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# The Ability of Green Open Spaces in Greenhouse Gas Control to Achieve Green Cities in Kendari City

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## ABSTRACT

The urban challenge in realizing a green city for the purpose of a sustainable city is air pollution resulting from vehicle emissions (Carbon monoxide/CO<sub>2</sub>). Reducing vehicle emissions can be done by providing green open spaces. In Kendari City, a potential area for the development of green open space is the Bahteramas General Hospital. Activities in the area and around the Bahteramas General Hospital in Kendari City are quite high so that they contribute to emissions (CO<sub>2</sub>). The object of research analysis is the number of vehicles (daily traffic), the capacity of electricity use, the area of the Bahteramas General Hospital and the area of the existing green open space. The results showed that the type of vehicle that contributes high to CO<sub>2</sub> is a motorcycle. The use of fuel as a source of emission (CO<sub>2</sub>) which contributes to premium types of greenhouse gases, diesel and the use of electrical energy. The absorption capacity of the existing green open space has not been able to reduce CO<sub>2</sub> emissions, so it is necessary to expand the green open space to control greenhouse gases.

**Keywords:** Green Open Space, Emissions, Greenhouse Gases

**JEL Classifications:** O13, P28, Q42, Q56

## 1. INTRODUCTION

Sustainable development is defined as development activities (especially urban areas) that are carried out continuously and provide continuous benefits for the survival of future generations. the concept of a green city as an effort to realize sustainable city development by presenting various development alternatives that are more equitable and humanistic (Mamie et al., 2021). The concept of sustainable development (which gave birth to the green city concept) was introduced in 1987 by the environmental commission through the World Commission on Environment and Development (WCED), Then continued at a high-level conference in Rio de Janeiro, Brazil around June 1992.

Currently, the concept of sustainable development is packaged in the millennium development goals (MDGs) which are

further refined by the concept of sustainable development goals (SDGs). The SDG concept sets out twenty agendas for achieving sustainable development by 2030. Quoted from (Petrenko, 2021); (Bodrunov, 2019); (Du et al., 2020); (Ivanitsky and Petrenko, 2020); (Anderson et al., 2017); (Boehringer et al., 2014) that the sustainable development agenda with the concept of a green city is integrated with four aspects, namely social (points 1, 2, 3, 4, 5, and 10), environment (points 6,13,14, and 15), economics (points 7,8,9, and 12), and institutional (points 11, 16 and 17).

Aspects of the urban environment become an important issue in development planning. Its main goal is to make the city residents comfortable. The next challenge is population growth which results in an increase in people's needs and mobility, causing a decrease in air quality (increased CO<sub>2</sub>) by exhaust gases from vehicles, industry, and others. The decrease in environmental

quality from increased emissions is known as the greenhouse gas effect. Greenhouse gases are defined as gases contained in the atmosphere, both natural and from human activities (anthropogenic), which absorb and re-emit infrared radiation. The process of the greenhouse effect is caused by the entry of some of the solar radiation in the form of short waves received by the earth's surface and re-emitted into the atmosphere in the form of long wave radiation (infrared radiation).

Polluted air will make breathing difficult so that the quality of life decreases. Air pollutants can be in the form of polluting gases, which include Nitrogen Oxide (NO<sub>x</sub>), Sulfur Oxide (SO) and Carbon Monoxide (CO<sub>2</sub>), VHC (Volatile Hydro Carbon), and particulates. Carbon Monoxide (CO<sub>2</sub>) is the biggest contributor to greenhouse gases (Andriono, 2013; Ikhlas et al., 2017).

The transportation sector is the most contributing to air pollution which in turn has a negative effect on humans as a result of vehicle emissions that produce harmful substances (NO<sub>x</sub>, SO, CO<sub>2</sub>, VHC, and particulates) (Andriono, 2013). This is commonly found in cities in the world, especially developing countries such as Indonesia. That 70% of air pollution in Indonesia is generated from motor vehicle emissions (Ikhlas et al., 2017). Motorized vehicles produce hazardous substances (CO<sub>2</sub>) which contribute the most to emissions and greenhouse gases. More than 75% of the global warming effect and about 50% contribute to the total greenhouse gas effect. The factors that cause high pollution caused by the transportation sector include the imbalance of transportation infrastructure with the number of existing vehicles, centralized urban traffic patterns, similarity in traffic flow time, type, age and characteristics of motorized vehicles, vehicle maintenance factors, type of fuel used, type of road surface, and driving cycles and patterns.

The existence of green open spaces in a city is important as an ecological support, improving the quality of the living environment so as to produce a healthy and comfortable environment for city residents (Werner, 2014). On this basis, in Indonesia set policies in Law Number 26 of 2007 concerning Spatial Planning, and Regulation of the Minister of Public Works Number 5 of 2008 which require the availability (wide) of green open space in a city at least 30% of the total area. Several studies have stated that the availability of green open space can reduce the effect of greenhouse gases, as did (Oswald et al., 2020) by about 11%) and (Bottalico et al., 2016) able to reduce the impact of pollutants by about 0.16 tons/year.

Kendari city as the capital of Southeast Sulawesi Province makes this area a center of development and a destination for population mobility. The Kendari City Government itself has set a vision of urban development that is environmentally sound with the jargon of "city in a park." This vision was started in 2014. However, the area of green open space is currently not able to meet the percentage of 30% of the total area, this is of course the ability to reduce CO<sub>2</sub> emissions from motorized vehicles is not maximized. The Kendari City Environmental Office reports that there is an increase in CO<sub>2</sub> emissions due to vehicle fuel consumption in Kendari City. Vehicle emissions in 2015 were

265,910.92 tons/year, and in 2018 they reached 326,039.40 tons/year. This fact shows that Kendari City still needs the expansion of green open space to reduce emissions and control the effects of greenhouse gases.

If the wide discrepancy between green open space and motor vehicle exhaust emissions continues to occur, then in the future with the rate of population growth and increasing vehicle ownership, it is feared that it will be difficult to achieve the "city in a park" and the goal of sustainable urban development through the green city concept is difficult to realize.

This study evaluates the ability of green open spaces in Kendari City to reduce vehicle emissions as an effort to control the effects of greenhouse gases. This study takes the object of the Bahteramas General Hospital area which has the potential to be developed as a green open space. The area of the Bahteramas General Hospital is about 17 ha, currently, only 5 ha has been built, so there is 12 ha of potential for green open space. The second reason is that the Bahteramas General Hospital as a referral hospital in Southeast Sulawesi and its surroundings is intended as a densely populated urban development area so that community mobilization is very high which in turn contributes to CO<sub>2</sub>. At the same time, hospital visitors and the surrounding community need adequate oxygen intake for environmental comfort and health.

## 2. LITERATURE REVIEW

Green open space is an open space, both public and private, whose surface is covered by vegetation, either directly or indirectly available to users. Green open space in urban areas is part of the open space of an urban area filled with plants and plants to support ecological, social, cultural, economic, and aesthetic benefits. Green open space is defined as an area that forms pathways and/or clustered areas, which are used more openly, where plants are either naturally grown or planted (Mamie et al., 2021). According De-Jong et al. (2012); (Wang et al., 2019) that urban green open spaces (such as parks) are public spaces that support physical activity to support and improve their health.

Green open space serves three functions, namely: (1) Maintaining the availability of land as a water catchment area, (2) creating urban analog aspects through a balance between the natural environment and the built environment that is useful for people's lives, and (3) increasing the harmony of the urban environment as a means of environmental protection. Safe, comfortable, fresh, beautiful, and clean. Law Number 26 of 2007 concerning Spatial Planning, and Regulation of the Minister of Public Works Number 5 of 2008 mentions other functions of urban green open spaces including; (a) The function of edaphic is as a place to live for animals and other micro-organisms; (b) Hydro-oroological function, preservation of soil and water; (c) The climatological function is the creation of a microclimate; (d) Protective function: protects from wind, noise, and hot sun; (e) Hygienic function, reducing pollutants both in the air and in water; (f) The educational function is that green open space can be a source of public knowledge about the types and types of vegetation, their origins, scientific names, benefits, and others; and (g) Aesthetic function, to contribute beauty, through

color, shape, a combination of textures, smells or sounds of the wild animals that inhabit it.

Polluted air will make breathing difficult so that the quality of life decreases. Air pollutants can be in the form of polluting gases, including Nitrogen Oxide (NO<sub>x</sub>), Sulfur Oxide (SO), and Carbon Monoxide (CO<sub>2</sub>) (Ikhlas et al., 2017); (Andriono, 2013). Greenhouse gases are defined as gases contained in the atmosphere, both natural and from human activities (anthropogenic), which absorb and re-emit infrared radiation. The process of the greenhouse effect is caused by the entry of some of the solar radiation in the form of short waves received by the earth's surface and re-emitted into the atmosphere in the form of longwave radiation (infrared radiation).

Several studies report the benefits of urban green open spaces that have reduced various chronic diseases, maintain (positive) mental health (Wang et al., 2019; Liu et al., 2017; Akpinar and Cankurt, 2017), green open space for recreation, and provide comfort for pedestrians. The study supports the previous statement that green open space is able to create and maintain a microclimate as a result of the ability to reduce motor vehicle exhaust emissions as an effort to control greenhouse gas emissions on a macro basis.

### 3. DATA AND ANALYSIS METHODS

This study uses a qualitative and survey approach. The data analyzed include the number of vehicles (daily traffic), electricity usage capacity, the area of the Bahteramas General Hospital, and the existing open space. The data is sourced from primary data such as the number of vehicles (daily traffic) to obtain vehicle emissions, and the area of the existing green open space, while the primary data is the area of the hospital, and the use of electricity.

The analysis of the amount of greenhouse gas emissions from the fuel is analyzed using the equation:

$$\text{greenhouse gas emissions} = \left( \frac{\text{Kg}}{\text{Year}} \right) \quad (1)$$

$$= \text{Energy Consumption} \left( \frac{\text{tj}}{\text{Year}} \right) \times \text{Emission factor} \left( \frac{\text{Kg}}{\text{tj}} \right)$$

The emission factor according to the IPCC default is expressed in units of emission per unit of energy consumed (kg GHG/TJ). Therefore, before being used in Equation 1, the energy consumption data must first be converted into Terra Joule energy units (tj) with the equation:

$$\text{Energy Consumption (tj)} = \text{Energy Consumption (physical unit)} \times \text{Calorie Value} \left( \frac{\text{tj}}{\text{physical unit}} \right) \quad (2)$$

For the calculation of emissions from the consumption of electrical energy, the following equation is used:

$$\text{Emission} = \sum \text{Electricity Consumption} \times \text{Factor Conversion} \quad (3)$$

Calculating the area of the existing green open space is then multiplied by the absorption capacity based on the type of vegetation cover. The result of this multiplication will be a deduction from the value of CO<sub>2</sub> emissions obtained from the calculation of the number of emissions in the research area. The calculation uses the equation:

$$\text{Existing Green Space Absorption} = \text{CO}_2 \text{ Absorption Power} \times \text{Vegetation Cover Area} \quad (4)$$

The absorption of CO<sub>2</sub> gas based on the type of vegetation cover consists of: (a) Trees: 129.92 kg/ha/h or 569.07 tons/ha/year; (b) Shrub: 12, 56 kg/ha/h or 55 tons/ha/year; (c) Grassland: 2.74 kg/ha/h or 12 ton/ha/year; and (d) Agricultural land: 2.74 kg/ha/h or 12 tons/ha/year.

Before calculating the need for green open space, it will be calculated the remaining emissions that have not been able to be reduced by the existing green open space. The remaining emissions are obtained from the total CO<sub>2</sub> emissions minus the absorption capacity of the existing green open space to CO<sub>2</sub>, using the equation:

$$\text{Remaining Emissions} = \text{Total CO}_2 \text{ Emissions, Actual} - \text{Existing Green Space Absorption} \quad (5)$$

Calculating the need for green open space that is not appropriate or cannot reduce emissions is carried out using the equation:

$$\text{Green Open Space Needs} = \left( \frac{\text{CO}_2 \text{ Remaining Emissions}}{\text{Vegetation Absorption Against CO}_2} \right) \quad (6)$$

### 4. RESULTS AND DISCUSSION

The amount of CO<sub>2</sub> emissions resulting from surrounding activities consists of movable emission sources and immovable emission sources. The source of mobile emissions comes from motor vehicles. Meanwhile, the source of stationary emissions comes from the use of electricity from the Bahteramas General Hospital, Southeast Sulawesi Province. Calculation of the magnitude of mobile emission sources originating from motorized vehicle activities by calculating the average volume of vehicles in the average daily traffic volume and fuel consumption per vehicle type based on the distance traveled in the study area. The amount of fuel consumption per unit based on vehicle type is obtained by adapting the specific energy consumption per vehicle type according to the Agency for the Assessment and Application of Technology of the Republic of Indonesia as presented in Table 1.

The results of the calculation of the average volume of vehicles entering the study area based on parking data managed by the Bahteramas General Hospital of Southeast Sulawesi Province are presented in Table 2.

Based on Table 2, it is known that the daily vehicle volume in the research area is 2,656 units consisting of 2,172 motorcycles, 450 minibusses, and 34 trucks. From this data, fuel consumption is calculated. Total consumption of fuel oil in transportation activities is carried out by calculating fuel consumption per vehicle type based on distance traveled. The amount of fuel oil consumption per unit based on vehicle type is obtained by adapting the specific energy consumption per vehicle type (Table 1). The fuel consumption of one motorbike requires 2.66 L/100 km, so one motorbike requires  $\pm 0.03$  L to cover the length of the main road Piere Tendean (Gate of Bahteramas General Hospital) to the parking lot is 600 m, so the distance is 600 meters. Which is taken by motorbike for a round trip is 1.2 km. For types of minibusses and trucks, the calculation is carried out in the same way for motorcycles based on the amount of fuel oil consumption

**Table 1: Specific energy consumption**

No.	Transportation type	Type of Fuel Oil	Specific energy conversion (L/100 Km)
1	Motorcycle	Premium	2.66
2	Sedan	Premium	10.88
3	Mini Bus	Premium	11.35
4	Small Truck/Pick up	Premium	8.11
5	Big Bus	Solar	16.89
6	Big Truck	Solar	15.82

Source: Analysis Results (2021)

**Table 2: Vehicle volume by vehicle type and fuel use on the Piere Tendean Road, Bahteramas General Hospital**

No.	Transportation type	Type of fuel oil	Average vehicle volume/day
1	Motorcycle	Premium	2.172
2	Mini Bus	Premium	450
3	Truck	Solar	34
	Total		2.656

Source: Analysis Results (2021)

**Table 3: Consumption of fuel oil by vehicle type**

Transportation type	Type of fuel oil	Distance (1.2 km)			
		Consumption of fuel oil per unit/day (Ltr/Unit/Day)	Average vehicle volume/day (Units/day)	Total fuel consumption/type of vehicle (Ltr/Dau)	Total fuel consumption/type of vehicle (Ltr/Yy)
Motorcycle	Premium	0,03	2.172	69	25.306
Mini Bus	Premium	0,14	450	61	22.371
Truck	Solar	0,19	34	6	2.357q

Source: Analysis Results (2021)

**Table 4: Total CO<sub>2</sub> emissions from mobile and fixed sources**

Sumber Emisi Bergerak						
Type of fuel oil	Total consumption of fuel oil/type of fuel oil (litr)	Calorific value ( $\times 10^{-6}$ tj/ltr)	Conversion (tj)	FE (Kg/tj)	CO <sub>2</sub> emission (kg/year)	CO <sub>2</sub> emission (ton/year)
Premium	47.676	33	1,57	69.300	109.031	109
Solar	2.356	36	0,08	74.100	5.761	6
Amount						115
Sumber Emisi Tak Bergerak						
Energy consumption type	Total Energy Consumption (kWh/year)	Calorific Value	Conversion	FE	CO <sub>2</sub> Emission (kg/year)	CO <sub>2</sub> Emission (ton/year)
Electricity	269.058	-	-	0,719*	193.435	193
Amount						193
Total						308

Source: Analysis Results (2021)

and specific energy consumption based on the distance traveled (Table 3).

Table 3 shows that the premium consumption for bicycles is 25,306 L/year, the premium consumption for minibus vehicles is 22,371 L/year and the total diesel consumption for trucks is 2,357 L/year. If the annual premium consumption for motorcycles and minibusses is 47,676 L and the premium calorific value in Indonesia is  $33 \times 10^{-6}$ , the premium consumption value for motorcycles and minibusses in terra joules is 3.30. This value is obtained through the conversion from physical units to energy units. After getting the premium consumption per year in energy units, which is 3.30 tj, then this value is multiplied by the CO<sub>2</sub> emission factor for premium fuel for motorcycles and minibusses, which is 69,300 kg/tj. Then it was found that the value of CO<sub>2</sub> emissions at premium usage was 109,031 kg/year or equivalent to 109 tons/year. The calculation of emissions from diesel fuel consumption in truck types is carried out in the same stages, taking into account the calorific value of diesel in Indonesia and the CO<sub>2</sub> emission factor for types of diesel fuel. The value of CO<sub>2</sub> emissions in trucks is 5761 kg/year or the equivalent of 6 tons/year. The emission value from the use of electrical energy at the Bahterahmas General Hospital is 269,058 kWh/year and the emission factor for electrical energy is 0.719 kg/kWh, so the emission value of the use of electrical energy is 193,453 kg/year or 193 tons/year. The total CO<sub>2</sub> emission is 308 tons/year. The data from the research are presented in Table 4.

The absorption capacity of green open space is calculated based on the area of vegetation cover. The ability to absorb CO<sub>2</sub> based on the type of tree vegetation cover is 129.92 kg/ha/h or 569.07 tons/ha/year. Vegetation cover in the Bahteramas green open space area is intended for green open space for the green road, this vegetation is spread on the left and right shoulders of the entrance to the Bahteramas General Hospital area and part of the



distribution of vegetation is in the parking area which functions as shade and aesthetics. The area of tree vegetation cover based on the results of the field inventory is 4200 m<sup>2</sup> or 0.42 ha. Thus, the absorption capacity of the existing green open space in reducing CO<sub>2</sub> emissions based on the tree cover area is 239 tons/year.

After finding the ability of the existing green open space to reduce actual CO<sub>2</sub> in the research area, then this result will be reduced by the total amount of actual CO<sub>2</sub> emissions that have been obtained from the previous calculation results, so that the remaining actual CO<sub>2</sub> emissions that have not been reduced will be found. The results of the calculation of the remaining emissions are obtained from the actual total CO<sub>2</sub> emissions of 308 tons/year minus the actual CO<sub>2</sub> emissions reduced by the existing green open space of 239 tons/year. So that the remaining CO<sub>2</sub> emissions that have not been able to be reduced by existing green open spaces are 69 tons/year.

Thus, to realize a green city as one of the instruments of a sustainable city, the Bahteramas General Hospital at least requires an expansion of the ideal green open space area of 1 ha. Considering population growth which has an impact on increasing vehicles and energy consumption (electricity), then the area of green open space can be built beyond the planned area. Likewise, cases or other public areas that have the potential to build green open spaces need to be increased by referring to the dynamics of existing developments (population, vehicles, and other energy consumption). Thus, the vision of a “city in a park” initiated by the Kendari City Government can be achieved and contribute to the achievement of a green city for a sustainable city.

## 5. CONCLUDING REMARKS

The results showed that the total daily traffic of vehicles on the roads around the Bahteramas General Hospital is 2,656 units/day, generally, motorcycles are 81.78%. The amount of CO<sub>2</sub> emissions that contribute to greenhouse gases from the use of premium fuels, diesel, and the use of electrical energy is 308 tons/year. The absorption capacity of the existing green open space in reducing CO<sub>2</sub> emissions is 239 tons/year, meaning that the remaining CO<sub>2</sub> emissions that have not been able to be reduced by the existing green open space are 69 tons/year, so it is necessary to add a minimum green open space of about 0.12 ha or 1,200 m<sup>2</sup>. An area of 0.12 ha is the current minimum area requirement, but along with the increasing number of residents and the number of vehicles in the future, it is recommended to build an ideal green open space of 1 ha.

The limitation of the study is calculating emissions from the number of vehicles and electricity use, so further research needs to add other variables such as the number of people living around, the number of visits and identify types of green open space vegetation that have good emission absorption rates and have aesthetic value. In the future, there needs to be an expansion of the object

of analysis by taking the entire area of green open space in one city for generalization.

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