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Analysis of needed forest in Universitas Negeri Semarang (UNNES) based on calculation of carbon dioxide emissions

M Rahayuningsih^{1*}, N E Kartijono² and M S Arifin³

^{1,2}Biology Department, Faculty of Science and Mathematics, Semarang State University, Semarang 50275, Indonesia

³Master of Environmental Science, Diponegoro University, Semarang 50275, Indonesia

* Corresponding author : etak_sigid@mail.unnes.ac.id

Abstract. Increasing number of staffs and academicians as a result of UNNES's popularity becoming a favourite university in Indonesia has demanded more facilities to support the learning process, student activities and campus operations. This condition has declined forest covered area in the campus, even though. Optimum extent must be prevented to support ecological function in campus areas. This research is conducted to determine the optimum areas of needed campus's forest based on CO₂ emissions in the UNNES area in Sekaran sub-district. The results showed that forest need for campus of UNNES in 2017 is 14.25 ha, but the existing area is only 13.103 ha. Campus forest in western campus area is sufficient to absorb CO₂ emissions with forest availability is about 8,147 ha while forest requirement is about 4.47 ha. Campus forest in eastern campus area is not sufficient to absorb CO₂ emissions. The need of campus forest in eastern campus area is much bigger that is 9,78 ha from campus forest which available is about 4,956 ha. The results of this study can be used as a reference in the development of green space both on campus and in the city of UNNES Semarang.

1. Introduction

Universitas Negeri Semarang (UNNES) establishes itself as Conservation University since 12 March 2010. The consequence of the status is the implementation of visions as Conservation University in the way of green movement. As a result "one student one tree" is initiated, which has been regulated by a ruler as chancellor number 26 the year 2009 about the movement of one student one tree [1]. Tree planting movement makes the campus greener and shadier.

The existing forest in the campus has important ecological functions for UNNES. Such as reducing air temperature, oxygen suppliers, prevent from floods and drought around campus environment and CO₂ sink, and water storage. UNNES campus forest in urban areas (urban forest) has many benefits, especially ecological benefits. The benefits of urban forest include maintaining air temperatures thus saving electricity from air-conditioning, water-storage and CO₂-absorbing [2]. To better understand the changes occurring in our urban areas, we first need to appreciate our environment and what it provides humans [3].

Converted area of the forest increases as same as UNNES popularity that become favorite University in Indonesia. It increases the number of student from year to year. A facility improvement



are needed to support the learning process, student activity and campus operational. It caused reducing large areas of campus forest. The decrease in forest area causes Carbon originally deposited in forest trees to be released into the atmosphere through decomposition during land clearing [4]. Its important to know the new tools that are providing decision support for forest management, conservation biology, and ecological restoration [5].

The objective of the study was to determine the minimum forest area that is required based on CO₂ emissions in UNNES and comparison with remain forest after built.

2. Methods

This research was conducted for six months from April until September 2017 at UNNES main campus at UNNES Sekaran campus, Sekaran Village, Gunungpati Sub-district, Semarang City. It is located between 110°04'32.78"00° and 07° 03'02.21"LS. Data management was analyzed in Biology Laboratory, UNNES.

Data were collected from primary and secondary data. Primary data was collected from CO₂ emissions that come from energy consumption, then campus forest condition obtained by observation, interview, and direct observation on location. While secondary data obtained from various institutions related to research, maps and literature study.

At first, CO₂ was measured from energy sources consumption by knowing majority fuel produced and amount of fuel consumption. In the other CO₂ is a residual product from energy consumption. The measuring CO₂ is conducted by calculating CO₂ emissions from actively used motorcycle, electricity generators, and LPG consumption from canteen inside UNNES. CO₂ emissions from motor vehicles are obtained by sampling the volume of vehicles entering the west campus (via the main gate and FMIPA gate) and the eastern campus (T-junction BNI and Cempakasari alley) for three days, ie on August 28, 2017 (representing the beginning of the week), Wednesday 30 August 2017 (representing midweek) and Sunday 3 September 2017 (weekend). Measurement CO₂ refers to [6] and [7]. The amount of fuel consumption can be determined by:

$$C \text{ (TJ/year)} = a \text{ (103 ton/year)} \times b \text{ (TJ/103 ton)}$$

explanation :

C: Total fuel consumption by type fuel (TJ / year)

a: Fuel consumption by material type burn (103 tons / year)

b: Net calorie value / conversion factor by type of fuel (TJ / 103 tons).

Table 1. Net calorie value by material type burn

Value of Clean Calories From Fuel	
Products of Petroleum	Faktor (TJ/10 ³ ton)
gasoline	44.80
Diesel	43.33
kerosene	44.75
LPG	47.31

The carbon content present in each of the oil and gas fuels is calculated by:

$$E \text{ (t C/year)} = C \text{ (TJ/year)} \times d \text{ (t C/TJ)}$$

explanation:

E: Carbon content by type of fuel (t C / year), c: Total fuel consumption by type fuel (TJ / year)

d: Carbon emission factors based on the type of fuel (t C/TJ)

Table 2. Carbon emission factors based on fuel type

Carbon Emission Factor	
Products of Petroleum	Emission Factor (t C/TJ)
Gasoline	18.9
Diesel	20.2
Kerosene	19.5
LPG	17.2

Source: IPCC (1996)

Actual carbon emissions generated from each fuel are calculated by:

$$G \text{ (Gg C/year)} = E \text{ (t C/year)} \times f$$

explanation :

G: Actual carbon emissions by type of fuel (Gg C / year)

E: Carbon content based on fuel type (t C / year)

f: CO₂ fraction, CO₂ fraction for fuel oil is 0.99 while for gas fuel is 0.995So the total CO₂ emissions generated from fuel oil and gas can be obtained by:

$$H \text{ (Gg CO}_2\text{/year)} = G \text{ (Gg C/year)} \times (44/12)$$

explanation :

H: Actual CO₂ emissions by material type burn (Gg CO₂ / year)

G: Actual carbon emissions by type of fuel (Gg C / year)

The need for campus forest area based on CO₂ absorption is derived from the ability of the campus forest to absorb CO₂. The needs of the campus forest are obtained from the amount Campus forest needs derived from the amount of CO₂.

CO₂ emissions in UNNES divided by the ability of urban forests to absorb CO₂.

$$L \text{ (ha)} = \frac{w \text{ (Gg CO}_2\text{/year)} + x \text{ (Gg CO}_2\text{/year)} + y \text{ (Gg CO}_2\text{/year)} + z \text{ (Gg CO}_2\text{/year)}}{K \text{ (ton/year/ha)}}$$

explanation:

L: Urban forest area needs (ha)

w: Total CO₂ emissions from energy (Gg CO₂ / year)x: Total CO₂ emissions from livestock (Gg CO₂ / year)y: Total CO₂ emissions from rice fields (Gg CO₂ / year)z: Total CO₂ emissions from humans (Gg CO₂ / year)K: The value of CO₂ uptake by forests of 58.2576 CO₂ (ton/year / ha), according to (Inversion 1993 in Tinambunan 2006) [8].

3. Results and discussion

3.1. CO₂ Emission Source Calculation

The several types of vehicles was measured in this measurement include motorcycles, cars (petrol), cars (diesel), buses, pickup trucks and three-wheeled motorcycles. Graph of percentage of vehicle volume composition on the campus of UNNES Sekaran presented in Figure 1.

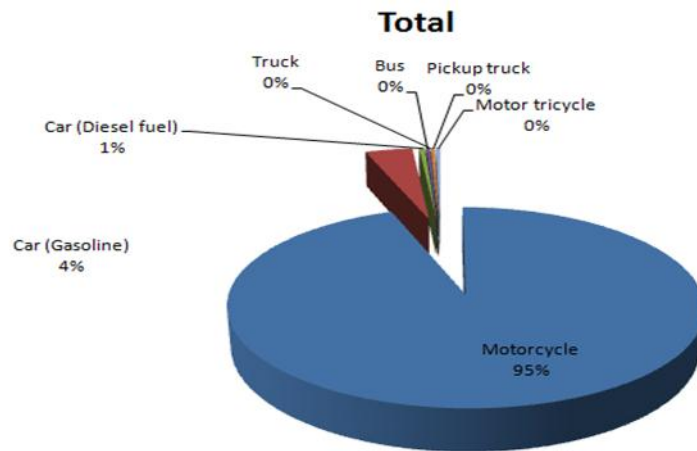


Figure 1. Percentage of vehicle volume in each category

Based on the percentage, motorcycle volume composition is the biggest volume that reaches 95% (161.262 units/year) from a total motor vehicle entering UNNES Sekaran campus (170.626 unit/year). The campus student who chooses motorcycles because of affordable price. The truck is the type of vehicle with the least volume of that is only 62 units/year or less than 0.5% of the total motor vehicles on the campus of UNNES. The volume of trucks is small due to the limited number of trucks owned by UNNES which are fire trucks and tank trucks to water the plants.

The calculation results of CO₂ emissions sourced from motor vehicles in the area of UNNES campus can be seen in table 3 below.

Table 3. Carbon emissions of motor vehicles

Transportation type	Western Campus (tC/Year)	East Campus (tC/Year)
Motor cycle	150,78	454,91
Passenger Car (gasoline)	62,88	49,03
Passenger Car (diesel)	8,12	6,19
Bus	0	16,39
Truck	1,57	0,27
Pick up	4,17	3,93
Three Wheel Motor	2,19	0,99
Total	229,71	531,71

The emissions from motor vehicles on the eastern campus have higher emission levels (531.71 t C / year) than from west campus (229.71 t C / year). Higher CO₂ emissions in eastern campus are influenced by major student takes study than on the west campus. The number of campus student on the eastern campus is as much as 23,168 inhabitants while the campus residents on the west campus are as many as 10.983 inhabitants [9]. The eastern campus parking enclaves, mostly located inside to the campus area, this condition is different from on the west campus, where the parking lot is mostly located on the edge of learning area. Also, the eastern campus is a path that is passed by trans Semarang bus while the west campus is not a path through which trans Semarang bus.

Motorcycles produce the highest CO₂ emissions among other vehicles on the UNNES campus of 605.69 t C/year, while the lowest CO₂ emissions are generated by trucks at 1.84 t C / year. High emissions from motorcycles are due to the large volume of motorcycles that enter the campus is high among other motor vehicles that reach 95%. The greater the volume of the motorcycle, the higher the fossil fuels consumption.

CO₂ emissions from the canteen were obtained by sampling the LPG gas requirement in the canteen in the UNNES campus area. The result of calculation of CO₂ emission which is sourced from LPG gas usage in the cafeteria can be seen in table 4 below.

Table 4. Carbon emissions from LPG consumption

No	Campus Cafeteria	Actual CO ₂ Emissions (tC/Th)
1.	Rectorat cafeteria	14.96
2.	FMIPA cafeteria	6.41
3.	FBS cafeteria	8.55
4.	FIP cafeteria	7.69
5.	FIS cafeteria	9.62
6.	FH cafeteria	0.86
7.	FIK cafeteria	10.69
8.	FT cafeteria	8.55
Total		67.33

The CO₂ emissions from generators are obtained by sampling diesel fuel requirements through interviews with genset management officers. Based on interviews with genset management officers, the number of gensets operating in the UNNES campus area is 10 units consisting of five units of generators located in the west campus area, and five other units are in the eastern campus area. The result of calculation of CO₂ emission from the use of generator obtained emission equal to 1.52 t C / year

3.2. Campus Forest Needs Based on CO₂ Emissions

Campus forest as one of green open space is very important in supporting the sustainability of the campus, regarding ecological aspects. The Well managed of green open space can provide various ecological benefits [10][11]. One of the ecological advantages of green open space is the ability to absorb CO₂. CO₂ can be absorbed by the vegetation contained in green open space [12]. The absorption of CO₂ by 10000 trees stand aged 16-20 years can reduce the CO₂ as much as 800 tons per year [13].

The need for campus forest UNNES Sekaran can be known by CO₂ absorption approach. Urban forest needs are derived from the amount of CO₂ emissions found on the UNNES Sekaran campus with the ability of urban forests to absorb CO₂. The CO₂ gas content contained in the UNNES campus can be seen from CO₂ emissions derived from energy in the form of burning fossil fuels motor vehicles, genset, and consumption of LPG in the campus canteen. Total CO₂ emissions from motor vehicles, generators and LPG are 830.27 t CO₂ / yr as presented in Table 5, campus forest gods Based on CO₂ Emissions

Table 5. The need for campus forests based on CO₂ emissions

No	CO ₂ Emission Source	Western Campus	East Campus
1	LPG cafeteria	29.92	37.41
2	Number of CO ₂ Emissions (tC/Th)	260.39	569.88
3	the required area of campus forest (Ha)	4.47	9.78
Total area of campus forest required on campus UNNES (Ha)		14.25	

The calculation shows that the need of campus forest on UNNES Sekaran campus based on CO₂ emission is 14.25 Ha consisting of 4.47 Ha of forest in the west campus area and 9.78 Ha forest in

the eastern campus area. The need for forests in the eastern campus area is higher than that of the western campus area due to the total CO₂ emissions on the eastern campus which are greater than the total emissions on the west campus. Total CO₂ emissions on the eastern campus are 569.88 t C / year, while total CO₂ emissions on the west campus are 260.39 t C / year.

3.3. Adequacy of Campus Forest Based on Current Condition

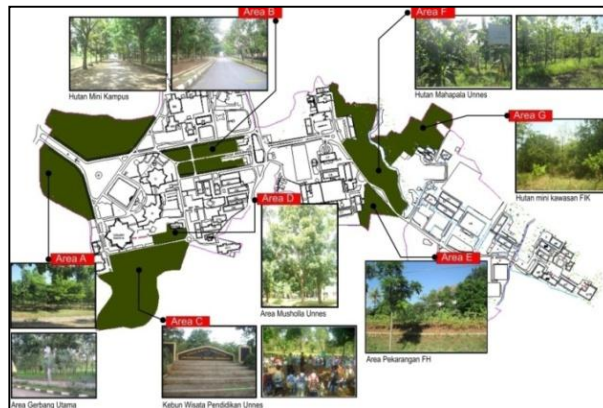


Figure 2 UNNES forest campus map distribution [14]

Based on current conditions, UNNES campus forest is not sufficient to absorb CO₂ emissions. Campus forest that should be provided by UNNES is an area of 14.25 Ha whereas the state of the available field campus forest is 13.103 ha.

Campus forest in the western campus area still sufficient to absorb CO₂ emissions. Campus forest in western campus area currently available is about 8.147 ha while the need for the forest that needs to be provided is about 4.47 ha. The addition of campus forest development needs to be done in the eastern campus area. The calculation shows that forest needed in eastern campus area is 9,78 Ha while the remaining forest area is around 4.956 ha.

4. Conclusion

CO₂ emissions contained in UNNES derived from energy (fuel) of motor vehicles with emission amount of 761.42 t CO₂ / yr, use of genset with emission amount of 1.52 t CO₂ / year and LPG requirement with emission amount of 67.33 t CO₂ / year. Total CO₂ emissions from these three sources are 830.27 t CO₂ / yr. The needs of campus forests on UNNES Sekaran campus based on CO₂ emissions of 14.25 t Ha consisting of 4.47 Ha of forest in western campus and 9.78 Ha forest in the eastern campus area.

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