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Using the IPCC Formula to Calculate CO2 Emissions from Everyday Motorized Vehicles as the Baseline for Climate Change Mitigation Policies

Using the IPCC Formula to Calculate CO2 Emissions from Everyday Motorized Vehicles as the Baseline for Climate Change Mitigation Policies

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Abstract. Climate change has attracted the attentions of every nation on earth, including Indonesia. Indonesia's commitment to minimize greenhouse gas emissions through the ratification of the Kyoto decree in Law no. 17 / 2004. Other regulations for the National Action Plan for Reducing Carbon dioxide are regulated in Presidential Regulation No. 61/2011 and No. 7/2021 for the National Greenhouse Gas Inventory. The East Java provincial government adopted this policy through East Java's Province Regulation No. 67/2012. This article predicted an increase in carbon dioxide from the daily vehicles. The study will be done in Jember, a third city in East Java Province. Data is calculated using IPCC formula. The secondary data from 2018 to 2020 was analyzed, as well as predictions for 2030. The number of motorized vehicles growth is 4.5% each year. CO2 emissions from the daily transportation sector will reach 3,846,049.49 tons in 2030. Motorcycles contribute 2,055,244.87 tons. CO2 gas emissions from the 8 main streets of the Jember Gold Triangle are 62,190.52 tons.

1. Introduction

Climateology, which includes both natural and man-made climate and air quality events, is linked with GHG analysis[1], [2]. Human behaviour impacts the composition of the global atmosphere and natural climatic variability, whether directly or indirectly, and these changes can be measured easily[3], [4]. Greenhouse gas emissions are pollutants that contribute to environmental degradation because of rising global temperatures[5], [6]. The world warms as the quantity of gas in the atmosphere continues to grow, a phenomenon known as global warming[7].

Meanwhile, in recent years, CO2 emissions from the transportation sector get a lot of attention[8]. The transportation sector is thought to be responsible for 23% of worldwide CO2 emissions, with land transportation contributing for 74% of overall transportation CO2 emissions[9]. CO2 emissions from land transportation continue to rise as the urban economy and population grow. It is critical to track and maintain CO2 emissions from land transportation. The number of vehicles in Indonesia has increased year after year[10]. Vehicle emissions are a major source of gas and particle air pollution, both of which result in greenhouse gas emissions. One of the greenhouse gases is CO2. The release of CO2 into the atmosphere creates a protective layer in the atmosphere, which contributes to global warming[11]. A variety of human activities, such as transportation, industry, and settlements, can release CO2 into the atmosphere. CO2 emissions can originate from a variety of sources, including fossil fuel burning and renewable fuels like biomass[12].

Indonesia has ratified the Kyoto Protocol, with a target of reducing greenhouse gas emissions by 29% through self-development and 41% with international help by 2030[13]. According to the United Nations Framework Convention on Climate Change (UNFCCC), reducing greenhouse gas emissions entails increasing carbon storage in forests as well as mitigating the effects of global warming and climate change[12]. The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations to conduct research to get a formula for reducing greenhouse gas emissions. Using the

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IPPC formula, this article calculates CO2 emission daily vehicle reductions of 29 and 41% in Jember.[14], [15]

2. Methods

2.1 Data Resources

This study has used the secondary data from the Central Statistics Agency (Badan Pusat Statistik). Data contains of the number and types of motorized vehicles that travel on the main streets which is also known as The Golden Triangle in Jember every day during three years.

2.2 The IPPC Formula

$$CO2\ Emission = \sum Ai\ x\ NCV\ x\ EFi\ x\ {}^{44}12\ x\ oxidation\ factor$$

Emissions = CO2 Emissions

Ai = Consumption of fuel type/or number of products i

= number of motorized vehicles x average fuel consumption x fuel density

NCV = Net Calorific Value

EFi = Emission Factor from fuel type/or product i

3. Rearch Finding and Discussion

Motor vehicle data calculated from 2018-2020. Table 1 show the number of vehicles registered in 2018 was 870,561, which climbed to 911,361 in 2019 and 948,926 in 2020[3]. The data indicates approximately 4.5 percent annual increase on average. Motorcycles are the fastestgrowing from 787,131 in 2018 to 824,085 in 2019 and become 854,728 in 2020. The lowest growth of motorized vehicles came from ambulances from 293 in 2018 increased to 319 in 2019 and growing to 322 in 2020[16].

All types of these motorized vehicles are used by the community for daily routine activities. But among the public, motorcycles are the most popular mode of transportation. The data in Motor vehicles produce CO2 whThe number of motorcycles continues to grow.ich pollutes the air. For three years the number of motorized vehicles has increased, so in three years the air pollution rate will also increase.

Table 1. The Growth of the Number of Vehicle (Units) Types during 2018 – 2020

	2018	**2019**	**2020**
Motorcycle	787.131	824.085	854.728
Jeep	5.719	5.848	6.178
Sedan	9.020	9.025	9.109
Colt station	44.720	47.405	50.446
Truck	9.616	9.790	10.178
Colt pick up	11.086	11.654	13.109
Bus	891	915	996
Ambulance	293	319	322
3 Wheel Vehicles	2.085	2.320	3.860
Total	***870.561***	***911.361***	***948.926***
Average growth (r)			**4,5%**

Source: [16]

The percentage growth of CO2 is proportional to the high growth of everyday vehicles. CO2 emissions from motorized vehicles will reach 3,846,049.49 tons in 2030 (table 2)

3.1 Estimation of the Number of Motor Vehicle and CO_2 Emissions

Table 2. Estimation of motorized vehicles and CO2 emissions in 2020 and 2030

Type of vehicles	**Base data (units)**	**Estimated number of vehicles (units)**			**Estimated CO_2 emissions (tons CO_2)**			
	2020	2025	2030	%	2020	2025	2030	%
Motorcycle	854.728	1.065.189	1.327.472	90,07	1.323.323,53	1.649.167,63	2.055.244,87	53,44
Jeep	6.178	7.699	9.595	0,65	70.643,43	88.038,08	109.715,84	2,85
Sedan	9.109	11.352	14.147	0,96	75.469,64	94.052,65	117.211,39	3,05
Colt station	50.446	62.867	78.347	5,32	417.953,83	520.867,28	649.121,27	16,88
Truck	10.178	12.684	15.807	1,07	201.819,86	251.514,29	313.445,07	8,15
Colt pick up	13.109	16.337	20.359	1,38	271.416,12	338.247,35	421.534,55	10,96
Bus	996	1.241	1.547	0,10	80.265,35	100.029,22	124.659,57	3,24
Ambulance	322	401	500	0,03	2.667,83	3.324,73	4.143,38	0,11
3 Wheel Vehicles	3.860	4.810	5.995	0,41	32.820,67	40.902,15	50.973,56	1,33
Jumlah	***948.926***	***1.182.582***	***1.473.771***	***100,00***	***2.476.380,24***	***3.086.143,38***	***3.846.049,49***	***100,00***

Source: Calculated primary data, 2022

3.2 CO2 Emissions in the Golden Triangle

Jember has eight main streets that are always busy. The name of the streets are Jalan Jawa, Jalan Slamet Riadi, Jalan Moch. Seruji, Jalan PB Sudirman, Jalan Ahmad Yani, Jalan Trunojoyo, Jalan Sultan Agung and Jalan Gadjah Mada. These streets are connected to each other and are known as the golden three angle region[17].

Table 3. The Daily Transportation and Gas Emission CO_2 Estimation

Name of street	**Base data**	**Daily Transportation Estimation**		**Gas emission CO_2 (ton CO_2)**			**%**
	2020	2025	2030	2020	2025	2030	
Jawa	2.758	3.520	4.492	4.270,04	5.449,78	6.955,45	11,18
Slamet Riyadi	1.795	2.291	2.924	2.779,09	3.546,90	4.526,84	7,28
Moch. Seruji	4.326	5.521	7.047	6.697,68	8.548,13	10.909,82	17,54
PB Sudirman	1.793	2.288	2.921	2.775,99	3.542,95	4.521,80	7,27
A. Yani	3.266	4.168	5.320	5.056,55	6.453,58	8.236,59	13,24
Trunojoyo	3.222	4.112	5.248	4.988,43	6.366,64	8.125,62	13,07
Sultan Agung	3.656	4.666	5.955	5.660,36	7.224,22	9.220,14	14,83
Gajah Mada	3.844	4.906	6.261	5.951,43	7.595,70	9.694,26	15,59
Total	24.660	31.473	40.169	38.179,58	48.727,90	62.190,52	100,00

Source: Calculated primary data, 2022

These streets are extremely crowded, and they have the potential to pollute the air. CO2 pollution from vehicles has contributed to greenhouse gas emissions.[18]–[20] Jalan Moch Seruji, is the highest rate of air pollution (17,54%), then Jalan Gadjah Mada (15,59%), Jalan Sultan Agung (14,83%), Jalan Ahmad Yani (13,24 %), Jalan Trunojoyo (13,07 %), Jalan Jawa (11,18%), Jalan PB Sudirman (7,27 %), Jalan Selamet Riadi (7.28%). There must be a reduction in GHG emissions to avoid having an impact on climate change.

Table 4. CO_2 Emissions Reduction Target

Vehicle type	CO_2 emission estimation (tons CO_2)	Emission Reduction 29% (tons CO_2)	Emission Reduction 41% (tons CO_2)
	2030	2030	2030
Motor Cycle	2.055.244,87	1.459.223,86	1.212.594,47
Jeep	109.715,84	77.898,25	64.732,34
Sedan	117.211,39	83.220,09	69.154,72
Colt station	649.121,27	460.876,10	382.981,55
Truck	313.445,07	222.546,00	184.932,59
Colt pick up	421.534,55	299.289,53	248.705,38
Bus	124.659,57	88.508,30	73.549,15
Ambulance	4.143,38	2.941,80	2.444,60
3 Wheel vehicle	50.973,56	36.191,22	30.074,40
Total	3.846.049,49	2.730.695,14	2.269.169,20

Source: Calculated primary data, 2022

As seen in table 4, motorcycles are the key target for reducing CO_2 emissions (53.44%) which predicted to be 2,055,244.87 tons in 2030. It must be reduced to 1,459,223.86 tons (29%) and to be decreased to 1,212,594.47 tons (41%).[21], [22]

Table 5. CO_2 Emissions Reducing Target on the Golden Triangle Region 2030

No.	Name of street	CO_2 emission estimation (tons CO_2)	Emission reduction 29% (ton CO_2)	Emission reduction 41% (ton CO_2)
		2030	2030	2030
1.	Jl. Jawa	6.955,45	4.938,37	4.103,72
2.	Jl. Slamet Riyadi	4.526,84	3.214,06	2.670,84
3.	Jl. Moch. Seruji	10.909,82	7.745,97	6.436,79
4.	Jl. PB Sudirman	4.521,80	3.210,48	2.667,86
5.	Jl. A. Yani	8.236,59	5.847,98	4.859,59
6.	Jl. Trunojoyo	8.125,62	5.769,19	4.794,12
7.	Jl. Sultan Agung	9.220,14	6.546,30	5.439,88
8.	Jl. Gajah Mada	9.694,26	6.882,92	5.719,61
	Total	***62.190,52***	***44.155,27***	***36.692,40***

Source: Calculated primary data, 2022

In 2030, total CO_2 emissions in Jember's Golden Triangle Region should be reduced to 62,190.52 tons. CO_2 emissions are expected to decline to 44,155.27 tons if the strategy is followed without outside help (29 percent). CO_2 emissions will be reduced to 36,692.40 metric tons if the government obtains international aid[8], [23]. The CO_2 concentration in Jalan Moh Seruji is the highest, at 10,909.82 tons, and must be reduced to 6.436.79 tons. The lowest is 4.521,80 tons on Jalan PB Sudirman, with an expected reduction of 2.667,86 tons in the same year.

4. Discussion

The IPPC formula calculation results reflect the overall CO2 emissions from daily motorized vehicles that are commonly used throughout the community[10], [12], [22]. The government is forced to engage in hierarchical policymaking to reduce CO2 emissions[11], [13], [24]. The government has ratified and regulated current policies as well as provincial action plans following the adoption of the Kyoto Protocol[25]–[27]. The local administration, on the other hand, seems unprepared. The government of Jember Regency has yet to adopt a CO2 reduction policy[27], [28].

5. Conclusion

The importance of reducing CO2 emissions has been highlighted by the IPPC formula. This calculation is based on the Indonesian government's commitment as stated in the Tokyo Protocol. This commitment is expected to be achieved in 2030. This commitment is ratified by the government through national policies, which are followed up by action plans at the provincial and regional levels. This policy, however, has no coercive clausula. CO2 emission reduction regulations aren't even in implemented in all local governments, including Jember's.

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