated way adjustment factor ($FC_{SP}$).**

| *FCsp* | Police Station | | | | |
|---|---|---|---|---|---|
| | **50-50 %** | **55-45%** | **60-40%** | **65-35%,** | **70-30%** |
| **Two lanes 2/2** | 1,000 | 0,970 | 0,940 | 0,910 | 0,880 |
| **Four lanes 4/2** | 1,000 | 0,985 | 0,970 | 0,955 | 0,940 |

### d. Side friction adjustment factor (*FCsf*)

*FCsf* can be determined by the function of roadside width or distance of the drain barrier and the type of road. Sukajadi road has a side obstacle capacity with functions as a commercial area and high roadside activity, so it is classified in the Side Friction Class (SFC) as high with the code H. Sukajadi road has an *FCsf* by

0.88, due to the cross-section (without roadside) with a barrier distance is less than 0.5.

**e. City Size adjustment factor (*FCcs*) based on population capacity in the study area**

The research location in Sukajadi District has a population of 2,470,802 people or 4.37% of the population of Bandung City. Therefore, according to MKJI for a population of between 1-3 million people with the *FCcs* is 1.00 [12].The capacity of Sukajadi road is 5,343.36 pcu / hour, with the following calculation:

Capacity ($C$) = 6,600 × 0.92 × 1.00 × 0.88 × 1 = 5,343.36 pcu / hour

The level of service on Sukajadi road section in front of the Sukajadi Sector Police Station and the PVJ Shopping Center was calculated using the formula (1) . It is classified as service level F with the road characteristics consisting of obstructed current, low speed, above-capacity volume, and frequently-occurred congestion. The level of service of the road section in front of the Sukajadi Sector Police Station is 11.94, with the following calculation:

$$LoS = \frac{63.836}{5.343{,}36} = 11.94$$

The service level of the road section in front of the PVJ Shopping Center is 3.02 with the following calculation:

$$LoS = \frac{16.149}{5.343{,}36} = 3.02$$

From the calculations, the road section in front of the Police Station and in front of the PVJ Shopping Center have the same level of service. This causes delays in the flow of vehicles that cause congestion at certain hours, especially in the morning and afternoon which are caused by the excessive number of vehicles going through the road. Therefore, even though one-way traffic has been implemented, it will only help at certain hours other than morning when the peak flow of vehicles for activities (7:00 a.m. - 9:00 a.m.), and in the afternoon when there is a flow after work or activity (at 04:00 p.m. - 06:00 p.m.)

## 4. Conclusion

The results of this study indicated that traffic management with the application of one-way lanes has not effectively reduced congestion on Sukajadi road. This can be seen from the service class that is still classified as class F with the characteristics of the road that still has a hampered road current. Transportation management to reduce congestion in the morning and afternoon is not effective yet without private and public transportation management. Unintegrated transportation management between road capacity and vehicle affects the emergence of congestion on other roads as a result of one-way transportation management.

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