Assessing the Requirement for Green Open Spaces on the Soekarno Hatta Street's Road Median in Balikpapan City Based on Motorized Vehicle's Greenhouse Gas Emissions

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Abstract. Growing number of populations can lead to an increase of Greenhouse gas (GHG). The increasing amount of GHG can lead to devastated environment and global warming. From all human activities, transportation contribute highest, as previous study mentioned that motorized vehicle emissions contribute to 70% to air pollution in Indonesia. In Balikpapan city, in 2022, the number of motorized vehicles was 3,527,657 units. This number is increasing from 2021 which is 700,457 units. The increasing number of vehicles can result in an increase in CO2 which can have an impact on health and global warming. One way to reduce CO2e is with Green Open Space (GOS). In this study, the amount of CO_2 emissions was calculated using the fuel consumption method. After that yearly emission was forecasted. Furthermore, GOS needed in the Soekarno Hatta Road segment was calculated based on the amount of forecasted CO_2 per year. It was found that the busiest time in Soekarno Hatta Street segment is 16.00-18.00 WITA with estimated CO_2emissions in weekday is higher than that in weekend. The estimate number of emissions in one day reaching 2,910.89 Kg- CO_2/day in weekend and 2,072.44 Kg-CO_2/year in weekend with a total estimated CO_2 emissions per year of 977,348.49 Kg- CO_2/year. Thus, 717 units of Pucuk Merah (*Syzygium oleana*) per year needed to absorb this CO_2 emissions.

1 Introduction

Use Growing number of populations will also increase daily activities in industrial, agricultural, transportation and household sectors. This can lead to an increase of greenhouse gases (GHG) emission in the air. The increase of GHG like CO_2 is known to increase climate change [1][2]. From all human activities, transportation contribute highest, as previous study mentioned that motorized vehicle emissions contribute to 70% to air pollution in Indonesia [3].

Balikpapan, a city which become a hub to new capital city of Nusantara, experiencing an increase of transportation. From the data of central agency of statistic of Indonesia, in 2022, the number of motor vehicles in Balikpapan reaching 3,527,657 units, which was higher than that in 2021 (700,457 units)[4]. From this trending, greenhouse gases from

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motorized vehicle will also increase. Thus, calculation on how many greenhouse gases emission is needed to further discuss mitigation strategies.
One of the methods to reduce greenhouse gas emissions is by having a green open space (GOS). From previous study GOS can reduce about 10% greenhouse gas, and can reduce the number of pollutants for about 0.16 tons/year [5][6]. Type of GOS which usually be found in a road can be put in road median or road side.

This research was done in the segmentation of Soekarno Hatta Street in Balikpapan city as this street being a hub into commercial area and near a high density of populations. Thus, we need to quantify the CO_2 emission based on motorized vehicles and also quantify the green open space needed to absorb CO_2 emission. This research aims to know how many motor vehicles crossing this street, calculating how many GHG they will emit, and to calculate how many plantations needed for the road median. This research may give more understanding on the GHG emissions that can be used by the city government to further develop more green open space, especially in the primary arterial road like in the segmentation of Soekarno Hatta Street in Balikpapan city.

2 Methods

This research was conducted in three steps. First, traffic counting was done. After that, the data from traffic counting was used to calculate Greenhouse Gas (GHG) emissions. Lastly, from the amount of GHG emissions, calculation of chosen plantation was done.

2.1 Traffic Counting

The number of motorized vehicles were collected using the traffic counting method with an application called *minima traffic counter*. Traffic counting was done once in *weekday* (Thursday, May 9th 2024) and once in weekend (Saturday, May 11th 2024), with different timing as below:

- Morning : 7:00 a.m to 9:00 p.m WITA (UTC+08:00)
- Mid-day : 11:00 a.m to 1:00 p.m WITA (UTC+08:00)
- Afternoon : 4:00 p.m to 6:00 p.m WITA (UTC+08:00)

Traffic counting was done in segmentation of Soekarno Hatta Street in Balikpapan city as shown in **Fig 1.**

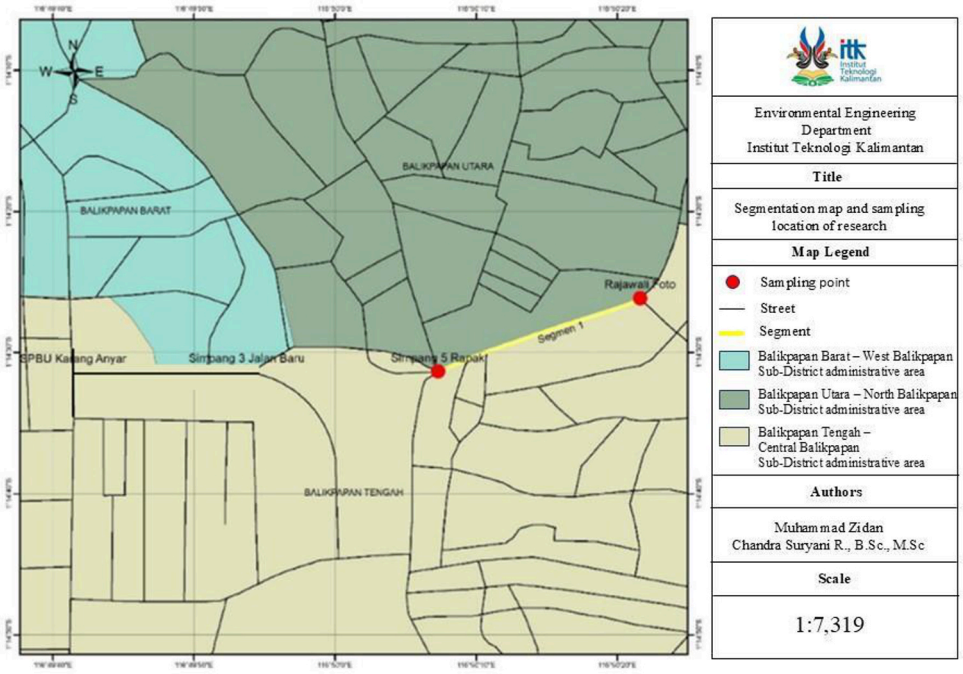


Fig 1. Research location map (yellow line)

Two point that were chosen was listed on **table 1**.

Table 1. Traffic counting point

No	Point	Location
1	A	Rapak Roundabout Junction
2	B	Rajawali foto intersection

2.2 Emission Calculation

Greenhouse gas emission estimated in this research was in the form of CO_2. Emission of CO_2 was calculated using following equation:

$$Emission\ of\ CO_{2i} = \frac{FC_i\ x\ EF_i\ x\ n_i}{1000} \qquad (1)$$

Where:

Emission of CO_{2i} = CO_2 emission of type i vehicle (Kg)
FC_i = Fuel Consumption for type i vehicle (Kg-Fuel)
EF_i = Emission Factor for type i vehicle (g/Kg-Fuel)

Fuel consumption of every type of vehicle was calculated using this following equation:

$$FC_i = \frac{Road\ Length}{SFC}\ x\ FD \qquad (2)$$

Where:

FC_i	= Fuel Consumption for type i vehicle (Kg-Fuel)
Road Length	= Length of road, in this research was 0.469 Km
SFC	= Standard fuel consumption, based on Environment Minister Regulation No. 12/2010 on the Implementation of Air Pollution Control in the Region [7] : 28 Km/L for motorcycle, 9.8 Km/L for gasoline car, 8 Km/L for diesel car, 4.4 Km/L for truck, 3.5 Km/L for bus.
FD	= Fuel density based on fuel type: Gasoline 0.7 Kg/L, diesel 0.8 Kg/L

Vehicles which assumed to use gasoline were motorcycle and gasoline car. In the other hand, truck, bus, diesel car was all assumed consume diesel. Four-wheel drive cars (4WD) were all counted as diesel car. Electric vehicle was not calculated in this traffic counting method.

Emissions were calculated based on CO_2, CH_4 and N_2O pollutant, which then converted into CO_2 equivalent (CO_2e) by multiplying with value of global warming potential and summing up the amount.

2.3 Green Open Space (GOS) Calculation

The total number of green open space was calculated as plantation in road median. Plantations needed for absorbing CO_2 in this research area was calculated using this equation:

$$Number\ of\ Plantation\ (unit) = \frac{Total\ GHG\ emission\ (Kg\frac{CO2}{year})}{CO2\ absorption\ capacity\ (\frac{\frac{Kg}{year}}{tree})} \qquad (3)$$

Type of plantation was determined by considering Indonesia's Ministry of Public Works and Housing's regulation. The number of plantations needed was calculated using projected annual emission. Annual emission was projected merely by multiplying the total amount of daily's emission obtained in this research with total number of weekend and weekday in the year of 2024, where there are 261 days of weekdays and 105 days of weekends.

2.4 Data Analysis

All the data was analyzed quantitatively and graphically to show the trending and amount of CO_2 in the segmentation of Soekarno Hatta Road in Balikpapan City in 2024.

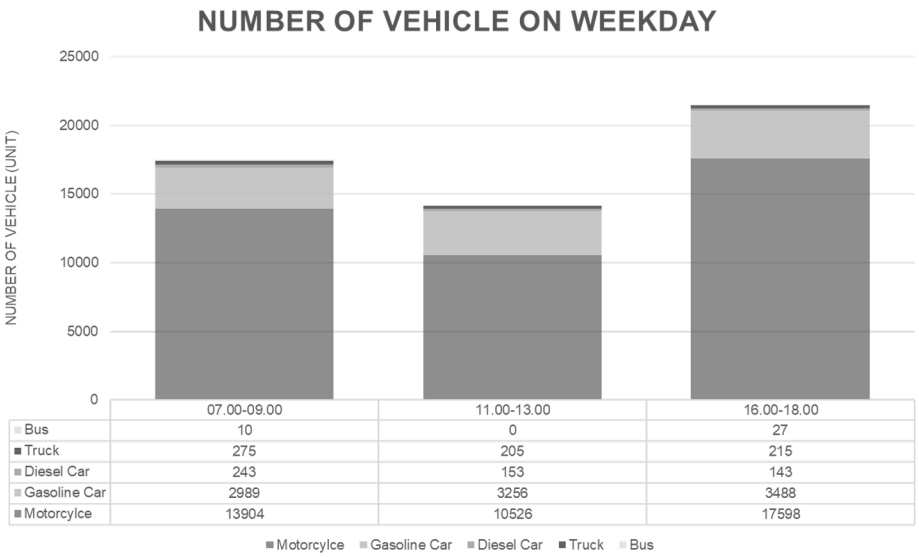
3 Results and Discussions

This research was conducted in three steps. First, traffic counting was done. After that, the data from traffic counting was used to calculate Greenhouse Gas (GHG) emissions. Lastly,

from the amount of GHG emissions, calculation of chosen plantation was done. The obtained results were discussed in detail below.

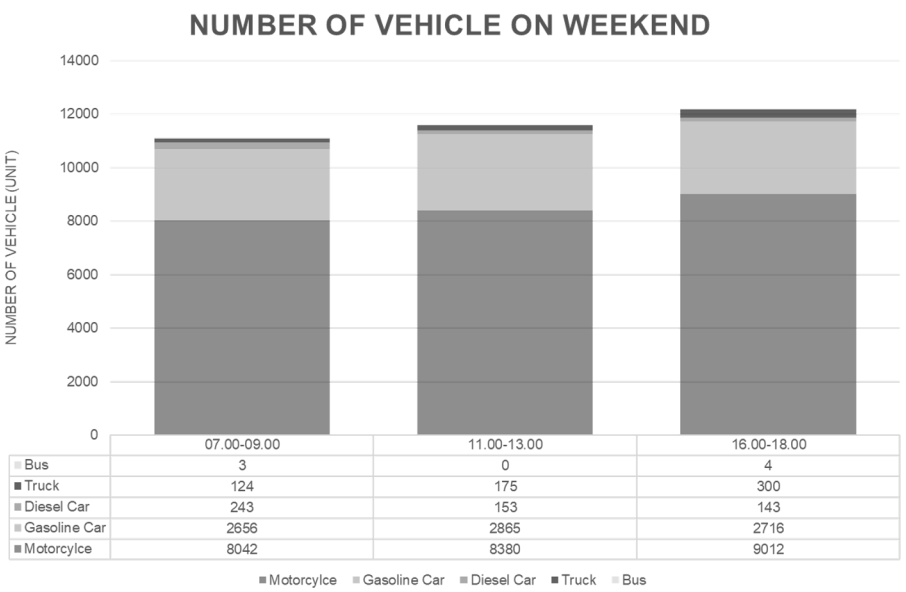
3.1 Traffic Counting Trending

The total number of vehicles in three sessions on weekday and weekend in Soekarno Hatta segmentation in Balikpapan city can be seen in **Fig 2** and **Fig 3**.



	07.00-09.00	11.00-13.00	16.00-18.00
Bus	10	0	27
Truck	275	205	215
Diesel Car	243	153	143
Gasoline Car	2989	3256	3488
Motorcylce	13904	10526	17598

Fig 2. Number of Vehicle on Weekday



	07.00-09.00	11.00-13.00	16.00-18.00
Bus	3	0	4
Truck	124	175	300
Diesel Car	243	153	143
Gasoline Car	2656	2865	2716
Motorcylce	8042	8380	9012

Fig 3. Number of Vehicle on Weekend

From **Fig 2 and Fig 3,** it can be seen that both weekend and weekday have the same trending. The number of vehicles passing by the road was peaking on 4:00 p.m to 6:00 p.m WITA (UTC+08:00) accounting for 14,367 units in weekday and 8,148 units in weekend. This might be due to a number of community activities, namely workers or students who make movements to return home after work or school activities during the weekday[8]. In the other hand, during the weekend, most community activities in Balikpapan city started in the afternoon. However, we need further study to justify the reason behind this phenomenon. Total number of vehicles reaching 35,488 on Thursday, may 9th 2024 and reaching 23,300 units on Saturday, may 11th 2024. In each period of time in both weekday and weekend, was dominated by motorcycle which accounting for 70% up. This phenomenon was also been observed in previous study, which the volume of vehicles in segmentation in Riau, was also dominated by 70% motorcycle [9]. The total number of vehicles were lower in weekend compare to weekday. This might be due to the characteristic of this segmentation. The segmentation in this research was a road that being a hub to commercial areas, working areas such as the Pertamina oil refinery, and several schools. Thus, the community activities in the weekend are less than in the weekday.

3.2 CO_2 Emissions from Road Vehicles

The From the total number of vehicles which were obtained in the previous section, CO_2 emissions from different type of vehicles was calculated using equation (1) and (2).

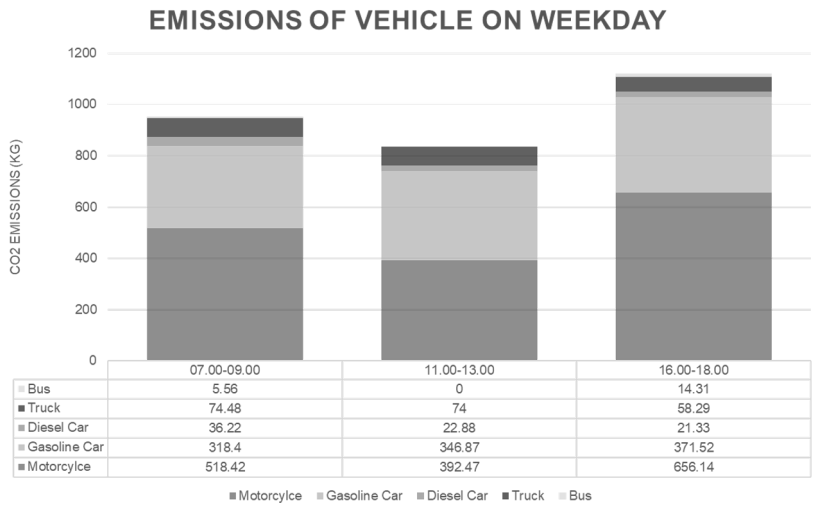


Fig 4. Emissions of Vehicle on Weekday

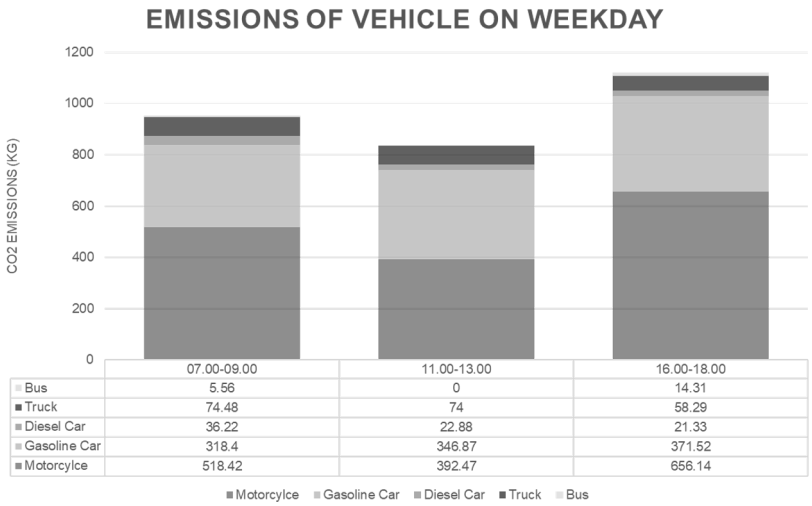


Fig 5. Emissions of Vehicle on Weekend

From **Fig 4** and **Fig 5** it can be seen that both weekend and weekday have the same trending. Highest emissions were found in 4:00 p.m to 6:00 p.m WITA (UTC+08:00). This can be caused by the increasing number of vehicles at that hour which can be caused by community activities as mentioned before as the reason of increasing number of vehicles passing by at 4:00 p.m to 6:00 p.m WITA (UTC+08:00).
Overall trending on the total emissions obtained in this research was summarized in **Fig 4.**

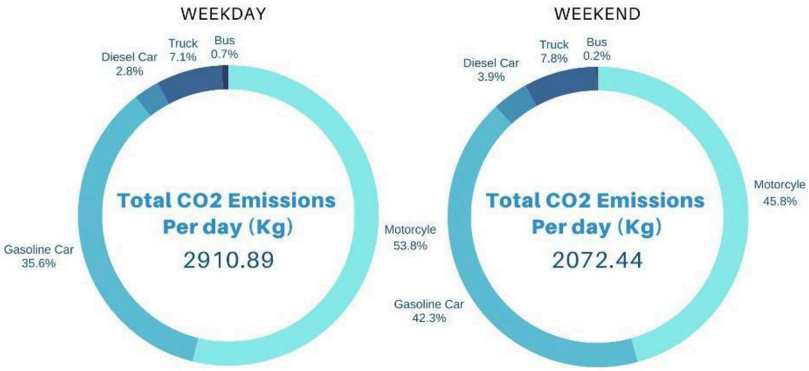


Fig 4. Overall Total CO_2 emissions per day trending in weekday and weekend

Fig 4 shows that total emissions of weekday were higher than weekend which differed by 838.45 Kg CO_2. CO_2 emissions was dominated by motorcycle accounting for 53.8% in weekday and 45.8% in weekend. The least contributor to total CO_2 emissions is bus. This might be due to the characteristic of Soekarno Hatta Road which is narrow and not passed by provincial road which connected to another province or other city in Kalimantan. Thus, the number of buses passing by this road was the least.

3.3 Plantation Needed to Absorb CO_2 emissions

One of the methods to reduce greenhouse gas emissions is by having a green open space (GOS). Type of GOS which usually be found in a road can be put in road median or road side. Thus, to choose type of plantation, a literature reviews were done.

According to the ministry of Public Works (2012), only shrubs and flowering plants should be planted on road median with height less than 1.5 meters. Plant height should not block vehicle lights. Plants planted on road medians that have a width of less than 1.5 meters must have a height of less than 1 meters and provided that no part of the plant branches obstruct the road body[10].

Previous study stated that the types of plants planted in the green belt are fast-growing, have aesthetics that can be enjoyed by motorist and pedestrians. Also, it should be strong enough to create a sense of comfort for pedestrians and motorists[11].

The segmentation of Soekarno Hatta Road in this study have a road side which is too narrow and was mean for pedestrian. The width of road median in this segmentation is less than 1.5 meters, so the plant should not block vehicle lights, must have a height of less than 1 meters and no part of the plant branches obstruct the road body.

With a consideration from previous mentioned literature review and including the number of amounts of CO_2 which can be absorbed by the plantation, in this research the number of plantations needed were based on red shoot shrubs (*Syzygium oleana*) or known as Pucuk Merah in Indonesia. Pucuk Merah is suitable for road medians primarily due to its fast growth rate, which allows for quick establishment of greenery in urban landscapes. This rapid growth not only enhances the visual appeal of roadways but also contributes to environmental benefits, such as improved air quality and reduced urban heat. Its resilience to various urban conditions, including pollution and heat, further solidifies its effectiveness as an ornamental and functional plant in such settings. It was also recommended by previous study as road median [10][12]. Furthermore, Pucuk Merah also has ability to absorb 0.1558 g-CO_2/hour/tree CO_2 or equal to 1,364.81 Kg/year [13][14]. Thus, using equation (3), the number of plantations needed was calculated with an annual projection of emissions with the detail that is shown in **table 2** below.

Table 2. Plantation Needed to Absorb CO_2

Variable	weekday	weekend
Emission per day (Kg-CO_2/day)	2,910.89	2,072.44
Total days per year (days)	261	105
Total Emission Per Year (Kg-CO_2/year))	977,348.49	
CO_2 Absorption of Pucuk Merah (Kg-CO2/year)	1,364.81	
Pucuk Merah needed (units)	717	

From **table 2**, it can be seen that the number of Pucuk Merah plantation needed is 716.11 units. Since a tree cannot be in decimal number, so we round up the number to 717 units per year.

4 Conclusions

This research shows that the busiest time in the segmentation of Soekarno Hatta Road is 4:00 p.m to 6:00 p.m WITA (UTC+08:00) with estimated CO_2 emissions in weekday is

higher than that in weekend. The estimate number of emissions in one day reaching 2,910.89 Kg-CO_2/day in weekend and 2,072.44 Kg-CO_2/year in weekend with a total estimated CO_2 emissions per year of 977,348.49 Kg-CO_2/year. Thus, 717 units of Pucuk Merah (*Syzygium oleana*) per year needed to absorb this CO_2 emissions.

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