IOP Conf. Series: Earth and Environmental Science **70** (2017) 012018 doi:10.1088/1755-1315/70/1/012018

Reduction of CO2 emission from transportation activities in the area of Pasar Besar in Malang City

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Abstract. The number of vehicles increases every year. Where vehicles are the largest contributor to air pollution up to 70%-80%, while 20%-30% caused by industrial activities. The increasing number of vehicles which perform movements will result in more emissions of vehicles in the free air of the city. Traffic is also influenced by the presence of land use. One of the types of land use that have considerable influence against the movement of traffic is trade. Along with the development of transport activities in the area of Pasar Besar Malang city (the Biggest Traditional Market in Malang), it will cause problems such as traffic jam and air pollution. Therefore, the need for proper handling of the problem of traffic jam and air pollution in the area of Pasar Besar that is to identify the performance of road traffic around area of Pasar Besar and calculate the quantity of CO2 emissions based on the footprint of transport on the area of Pasar Besar. Where is produced that level of service roads on its way around area of Pasar Besar have an average value between LOS A and B, while the quantity of CO2 emissions is based on the footprint of transport on area of Pasar Besar that is amounting to 4,551.42 tons/year. The magnitude of the emissions have exceeded the standard of composition in the air so that the need for recommendations. Recommendations in this research is in the form of simulated users of private vehicle redirects to public transportation based on the level of willingness to switch by the users of private vehicles. The selected simulation that is the second of four simulations with the output of emissions amounting to 3,952.91 tons/year in which can reduce emissions amounting to 598.51 tons/year or approximately 13.15%.

1. Introduction

Indonesia is a developing country with a high rate of urbanization. The increasing number of population leads to the increasing need of transportation. Transportation is defined as actions or activities of transporting or transferring loads (objects or people) from one place to another or from the original place to the destination [1]. According to Fidel Miro (2005), transportation is defined as efforts at transferring or moving both passenger and goods from one location to another using a certain equipment [2].

The high increase in population results in the high need of transportation. In Indonesia, motor vehicles have the biggest contribution to the air pollution in which the number is 70% - 80%, and the rest 20% - 30% are contributed by industrial activities [3]. The sources of exhaust gas emission come from non-point sources and point (stationary) sources. Non point sources of emission come from the activities of motor vehicles, while point sources comes from activities in one place like industrial activities [4]. One of exhaust gas emission from vehicles is carbon dioxide (CO2). The gas is one of the glass house gases.

The highest contributors of glass house gases (GHG) in increasing the emission are CO2, CH4 and N2O [5]. The highest contributor of GHG is CO2, that is 55%.

Transportation traffic is influenced by the land use. A travel is caused by the difference in the land use. In fulfilling the basic needs, each individual moves from a certain land use to another land use. It creates a very close relationship between the land use and transportation. One type of land use which has a great influence to the traffic movement is trade [6]. Trade facilities which are realized in the form of traditional market and stores is one type of land use that has attracted a significant number of travel. The boost and pull of travel by land use in the form of trade needs the support of transportation facilities performance. Without the support of transportation facilities, the demand and supply in travel will not be balances, and in turn it will create many traffic problems.

Pasar Besar of Malang City (the biggest traditional market in Malang) is one of trade facilities which is located in a strategic aerea in Kota Malang. Pasar Besar of Malang which is located in the center of the city has a potential to attract high movement of people in Malang. In the Urban Planning of Malang 2010 – 2030, Pasar Besar of Malang is planned to be a regional trade center.

The increase of activities in the area of Pasar Besar results in the increase of motor vehicles' movement in that area. In turn, the movement of motor vehicles also increases the number of exhaust gas produced. It is line with the theory that the increasing number of vehicles which perform movements will result in more emissions of vehicles in the free air of the city). The volume of vehicles influences the level of road services. The higher VCR (volume capacity ratio)/service level of a road in certain time, the higher exhaust gas emission from transportation [7].

According to the Regulation of East Java Governor No. 67 Year 2012, East Java targeted the reduction emission as much as 5.22% in the area of energy and transportation. To support the Regulation of East Java Governor, identification of CO2 Emission Reduction in Pasar Besar of Malang is needed. The results of CO2 emission analysis will be used in one of implementation of GHG emission reduction program in East Java. In this study, carbon emission will be measured from transportation activities based on the quantity and types of vehicles in the roads around the study area, Pasar Besar of Malang, using transportation ecological footprint.

2. Research Method

The study was conducted in four streets in the area of Pasar Besar of Malang namely Jalan Pasar Besar, Jalan Sersan Harun, Jalan Kyai Tamin, and Jalan Kapten Usman. The four streets was then divided into 7 (seven) segments namely Jalan Pasar Besar Segment 1, Jalan Pasar Besar Segment 2, Jalan Sersan Harun Segment 1, Jalan Sersan Harun Segment 2, Jalan Kyai Tamin Segment 1, Jalan Kyai Tamin Segment 2, and Jalan Kapten Usman. Methodology used in this research consist of, Road Level of Service Method and Total Amount of CO2 Emission Method.

3. Results

The observation of traffic volume in this study is conducted on weekdays and weekend. The duration of observation is 16 hours/day between 05.00 – 21.00. Survey method used is direct observation in the field. The results of the survey observation of the traffic volume in seven segments on weekdays and weekend. (Figure 1).

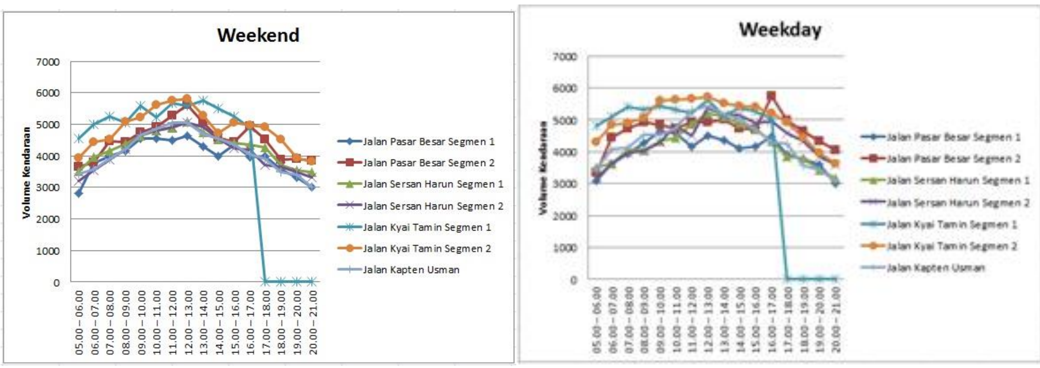

Figure 1. (a) Traffic Volume on Weekdays Recapitulation) and (b) Traffic Volume on Weekend Recapitulation

Based on the two graphics' information above, it can be identified the average peak of rush hour on weekdays and weekend are at 07.00 - 08.00, 12.00-13.00, and 16.00-17.00. It happens because at 07.00-08.00 most stores at the market start to operate, and then at 12.00-13.00 the activities in Pasar Besar Kota Malang are in the peak, and at 16.00-17.00 the stores end their operation/are closed.

3.1. Road Level of Service

The value of Road Service is influenced by traffic volume and road capacity. The lower the traffic volume, the better the road service level. Below are the values of road level of service in the seven segments of the streets on weekdays and weekend. (Table 1).

Table 1. Values of road level of service

Street Names	*Weekdays*		*Weekend*	
	Average V/C Ratio	**Average LOS**	**Average V/C Ratio**	**Average LOS**
Jalan Pasar Besar Segment 1	0.60	A	0.63	B
Jalan Pasar Besar Segment 2	0.66	B	0.64	B
Jalan Sersan Harun Segment 1	0.65	B	0.62	B
Jalan Sersan Harun Segment 2	0.66	B	0.61	B
Jalan Kyai Tamin Segment 1	0.54	A	0.54	A
Jalan Kyai Tamin Segment 2	0.65	B	0.67	B
Jalan Kapten Usman	0.66	B	0.63	B

Based on table 1, it can be identified that the road level of service on the seven segments has the values of A and B, on the average. The highest v/c ratio can be found on Jalan Pasar Besar Segment 2, both on weekdays and weekend. Meanwhile, the lowest v/c ratio can be found on Jalan Kyai Tamin Segment 1, both on weekdays and weekend.

3.2. Total CO2 Emission of Vehicles

In order to identify CO2 emission, we can multiply the total consumption fuels with factor emission of fuels. The factor emission is stated in kilogram/liter. The value of factor emission for gasoline fuel vehicles is 2.31 kg/liter; while, the factor emission for diesel fuel vehicles is 2.68 kg/liter (Andriono, et al, 2013). Below are the results of CO2 emission for each type of vehicles, both private and public transportation (Table 2).

Table 2. Total CO2 emission of private vehicles

Street Names	Types of Vehicles	Total CO_2 Emission (tons/year)
Jalan Pasar Besar Segment 1	2-wheel (Gasoline)	326.61
	Private 4-wheel (Gasoline)	272.92
	Private 4-wheel (Diesel)	135.73
	Truck (Diesel)	4.07
	Bus (Diesel)	0.26
Jalan Pasar Besar Segment 2	2-wheel (Gasoline)	418.70
	Private 4-wheel (Gasoline)	173.74
	Private 4-wheel (Diesel)	161.46
	Truck (Diesel)	2.49
	Bus (Diesel)	0.05
Jalan Sersan Harun Segment 1	2-wheel (Gasoline)	143.40
	Private 4-wheel (Gasoline)	57.95
	Private 4-wheel (Diesel)	56.18
	Truck (Diesel)	0.21
	Bus (Diesel)	0.00
Jalan Sersan Harun Segment 2	2-wheel (Gasoline)	217.39
	Private 4-wheel (Gasoline)	88.16
	Private 4-wheel (Diesel)	75.65
	Truck (Diesel)	0.31
	Bus (Diesel)	0.00
Jalan Kyai Tamin Segment 1	2-wheel (Gasoline)	386.39
	Private 4-wheel (Gasoline)	138.20
	Private 4-wheel (Diesel)	90.41
	Truck (Diesel)	7.55
	Bus (Diesel)	0.08
Jalan Kyai Tamin Segment 2	2-wheel (Gasoline)	479.96
	Private 4-wheel (Gasoline)	167.69
	Private 4-wheel (Diesel)	100.33
	Truck (Diesel)	27.41
	Bus (Diesel)	0.37
Jalan Kapten Usman	2-wheel (Gasoline)	368.43
	Private 4-wheel (Gasoline)	142.35
	Private 4-wheel (Diesel)	123.16
	Truck (Diesel)	2.99
	Bus (Diesel)	0.00
Total		4,170.60

Table 3. Total CO2 emission of public transportation

Street Names	Types of Vehicles	Total CO_2 Emission (tons/year)
Jalan Pasar Besar Segment 1	4 Wheel-Public (Gasoline)	36.35
Jalan Pasar Besar Segment 2		26.36
Jalan Sersan Harun Segment 1		11.58
Jalan Sersan Harun Segment 2		17.09
Jalan Kyai Tamin Segment 1		21.67
Jalan Kyai Tamin Segment 2		27.42
Jalan Kapten Usman		30.01
Total		140.47

Based on table 3, it can be identified that the total CO2 emission of private vehicles is 4,170.60 tons/year in which the biggest emission is on the seven segments for 2-wheel vehicles. Then, based on table 13, it can be identified that the total CO2 emission of public transportation is 170.48 tons/year. Overall, the total CO2 emission for both private and public transportation is 4,341.08 tons/year.

4. Recommendation

There are two recommendations in this study. The first is a simulation CO2 emission reducation by efforts to migrate the private vehicles users to the public transportation, based on the willingness of the visitors of Pasar Besar Kota Malang who use private vehicles to migrate to the public transportation. The second is a simulation the expected change in road level of existing service and the service at the time of simulation because of the simulation of CO2.emission reduction.

4.1. Simulation of the Reduction Vehicles' CO2 Emission

Before conducting a simulation of CO2 emission of vehicles, we need to identify the precentage of willingness to shift from private vehicles to public transportation from the visitors of Pasar Besar area. Data of the level of willingness to migrate to public transportation by the visitors of Pasar Besar was taken from questionaires given to 400 respondents of Pasar Besar. The result is that the willingness to migrate to the public transportation by the visitors of Pasar is 34% (willing), and 64% (not willing) (Figure 2)

Figure 2. Willingness to use public transportation

Having identified the percentage of willingness to migrate by the visitors, the next step is calculating the simulation of willingness to migrate to public transportation by the visitors. The simulation of CO2 emission reduction consists of four, those are: Simulation I which is call do nothing simulation or a simulation which maintain the existing condition; Simulation II, that is a simulation in migrating the users of private vehicles by reducing 34% 2-wheel private vehicles, and then the result of reduction is added into the public transportation capacity; Simulation III, that is a simulation in migrating the users of private vehicles by reducing 34% 4-wheel private vehicles, and then the result of reduction is added into the public transportation capacity; Simulation IV, that is a simulation in migrating the users of private vehicles by reducing 34% 2-wheel and 4-wheel private vehicles, and then the result of reduction is added into the public transportation capacity. Below is the result of simulation of CO2 emission of vehicles (Table 4).

Table 4. Simulation CO_2 emission of vehicles

No.	Simulation	CO_2 Emission (tons/year)		Total (tons/year)
		Private Vehicles	Public Transportation	
1.	Simulasi I	4,170.60	170.48	4,341.08
2.	Simulasi II	3,374.70	416.32	3,791.02
3.	Simulasi III	3,563.77	222.57	3,786.34
4.	Simulasi IV	3,391.41	399.22	3,790.64

Based on table 4, it can be identified that the lowest CO2 emission from the simulation is simulation III with the number CO2 emission of 3,786.34 tons/year. In simulation III we can reduce CO2 emission as much as 554.74 tons/year or about 12.78% of CO2 emission in the existing condition.

4.2. Road Level of Service Simulation

The simulated calculcation of road level of service is conducted to identify the change in road level of service caused by CO_2 emission simulation which results in the change in the volume of vehicles . The simulated calculation of road level of service can only be done in simulation III. Below is the results of the comparison between the road level of service of the existing condition and the level of service in simulation III, both on *weekdays* and *weekend*. (Table 5 and Table 6).

Table 5. Simulation of the road level of service on weekdays

Street Names	*Weekdays*			
	Existing		Simulation III	
	Average Ratio of V/C	Average LOS	Average Ratio of V/C	Average LOS
Jalan Pasar Besar Segment 1	0.60	A	0.49	A
Jalan Pasar Besar Segment 2	0.66	B	0.56	A
Jalan Sersan Harun Segment 1	0.65	B	0.55	A
Jalan Sersan Harun Segment 2	0.66	B	0.57	A
Jalan Kyai Tamin Segment 1	0.54	A	0.56	A
Jalan Kyai Tamin Segment 2	0.65	B	0.57	A
Jalan Kapten Usman	0.66	B	0.56	A

Table 6. Simulation of the road level of service on weekend

Street Names	*Weekend*			
	Existing		Simulation III	
	Average Ratio of V/C	Average LOS	Average Ratio of V/C	Average LOS
Jalan Pasar Besar Segment 1	0.,63	B	0.50	A
Jalan Pasar Besar Segment 2	0.64	B	0.54	A
Jalan Sersan Harun Segment 1	0.62	B	0.54	A
Jalan Sersan Harun Segmenr 2	0.61	B	0.53	A
Jalan Kyai Tamin Segment 1	0.54	A	0.56	A
Jalan Kyai Tamin Segment 2	0.67	B	0.55	A

IOP Conf. Series: Earth and Environmental Science **70** (2017) 012018 doi:10.1088/1755-1315/70/1/012018

Weekend				
Street Names	**Existing**		**Simulation III**	
	Average Ratio of V/C	**Average LOS**	**Average Ratio of V/C**	**Average LOS**
Jalan Kapten Usman	0.63	B	0.52	A

Based on tables 5 and 6, it can be identified that there is a significant change in the road level of service in simulation III compared to simulation I in which the road level of service in simulation III has the total value of LOS A.

5. Conclusion

The road level of service on the seven segments has the values of LOS A and B, on the average. The highest v/c ratio can be found on Jalan Pasar Besar Segment 2, both on weekdays and weekend. Meanwhile, the lowest v/c ratio can be found on Jalan Kyai Tamin Segment 1, both on weekdays and weekend.

The total CO2 emission of vehicles based on the transportation footprint on the seven segments oi Pasar Besar Area of Malang City is 4,341.08 tons/year. The total CO2 emission for private vehicles is 4,170.60 tons/year, and the total CO2 emission for public transportation is 170.48 tons/year.

Based on the four simulation of CO2 emission reduction the lowest CO2 emission is in simulation III with CO2 emission 3,786.34 tons/year. In simulation III we can reduce around 554.74 tons/year or about 12.78% from CO2 resulted from the existing condition.

Based on tables 15 and 16, it can be identified that there is a significant change in the road level of service in simulation III compared to simulation I in which the road level of service in simulation III has the total value of LOS A.

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