Quantifying Carbon Footprint of Diponegoro University: Non-Academic Sector

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Abstract. This study focuses on quantifying the carbon footprint generated by non-academic activities at Diponegoro University, Indonesia. The carbon footprint study at Diponegoro University divides into three scopes, which are emissions from sources that are owned or controlled directly by the university, indirect emissions from electricity consumption, and other indirect emissions. Scope one covers clean water treatment, scope two includes electricity usage, while scope three involves wastewater and waste disposal in the campus area as a result of non-academic activities. The calculated emissions include CO₂, CH₄ and N₂O expressed in TonCO₂-eq. The carbon footprint resulting from non-academic activities at Undip is 13,945.55 TonCO₂-eq. The most significant carbon footprint contributors come from electricity activities with a total carbon footprint of 13,857.798 TonCO₂-eq, followed by wastewater and water supply activities.

1. Introduction
One of the biggest world’s challenges today is climate change. The impact of climate change has big influence to the human and environment. The main factor that contribute to climate change is global warming [1][2]. Global warming is triggered by greenhouse gases that generated during people’s activities through various sources [3]. Therefore, one of the approaches that should be performed in order to reduce global warming is by reducing the amount of greenhouse gases (GHG) released to atmosphere [4].

The quantity of the greenhouse gases generated depends on the each activity [4]. In the daily life, everybody uses water and electricity that produce carbon dioxide (CO₂) emissions. In campus activities (university), CO₂ is also emitted during the use of energy and other resources. The amount of emission can be calculated by quantify carbon footprint [5][6]. The existence of universities significantly contributed to greenhouse gas emissions from non-academic activities and academic activities. However, the information on the carbon footprint of non-academic activities is limited. Therefore, this study focuses to quantify the carbon footprint of non-academic activities at a university using the information obtained from Diponegoro University, Semarang, Indonesia.
2. Methodology

This research was carried out at main campus area of Diponegoro University, Semarang, Indonesia. The amount of carbon footprint was calculated from all non-academic activities that produce carbon emissions. All data was obtained through interviews, observation and university’s record. Those data were collected in the form of carbon emissions data in each buildings that mainly function to support non-academic activities at Diponegoro University.

There were three required stages to assess the carbon footprint of non-academic activities, which include setting operational limits, collecting data and calculating emissions using emission factors. GHG emissions from various operations are categorized into three "scopes" (scope 1, scope 2, and scope 3), to describe the sources of direct and indirect emissions [7]. In this study, the aspect of scope 1 is the provision of clean water. Scope 2 includes GHG emissions from consumption of electricity. While scope 3 is a consequence of activities on campus that occur from sources that are not owned or controlled by the university [8]. Wastewater and solid waste treatment include in scope 3 of this study. Two types of data are collected which are activity data and emission factors (EFs). Activity data is obtained from all activities within a specified limit for one year period. Parameters and relevant sources of the activity data related to every operation are presented in table 1.

![Table 1. Activity to calculate the carbon footprint](image)

| Scope | Activities | Parameters of Activity Data |
|-------|------------|-----------------------------|
| 1     | Water supply | Water consumption          |
| 2     | Electricity usage | Electricity consumption annually (kWh) |
| 3     | Waste disposal | Amount of waste generation annually (kg/floor/day) |
| 4     | Wastewater treatment | Wastewater treatment system |

Data processing was carried out to obtain GHG emissions by looking for emission factors from various non-academic activities. Calculation of each source and emission activity were stated in TonCO$_2$eq/year or kgCO$_2$eq/year [9]. The most relevant and appropriate EF is shown in table 2 using assumptions taken for the conditions of Central Java, Indonesia. Data processing and analysis are carried out using the calculation of emission factors that refer to the Intergovernmental Panel Guidelines on Climate Change (IPCC) for the 2006 National Greenhouse Gas Inventory.

![Table 2. Emission factors for different activities](image)

| Activities            | Parameters of Activity Data |
|-----------------------|-----------------------------|
| Motor gasoline        | 0.0693 Kg/MJ                |
| Gas/Diesel Oil        | 0.0741 Kg/MJ                |
| Electricity consumption | 0.919 KgCO$_2$e/kWh        |
| Waste disposal        | 427 KgCO$_2$e/ton           |

*Source: IPCC, 2006*

3. Results and Discussion

3.1. Total CFP of the organization

The results illustrate that total carbon footprint (CFP) of this campus activities is 13,945.55 TonCO$_2$eq/year as presented in Table 3. The most CFP generated is coming from electricity usage of 13,857.798 TonCO$_2$eq/year while the least CFP is produced by water supply (30.079 TonCO$_2$eq/year). The contribution of CFP from waste and wastewater treatment are accounted at 57.673 TonCO$_2$eq/year.
### Table 3. Calculated CFP of non-academic activities in Diponegoro University

| Scope   | Activities        | CFP TonCO₂eq/year | Subtotal TonCO₂eq/year |
|---------|-------------------|-------------------|------------------------|
| 1 (Direct) | Water supply    | 30.079            | 30.079                 |
| 2 (Indirect) | Electricity usage | 13,857.798        | 13,857.798             |
| 3 (Indirect) | Waste disposal | 0.064             | 57.673                 |
|          | Wastewater treatment | 57.609         |                        |
|          | Total            |                   | 13,945.55              |

#### 3.2. CFP in each sector

##### 3.2.1. Clean Water Sector from Non-Academic Activities

The carbon footprint value of the clean water sector at Diponegoro University is presented in table 4 and figure 1. In the Dormitory building, hospital, and commercial area, the carbon footprint value looks significantly different compared to other buildings, as dormitory building produces 11,747.50 kgCO₂eq/year of CFP. Meanwhile, the carbon footprint of the Senate Hall, Laboratory, Main Office, Training Center, and University hall were accounted below 2,000 kgCO₂eq/year.

The Senate Hall, Laboratory, Main Office, Training Center and University Hall generate CFP of 903.28 kgCO₂eq/year, 994.74 kgCO₂eq/year, 830.77 kgCO₂eq/year, 1535.02 kgCO₂eq/year and 17.22 kgCO₂eq/year respectively. Those amount of CFP can be categorized as low carbon footprint level. Meanwhile, hospital, commercial area and dormitory which produce CFP of 8,346.79 kgCO₂eq/year, 5,703.60 kgCO₂eq/year and 11,747.50 kgCO₂eq/year are classified into high carbon footprint level. Dormitory, hospital and commercial area has a high carbon footprint because they are influenced by a large population, clean water and electricity consumption [10].

### Table 4. Calculated water supply CFP of non-academic activities in Diponegoro University

| Reviewed Location | Per-capita value | Total population of 2019 | CFP of Water Supply 2019 |
|-------------------|------------------|--------------------------|--------------------------|
| Senate Hall       | 2.54             | 356                      | 903.28                   |
| Laboratory        | 8.80             | 113                      | 994.74                   |
| Main Office       | 4.54             | 183                      | 830.77                   |
| Training Center   | 7.17             | 214                      | 1,535.02                 |
| University Hall   | 0.54             | 33                       | 17.72                    |
| Hospital          | 20.97            | 398                      | 8,346.79                 |
| Dormitory         | 18.50            | 635                      | 11,747.50                |
| Commercial Area   | 9.80             | 582                      | 5703.60                  |
| TOTAL             |                  |                          | 30079.43                 |
3.2.2. Electrical Sector from Non-Academic Activities. The carbon footprint value of non-academic activities at Diponegoro University in terms of the electricity sector can be seen in table 5 and figure 2. The commercial area, which produces CFP of 4,312,350.00 kgCO$_2$eq/year, become the highest carbon footprint contributor, while the lowest carbon footprint contributor is University Hall, which produces CFP of 11,896.5 kgCO$_2$eq/year. Existing trends in the carbon footprint from the electricity sector are quite varied. In the commercial area, dormitory, hospital and training center, the carbon footprint value looks significantly different compared to other buildings. Commercial area generated of 4,312,350.00 kgCO$_2$eq/year of CFP, while Senate hall, laboratory, main office, and University hall produce a total below 1,000,000 kgCO$_2$eq/year of CFP. The carbon footprint of training center, hospital, dormitory, and commercial area tend to be high because the usage intensity of the building which is higher than other buildings. The University hall has the lowest carbon footprint value even though the area and capacity of the building are large. This is because of the usage intensity of the University hall is not regular. The Senate hall also has a low carbon footprint of 312,602.42 kgCO$_2$eq/year due to the minimal use of electricity in the building. The large carbon footprint of the electricity sector is influenced by large populations followed by high periodic electricity consumption [11]

Table 5. Calculated electricity CFP of non-academic activities at Diponegoro University

| Reviewed location | Per-capita value | Total population of 2019 | CFP of Electricity 2019 |
|------------------|-----------------|-------------------------|-------------------------|
| Senate Hall      | 878.10          | 356                     | 312,602.42              |
| Laboratory      | 4,937.05        | 113                     | 557,886.56              |
| Main Office     | 4,171.77        | 183                     | 764,276.96              |
| Training Center | 12,524.71       | 214                     | 2,680,287.06            |
| University Hall | 360.50          | 33                      | 11,896.50               |
| Hospital        | 6,308.41        | 398                     | 2,510,748.84            |
| Dormitory       | 4250            | 635                     | 2698750                 |
| Commercial Area | 7425            | 582                     | 4321350                 |
Table 6. Calculated waste disposal CFP of non-academic activities in Diponegoro University

| Reviewed location | Per-capita value | Total population 2019 | CFP of Waste Disposal 2019 |
|-------------------|------------------|------------------------|---------------------------|
| Senate Hall       | 0.0073           | 356                    | 2.61                      |
| Laboratory        | 0.0042           | 113                    | 0.48                      |
| Main Office       | 0.0396           | 183                    | 7.24                      |
| Training Center   | 0.0461           | 214                    | 9.86                      |

3.2.3. Waste Disposal Sector from Non-Academic Activities. The CFP values of the waste disposal sector at Diponegoro University are presented in table 6 and figure 3. The highest CFP is produced by dormitory which is 17.46 kgCO₂eq/year, while the lowest CFP is generated by University hall which is 0.41 kgCO₂eq/year. Existing trends in the CFP of the waste sector are quite varied. The value from laboratory and University hall are quite similar, which are 0.48 kgCO₂eq/year and 0.41 kgCO₂eq/year. The CFP values of all buildings are still below 313,241 kgCO₂eq/year which mean that they can be classified as low carbon footprint.

The dormitory has the highest carbon footprint because the usage intensity of the building which is higher than others. The main office has the lowest carbon footprint value, although the area and capacity of the building are quite large since its irregular usage. The laboratory also has a low carbon footprint value which is 0.48 kgCO₂eq/year due to the small amount of waste disposed from laboratory activities. The main office and training center have quite same carbon footprint values because both of the building have the same function as operational office.
3.2.4. Wastewater sector from non-academic activities. The highest CFP value comes from the dormitory, which is 13,017.5 kgCO₂eq/year followed by Senate hall (11,911.28 kgCO₂eq/year) as presented in table 7 and figure 4. The lowest CFP value is from university hall, which is 355.53 kgCO₂eq/year. Laboratory, main office and training center have CFP value of 3,780.83 kgCO₂eq/year, 6,122.94 kgCO₂eq/year, and 7,160.16, kgCO₂eq/year respectively. The carbon footprint values of all buildings are still below 53,536.3 kgCO₂eq/year which can be classified as low carbon footprint. The dormitory and Senate hall have a quite high value of the wastewater sector of CFP which is in line with the number of population in the building. The lowest CFP value comes from the University hall because the usage intensity of the building is irregular and low in population.

Table 7. Calculated wastewater CFP of non-academic activities in Diponegoro University

| Reviewed location | Per-capita value | Total population of 2019 | CFP of Wastewater 2019 |
|-------------------|-----------------|--------------------------|------------------------|
| Senate Hall       | 33.46           | 356                      | 11,911.28              |
| Laboratory        | 33.46           | 113                      | 3,780.83               |
| Reviewed location | Per-capita value | Total population of 2019 | CFP of Wastewater 2019 |
|-------------------|-----------------|-------------------------|------------------------|
| Main Office       | 33.46           | 183                     | 6,122.94               |
| Training Center   | 33.46           | 214                     | 7,160.16               |
| University Hall   | 10.77           | 33                      | 355.53                 |
| Hospital          | 21.53           | 398                     | 8,568.49               |
| Dormitory         | 20.50           | 635                     | 13,017.50              |
| Commercial Area   | 11.50           | 582                     | 6,693.00               |
| TOTAL             |                 |                         | 57,609.73              |

**Table 1.** Calculated waste disposal CFP of non-academic activities in Diponegoro University

![Wastewater Treatment (kgCO₂eq) per year](image)

**Figure 4.** Calculated waste disposal CFP of non-academic activities in Diponegoro University

4. Conclusions

The carbon footprint resulting from non-academic activities at Diponegoro University in 2019 amounted to 13,945.55 TonCO₂-eq. This total carbon footprint consists of a scope of one, two and three with a percentage of 0.21%, 99.37%, and 0.41%. The main contributor to CFP is electricity sector with a total carbon footprint of 13,857.798 TonCO₂-eq/year. Meanwhile, the highest carbon footprint is generated by commercial area. The best recommendation to reduce the carbon footprint is to propose energy conservation, such as applying an electricity-saving culture and by optimizing the campus area as green open space.

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