Study of Carbon Dioxide (CO_2) Emissions Load from Transportation Sources in Sukorejo Village Gresik

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Abstract: Carbon dioxide (CO_2) emissions are gases that come out of the combustion of compounds that contain carbon. The location of Sukorejo Village, Kebomas District, Gresik Regency which borders the City of Surabaya and based on the provisions of the Gresik Regency Spatial Plan which states the coast of Kebomas District as an industrial and port area resulting in dense population so that there are many community activities and high transportation mobility. Energy consumption from transportation activities in Sukorejo Village, Gresik, produces exhaust emissions in the form of CO_2. The purpose of this research is to analyze carbon dioxide (CO_2) emissions from the transportation sector by vehicle type. The method used in this research is field observation for the transportation sector by counting which is carried out at two points for two weeks on active days, namely Monday, Wednesday, Friday and Sundays. The results of this study found that the total value of carbon dioxide (CO_2) emissions in the transportation sector was 132.83 tons/year.

1 INTRODUCTION

Air pollution is the entry of substances, energy, or other components into the surrounding air through human activities, thereby reducing air quality to a certain level and damaging air quality (PP RI Number 22 of 2021). One of the ongoing air quality problems is the release of carbon dioxide (CO_2) which is a fundamental part of ozone-depleting substances that make up 50% of complete ozone-depleting substances (GHG) and significantly affects the increase in temperature throughout the earth. In recent years, air pollution has become an urgency due to the rapid increase of gas every day. Air pollution is a serious urgency because it has a fatal impact on the environment and human health (Ji et al. 2020). Air pollution is one of the main factors in decreasing air quality, and the occurrence of air pollution, air in conditions of dangerous levels of gas, dust, smoke or odors (Khan et al. 2020). Pollution from CO_2 emissions comes from two activities, namely natural (natural) and human (artificial). CO_2 emissions from human activities, transportation, waste and the use of household electrical energy are relatively high, thus disrupting the air balance system and endangering the environment and human welfare. The transportation sector plays a major role as a potential air pollution sector (Ni'am et al. 2021, Handriyono et al. 2020). Big cities contribute 60% to 70% of the source of CO_2 released from vehicle exhaust.

The increase in modes of transportation is directly proportional to energy consumption in the form of fossil materials (Jiang and Li, 2022). Increased energy consumption can cause large amounts of greenhouse gas (GHG) emissions (Li et al. 2021). Energy consumption contributes to pollution across low, middle and high income groups. To overcome the environmental threat from electricity consumption, it is necessary to add renewable energy to reduce dependence on fossil fuels (Danis et al. 2019). The transportation sector is a major contributor to increased energy consumption and carbon emissions in recent decades (Chen et al. 2023). Several studies show that CO_2 emissions have increased significantly in the transportation sector

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(Zam-zam. 2020, Setyo, 2021, Hou et al. 2022). Carbon dioxide emissions have increased by around 30 percent in recent years, and 25 percent comes from urban transportation carbon emissions (Zhang, 2022).

Carbon dioxide (CO_2) is a substance consisting of one carbon atom (C) and two oxygen atoms (O_2). Carbon dioxide is one of the many gases that make up the earth's atmosphere, including nitrogen, oxygen, and argon (Subkhan, 2017). Carbon dioxide gas accounts for 50% of all Greenhouse Gases. CO_2 emission is the emission or release of CO_2 gas into the atmosphere. CO_2 emissions are expressed in tonnes of CO_2 equivalent. CO_2 emissions are the number one cause of global warming followed by methane gas (CH_4). More than 75% of the composition of Greenhouse Gases (GHG) in the atmosphere is carbon dioxide (Rawung, 2015). Carbon dioxide is a greenhouse gas (GHG) that has a major impact on increasing global average temperatures (Rachmayanti, 2020). The greenhouse effect occurs when greenhouse gases absorb the sun's heat and then reflect it back to the earth's surface (Zubair et al. 2023). Greenhouse gases are continuously increasing and have implications for climate change (Godil et al. 2021). The increase in CO_2 emissions is in line with the increase in population and daily energy use activities (Fitri, 2020). In addition, increased CO_2 emissions not only threaten the health of biophysical ecosystems but also have a major impact on human health (Liu et al. 2020a). However, good economic governance can significantly reduce CO_2 emissions and pollution levels (Liu et al. 2020b).

Sukorejo Village, Kebomas District, Gresik Regency located on the banks of Lamong River, which is located on the border between Gresik and Surabaya in accordance with the Gresik Regency Spatial Plan where the coastal area of Kebomas District is designated as an industrial and port area. The location of Sukorejo Village, Kebomas District, Gresik Regency which borders the City of Surabaya so that it is one of the factors where many community activities, transportation and industry contribute to CO_2 emissions. This research was conducted because Sukorejo Village, Kebomas District, Gresik Regency itself is in the middle of the industry where right, left, front is one of the large industries with transportation operations from industry and high workers and Sukorejo Village, Kebomas District, Gresik Regency is a village with a high population density.

2 METHODS

In this research, the method applied is descriptive quantitative. Quantitative descriptive is a method that describes, describes and or explains a condition that occurs factually, systematically and accurately with numbers or numeric. The initial stage of this research is to study literature from journals and thesis reports, field surveys, collect primary data in the form of transportation sector data with traffic counting to find vehicle type data. Primary data collection from the transportation sector is carried out through traffic counting at 2 points for 2 weeks on 16 May 2022 - 29 May 2022 Monday, Wednesday, Friday and Sunday. The selection of the day and time of measurement is carried out so that the value validation is more accurate with the average concentration every 1 hour, the average concentration of active days and the average concentration of holidays and is based on high mobility on active days, namely Monday, Wednesday and Friday and the selection of holidays is the week where mobility is estimated to be in Sukorejo Village and or to the Kali Lamong Mangrove Ecotourism. Measurements were carried out at the busiest hours, namely in the morning from 07.00-08.00 WIB, in the afternoon at 16.00-17.00 WIB and in the evening at 20.00-21.00. The tools used are cellphone cameras and traffic counting applications. Traffic counting The types of vehicles that are calculated are 2-wheeled vehicles, 4-wheeled vehicles, trucks and buses. This study has the limitation that it does not distinguish between types of trucks

The Calculation of CO_2 emission load of the transportation sector can be done with the following equation (1) (Suharto, 2017). Table 1 is The CO_2 emission factor value based on the type of vehicle (Kondorura, 2018). Then Table 2 is values for calculating motorized fuel consumption from the calculation of emission factors.

$$CO_2 \text{ emission} = n \times FE \times K \times L \quad (1)$$

Description :

n = Number of vehicles (unit/hour)
FE = Emission factor (g/L)
K = Fuel consumption (L/100 km)
L = road length (km)

Table 1: CO_2 Emission Factor Value.

Type of Vehicle	CO_2 (g/L)
2 Wheels	2597,86
4 Wheels	2597,86
Truck	2924,90
Bus	2924,90

Table 2: Value of Motor Fuel Consumption.

Type of vehicle	Energy Consumption (L/100 km)
2 Wheels	2,66
4 Wheels	11,79
Truck	15,15
Bus	13,04

3 RESULT AND DISCUSSION

In this study, measurements were also carried out in the transportation sector by way of traffic counting to calculate the volume of traffic vehicles. Measurements were carried out at 2 location points with the location of the first point, namely at the entrance to Sukorejo Village where the location of the first point is one of the access roads to enter Sukorejo Village and the second point is on the main road of Sukorejo Village (Figure 1).

Figure 1: Sampling Point Location for Transportation Sector.

Coordinate Point:
Point 1: 7°11'29.02"S, 112°38'9.10"E
Point 2: 7°11'23.83"S, 112°38'9.45"E

3.1 Counting Traffic Volume Data Point 1

Point counting 1 traffic volume is at the entrance to Sukorejo Village. The only access road to the settlement of Sukorejo Village is through point counting 1, this has resulted in a lot of vehicle mobility, both local residents and non-local residents who carry out daily activities such as commuting to work, traveling and other activities. The location of the counting point 1 is at latitude 7°11'29.02"S longitude 112°38'9.10"E.

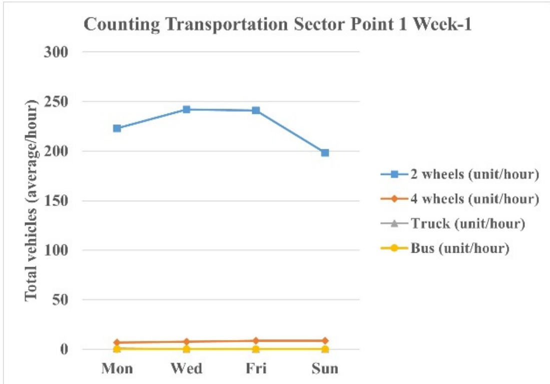

Figure 2: Average vehicle volume per hour of traffic at counting point 1 in week 1.

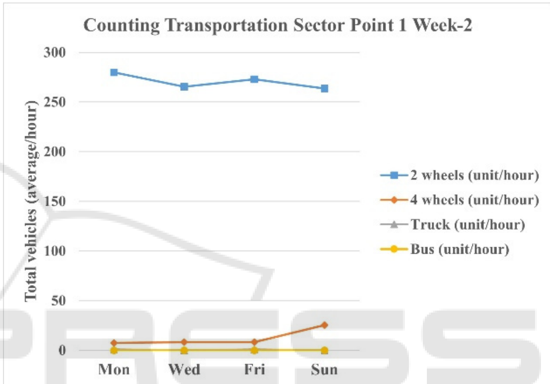

Figure 3: Average vehicle volume per hour of traffic at counting point 1 in week 2.

Based on Figure 2, it can be seen that the average total number of vehicles on active days, i.e Monday, Wednesday, and Friday, is more than on holidays, i.e Sundays. In the first week, the average active day is 243 units/hour with the average number of vehicles passing the most on Wednesday and Friday at as much as 250 units/hour and the average number of vehicles passing the least occurring on Monday as many as 230 units/hour while in the first week the average holiday is 207 units/hour. In the second week, the average active day is 281 units/hour with the average number of vehicles passing the most on Monday as much as 288 units/hour, and the average number of vehicles crossing slightly occurring on Wednesday being 274 units/hour. hours while in the second week the average holiday is 289 units/hour. Holidays at point 1 week 1 and week 2 have the least average value compared to active days because the most transportation mobility is due to work activities.

The average number of vehicles that pass on active days in week 1 and week 2 is more than the average number of holidays in week 1 and week 2 because Sukorejo Village itself is in an industrial area so More vehicle mobility on active days, i.e Mondays, Wednesdays, and Fridays. 2-wheeled vehicles have decreased on holidays, i.e Sundays, because on Friday, workers as residents of non-original residences in Sukorejo Village travel back to their place of origin, while 4-wheeled vehicles increase on holidays, namely Sundays due to the natives of the village. Sukorejo chooses to take a vacation and there are tourists who visit the Kali Lamong Mangrove Ecotourism. The most common types of vehicles in the first week and second week of counting point 1 are 2-wheeled vehicles and then 4-wheeled vehicles where the most accessible access to mobility for access to Sukorejo Village is by using a private vehicle.

3.2 Counting Traffic Volume Data Point 2

Counting point 2 is on the Sukorejo Village highway. This Sukorejo Village highway is one of the busiest access roads in the eastern part of the industrial area of Gresik Regency on the border with Surabaya City. The location of counting point 2 is latitude 7°11'23.83"S longitude 112°38'9.45"E.

Based on Figure 4, it can be seen that the average total number of vehicles on active days, namely Monday, Wednesday, and Friday, is more than on holidays, namely Sundays. In the first week, the average active day is 2,990 units/hour with the average number of vehicles crossing the most occurring on Friday as many as 3,523 units/hour, and the average number of vehicles passing the least occurring on Monday being 1,977 units/hour while on week 1 the average holiday is 1,728 units/hour. In the second week, the average active day is 3,883 units/hour with the average number of vehicles passing the most on Friday as much as 3,919 units/hour and the average number of vehicles

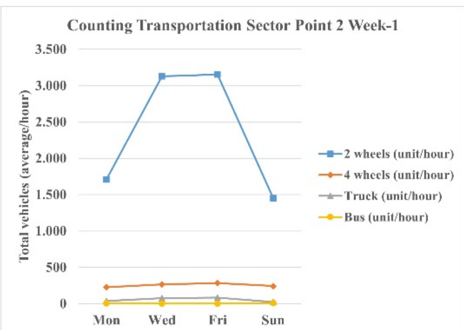

Figure 4: Average vehicle volume per hour of traffic at counting point 2 in week 1.

passing the least occurring on Wednesday as many as 3,858 units/hour. hours while in the second week the average holiday is 1,686 units/hour.

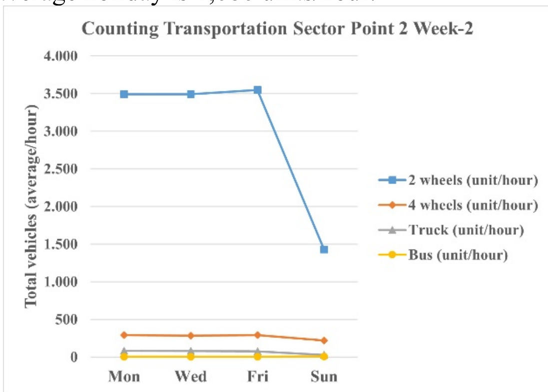

Figure 5: Average vehicle volume per hour of traffic at counting point 2 in week 2.

The average number of types of vehicles that pass on active days in the first and second week is more than the average number of holidays in the first and second week this is because the Sukorejo Village highway itself is in the area industry so that vehicle mobility is more on active days, namely Mondays, Wednesdays, and Fridays. The most types of vehicles in the measurement of week 1 and week 2 of the counting point 2 are 2-wheeled vehicles and the least are buses. The volume of private vehicles and public vehicles that pass on the Sukorejo Village highway because this highway is one of the accesses for tourism, industry, and between districts and cities.

The results of counting the number of vehicles at points 1 and 2 show that the number of vehicles on weekdays is greater than on holidays. These results are due to the fact that people often carry out driving activities on weekdays compared to holidays.

3.3 Emission CO_2 Total from Transportation Sector

Calculation of carbon dioxide (CO_2) emissions for each counting point is needed to determine the total carbon dioxide (CO_2) emissions of the transportation sector. Calculation of total CO_2 emissions is calculated by the total number of each type of vehicle multiplied by the emission factor multiplied by the fuel consumption multiplied by the length of the road when counting by the emission factor and fuel consumption obtained from IPCC and BPPT in Kondorura, 2018. Calculation of total CO_2 emissions from the transportation sector can be calculated with equation 1. with the average volume of vehicles in

Figures 1. and 2. and the value of FE in table 1. and the value of K in table 2.

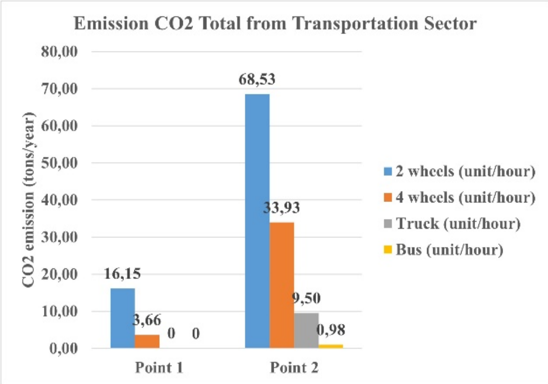

Figure 6: Total CO_2 emissions at point 1 and point 2.

Based on Figure 6 above, it can be seen that the highest total CO_2 emissions in the transportation sector are in 2-wheeled vehicles, point 1, 16.15 tons/year, point 2, 68.53 tons/year, totaling 84.68 tons/year and the lowest in buses, totaling 0.98 tons/year which is obtained from point 2. The highest and lowest values of CO_2 emissions are based on the number of vehicles that pass. The highest total CO_2 emissions in the transportation sector come from 2 wheels because transportation mobility mostly uses 2 wheels and 4 wheels at points 1 and point 2. Truck transportation mobility is bigger than the bus because Sukorejo Village itself is in an industrial area that uses trucks for activities and the mobility of buses is because the Sukorejo Village highway is one of the accesses to religious tourism areas in Kebomas District, Gresik Regency. The total value above is the total maximum emission contributed from the transportation sector in Sukorejo Village for 2 weeks of observation time which is then projected for 1 year.

Based on these results, efforts are needed to control CO_2 emissions from transportation sources. One of the efforts is to increase the number of plants in private green open space areas. Private green open space is an important part of the green open space structure in urban areas. Private green open spaces are able to provide air circulation systems, regulate microclimates, produce oxygen, absorb rainwater, and contaminants in air, water and soil media (Gunawansyah, 2019). Several combinations of plants such as trembesi, red snore, ketapang, and gldogan are able to absorb CO_2 emissions significantly (Kusuma et al. 2023). Some of those plants are classified as large plants that require large areas of land. Therefore, this study carried out a simulation using several small plants so that they could be planted on the residents' private land or in public facilities in Sukorejo Village, Gresik. Some of the small plants consist of chinese petai, fir cassowary feathers, red shoots, and yellow frangipani. There are 2 scenarios used, scenario 1 with 1 type of plant (Table 3), and scenario 2 with a combination of several plants (Table 4).

Table 3: Plants needs with 1 type.

Plant type	CO_2 absorption (ton/ plant/ yr)	Total Plant Scenario 1			
		A	B	C	D
Chinese petai (Leucaena Leucocephala)	0,72	5	-	-	-
Fir Cassowary Feathers (Casuarina Sumatrana)	0,20	-	18	-	-
Red shoots *(Syzygium Oleina)*	0,04	-	-	85	-
Yellow frangipani *(Plumeria Acuminata)*	0,02	-	-	-	222

Table 4: Plants needs with several type.

Plant type	CO_2 absorption (ton/ plant/ yr)	Total Plant Scenario 2
Chinese petai (Leucaena Leucocephala)	0,72	1
Fir Cassowary Feathers (Casuarina Sumatrana)	0,20	5
Red shoots *(Syzygium Oleina)*	0,04	21
Yellow frangipani *(Plumeria Acuminata)*	0,02	55

The simulation results show that scenario 1 requires 1 type of Chinese petai plant as many as 5, 18 cassowary feathers, 85 red shoots, and 222 yellow frangipani. 5, 21 red shoots, and 55 yellow frangipani. These plants are classified as small plants so that later they can be planted on community private land or public facilities in Sukorejo Village, Gresik.

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4 CONCLUSIONS

This study concludes that the total value of CO_2 emissions in the transportation sector is 132.83 tons/year which comes from 2 measurement points, namely the entrance to Sukorejo Village and the

Sukorejo Village highway. The total value of CO_2 emissions in the transportation sector is the maximum load assumption received by Sukorejo Village, Kebomas District, Gresik Regency.

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REFERENCES

Chen, B., Ji, Xiangfeng., Ji, Xiangyan. (2023). Dynamic and Static Analysis of Carbon Emission Efficiency in China's Transportation Sector, *Sustainability*, 15, 1508, 1-19. https://doi.org/10.3390/su15021508

Danish, Zhang, J., Wang, B., Latif, Z. (2019). Towards cross-regional sustainable development: The nexus between information and communication technology, energy consumption, and CO_2 emissions, *Sustainable Development*, 27 (5), 990-1000. https://doi.org/10.1002/sd.2000

Fitri, Y., Putri, A. N., Retnawaty, S. F. (2020). Estimasi Emisi CO2 Dari Sektor Rumah Tangga Di Kota Pekanbaru, *Photon Jurnal Sains dan Kesehatan*, 11 (1), 1-6. https://doi.org/10.37859/jp.v11i1.2061

Godil, D. I., Yu, Z., Sharif, A., Usman, R., Khan, S. A. R. (2021). Investigate the role of technology innovation and renewable energy in reducing transport sector CO2 emission in China: A path toward sustainable development, *Sustainable Development*, 29 (4), 694-707. https://doi.org/10.1002/sd.2167

Gunawansyah. (2019). The Development Of Private Green Open Space In The Residential Area In Makassar, *IOP Conference Series: Earth and Environmental Science*, 382, 1-9. DOI: 10.1088/1755-1315/382/1/012021

Handriyono, R. E., Ariyani, N., Pramestyawati, T. N. (2020). Kajian Emisi Gas Rumah Kaca Dari Kendaraan Bus Pada Saat Kondisi Diam (Idle) Berdasarkan Persamaan Taylor di Terminal Purabaya, *Specta Journal of Technology*, 4 (3), 81-88.

Hou, L., Wang, Y., Zheng, Y., Zhang, A. (2022). The Impact of Vehicle Ownership on Carbon Emissions in the Transportation Sector, *Sustainability*, 14, 12657, 1-23. https://doi.org/10.3390/su141912657

Ji, S., Chen, H., Chuan, Y., Gao, L., Liu, C., Liu, H., Lv, W. (2020). Relationship Verification Between CO_2 And Pollutant Emissions: Policy Evaluation Based On The Pollutant Discharge Fee In China, *Journal of Water and Climate Change*, 11 (3), 891 – 900.

Jiang, M., and Li, J. (2022). Study on the Change in the Total Factor Carbon Emission Efficiency of China's Transportation Industry and Its Influencing Factors, *Energies*, 15, 8502, 1-26. https://doi.org/10.3390/en15228502

Khan, T., Lawrence, A., Dwivedi, S., Arif, S., Dwivedi, S., Abraham, A., Roberts, V. (2022). Air Pollution Trend And Variation During A Mega Festival Of Firecrackers (Diwali) In Context To Covid-19 Pandemic, *Asian Journal of Atmospheric Environment*, 16 (3), 1 – 20.

Kondorura, C. F. (2018). Analisis Kapasitas Ruang Terbuka Hijau Balai Kota Makassar Dalam Mereduksi Emisi Kendaraan Bermotor. Universitas Hasanuddin.

Kusuma, M. N., Handriyono, R. E., Hafizah, N. E., Damayanti, T. V. (2023). Absorption of CO_2 Emissions from Industrial and Residential Sources by Green Open Space in Sukorejo Village, Gresik, *Journal of Ecological Engineering*, 24 (1), 135-145.

Li, J., Fang, H., Fang, S., Zhang, Z., Zhang, P. (2021). Embodied Energy Use in China's Transportation Sector: A Multi-Regional Input–Output Analysis, *International Journal of Environmental Research and Public Health*, 18, 7873, 1-18. https://doi.org/10.3390/ijerph18157873

Liu, J. L., Ma, C. Q., Ren, Y. S., Zhao, X. W. (2020). Do Real Output and Renewable Energy Consumption Affect CO_2 Emissions? Evidence for Selected BRICS Countries, *Energies*, 13, 960. https://doi.org/10.3390/en13040960

Liu, X., Latif, K., Latif, Z., Li, N. (2020). Relationship between economic growth and CO_2 emissions: does governance matter?, *Environmental Science and Pollution Research*, 27 (14), 17221-17228. https://doi.org/10.1007/s11356-020-08142-3

Ni'am, A. C., Handriyono, R. E., Hastuti, I. P., Kusuma, M. N. (2021). Analysis of Greenhouse Gas Emissions From Mobile Sources In Jombang Urban Area During The Covid-19 Pandemic, *Jurnal Ilmu Lingkungan*, 19 (3), 582 – 587.

Rachmayanti, L., Mangkoediharjo, S. (2020). Evaluasi Dan Perencanaan Ruang Terbuka Hijau (RTH) Berbasis Serapan Emisi Karbon Dioksida (CO_2) Di Zona Tenggara Kota Surabaya (Studi Literatur Dan Kasus), *Jurnal Teknik ITS*, 9 (2), C107 – C114 .

Rawung, F. C. (2015). Efektivitas Ruang Terbuka Hijau (RTH) Dalam Mereduksi Emisi Gas Rumah Kaca (GRK) Di Kawasan Perkotaan Boroko, *Media Matrasain*, 12 (20, 17–32.

Setyo, G. A., Handriyono, R. E. (2021). Analisis Penyebaran Gas Karbon Monoksida (CO) Dari Sumber Transportasi Di Jalan Tunjungan Surabaya, *Prosiding Seminar Nasional Sains dan Teknologi Terapan IX*, 360-369, Surabaya, 2 Oktober 2021.

Subkhan, A., Setyowati, D. L., Setyaningsih, W. (2017). Kajian Emisi CO_2 Dari Pemanfaatan Energi Rumah Tangga Di Kelurahan Candi Kota Semarang, *Geo Image*, 6 (2), 147-157.

Suharto, B., Haji T. S., and Pangestuti N. P. (2017). Evaluasi Emisi Karbon dioksida (CO_2) Terhadap Kecukupan Ruang Terbuka Hijau (RTH) Di Universitas Brawijaya Kampus I Kota Malang, *Jurnal Sumberdaya Alam dan Lingkungan*, 4 (2), 7–12.

Zam-zam, C. F., Handriyono, R. E. (2020). Pemetaan Beban Emisi Co Dari Kegiatan Transportasi Darat Di Kawasan Sidoarjo Utara, *Prosiding Seminar Nasional Sains dan Teknologi Terapan VIII*, 353-360, Surabaya, 26 September 2020.

Zhang, Q. (2022). Investigating the Impact of Transportation Infrastructure and Tourism on Carbon Dioxide Emissions in China, *Journal of Environmental and Public Health*, 1-9. https://doi.org/10.1155/2022/8421756

Zubair, M., Chen, S., Ma, Y., Hu, X. (2023). A Systematic Review on Carbon Dioxide (CO_2) Emission Measurement Methods under PRISMA Guidelines: Transportation Sustainability and Development Programs, *Sustainability*, 15, 4817, 1-19. https://doi.org/10.3390/su15064817