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Carbon Footprint of Universitas Airlangga Before and During the Covid-19 Pandemic

Permata Hajjarianti[1], Nurina Fitriani[1], Lauditta Chavia Zagita[1], Devi Ana[1], Trisnadi Widyaleksono[1], Agoes Soegianto[1], Wahid Dianbudiyanto[1], Karnaji[2], Muhammad Miftahussurur[3]*

[1]*Study Program of Environmental Engineering, Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia*

[2]*Department of Sociology, Faculty of Humanities, Universitas Airlangga, Surabaya, Indonesia*

[3]*Division of Gastroentero-Hepatology, Department of Internal Medicine, Faculty of Medicine-Dr. Soetomo Teaching Hospital, Universitas Airlangga, Surabaya, Indonesia*

[*]corresponding author: nurina.fitriani@fst.unair.ac.id

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Abstract. This study focus on calculating the carbon footprint from the activities of the Universitas Airlangga. CO_2 emission calculations were carried out using the UI GreenMetric method and the Intergovernmental Panel on Climate Change (IPCC) in two periods: before the Covid-19 pandemic and during the Covid-19 pandemic. Activities at Universitas Airlangga that produce carbon footprints are divided into two main sources, first, primary sources that come from direct combustion of fuel into energy, such as burning fuel in motorized vehicles and a secondary source that comes from an indirect source of using electricity in the campus area. The results showed that in the period before the pandemic, the total carbon emissions, based on the IPCC calculation method, were 23.830,34 tons of CO_2-eq/year. Meanwhile, based on the UI GreenMetric method, a total carbon emission of 26.325,36 tons of CO_2-eq/year was obtained. As for the time period during the pandemic, Universitas Airlangga's total carbon emissions obtained based on the IPCC calculation method were 20.506,69 tons of CO_2-eq/year. Meanwhile, based on the UI GreenMetric method, a total carbon emission of 22.321,63 tons of CO_2-eq/year was obtained. Secondary carbon footprint mapping is carried out to ascertain the distribution of secondary CO_2 emissions produced by Universitas Airlangga. The secondary carbon footprint both before and during the Covid-19 pandemic was mostly generated by the Universitas Airlangga Hospital.

Keyword:

IPCC, Carbon Footprint, Primary Carbon Emission, Secondary Carbon Emission, UI GreenMetric

1. Introduction

Every activity that is carried out by humans and requires energy will eventually produce waste or emissions. The more activities that are carried, the greater the need for energy, and so the greater the emission values. Greenhouse Gas (GHG) emissions are the main causative factor of the climate change phenomenon. [1] Therefore, an inventory regarding emissions using carbon footprint calculations is needed. The calculation of the carbon footprint is carried out to calculate the value of GHG emissions produced by a product during its lifetime. In general, the definition of carbon footprint is the amount of GHG emitted as a result of human activities, both directly and indirectly.[2] One of the Indonesian government's actions is to realize the 13th point of sustainable development goals, which is taking quick action to address climate change and its impacts. As a result, Indonesia is one of the participants in the 26th Conferences of Parties (COP) in Glasgow in November 2021 and was committed to reducing a total of 29% of GHG emissions with their own efforts and a reduction of up to 41%, if they receive support and assistance from international parties. This plan is targeted to be reached before 2030. In addition, Indonesia also has a comprehensive national action plan to reduce greenhouse gas emissions listed in the Presidential Regulation of the Republic of Indonesia Number 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions and Regulation of the President of the Republic of Indonesia Number 71 of 2011 concerning Implementation of the National Greenhouse Gas Inventory. [3]

The actions to help in realizing the 13th point of sustainable development goals in Indonesia are also supported by educational institutions by contributing in creating the existence of a green campus. One of the universities is the Universitas Airlangga. Universitas Airlangga is an educational institution in the city of Surabaya with a campus area divided into campus A, B, C. In general, activities at Universitas Airlangga that produce carbon footprints are divided into two main sources, first, primary sources that come from direct combustion of fuel into energy, such as burning fuel in motorized vehicles, and a secondary source that comes from an indirect source of using electricity in the campus.

This study will be focused on calculating the carbon footprint from the activities at Universitas Airlangga. CO2 emission calculations were carried out using the UI GreenMetric method and the Intergovernmental Panel on Climate Change (IPCC) in two periods: before the Covid-19 pandemic and during the Covid-19 pandemic.

2. Points of Results and Discussions

We will conduct a study of the carbon footprint from the campus activities in the Universitas Airlangga area, Campus A located in Tambaksari District, Campus B located in Gubeng District, and Campus C located in Mulyorejo District, Surabaya City. The data in this study come from primary and secondary data which were then calculated using the Intergovernmental Panel on Climate Change (IPCC) method regarding the inventory and calculation of national greenhouse gasses and the UI GreenMetric method which is a ranking standard from University of Indonesia that aims to find out the efforts of each institutions in managing campus sustainability.

A. IPCC

1) Primary sectors

EC (TJ/year) = EC (TJ/year) x CV **(2.1)**

PE (Kg.CO_2/year) = EC (TJ/year) x FE x GWP **(2.2)**

EC : Energy consumption (TJ/year)
CV : Calorific value (TJ/L)
PE : Primary CO_2 emission (Kg.CO_2-eq/year)
EF : Emission factor (Kg/TJ)
GWP : Global warming potential (GWP CO_2 = 1)

2) Secondary sectors

SE (Kg.CO_2-eq/year) = EC (TJ/year) x EF x GWP **(2.3)**

EC : Energy consumption
SE : Secondary CO_2 emission (Kg.CO_2-eq/year)
EF : Emission factor (Kg/KWh) (0,7749) [4]
GWP : Global warming potential (GWP CO_2 = 1)

3) Total emission

E (Kg.CO_2-eq/year) = PE (Kg.CO_2-eq/year) + SE (Kg.CO_2-eq/year) **(2.4)**

E : Total emissions CO_2 (Kg.CO_2-eq/year)
PE : Primary CO_2 emission (Kg.CO_2-eq/year)
SE : Secondary CO_2 emission (Kg.CO_2-eq/year)

B. UI GreenMetric

1) CO_2 emissions from vehicle activities

a. Campus bus

CO_2 emission = (n x Number of trips x Distance travelled x 240 x 0,01) / 100 **(2.5)**

b. Car

CO_2 emissions = (Number of vehicles x 2 x Mileage x 240 x 0,02) / 100 **(2.6)**

c. Motorcycle

CO_2 emissions = (Number of vehicles x 2 x Mileage x 240 x 0,01) / 100 **(2.7)**

CO_2 emissions : Carbon dioxide emissions produced in a year (tons.CO_2-eq/year)
n : Number of buses operating
Mileage : Approximate vehicle mileage per day in the campus area (km)
240 : The number of working days per year
0,01 : The coefficient for calculating metric tons of emissions per 100 km of bus/motorcycle (Source: carbonfootprint.com)
0,02 : The coefficient for calculating metric tons of emissions per 100 km of car (Source: carbonfootprint.com)

2) CO_2 emissions from electricity usage activities

CO_2 emissions from electricity usage

CO_2 Emissions = Electricity Consumption x 0.84 / 1000 **(2.8)**

Electricity Consumption : Amount of electricity used in a year (KWh/year)
0,84 : The coefficient for converting KwH to metric tons (Source: carbonfootprint.com)

3) Total emission

Total CO_2 Emissions =
CO_2 emissions from vehicle activities + CO_2 emissions from electricity usage **(2.9)**

The results obtained for mapping were carried out from the calculation of secondary sector carbon dioxide emissions produced at the Universitas Airlangga. The mapping was

done based on the range of carbon dioxide emission results by coloring the area of each unit at the Universitas Airlangga, according to the level of emissions produced, using ArcGIS 10.8 software. Before the coloring, a base map of the campus area was mapped using the ArcMap software to facilitate the coloring boundaries. Base mapping is done by tracing the Google Earth map with the ArcMap shapefile function. Next, coloring is done with symbology features. The color range is based on a previously calculated scale of secondary sector carbon footprint values. Visual presentation of data makes it easier to identify the units that produce the largest carbon footprint.

2.1. CO_2 Emissions Calculation

CO2 emission calculations were carried out in the period before and during the Covid-19 pandemic to identify which emission sectors were affected during the Covid-19 pandemic. Calculations were also carried out with the aim of inventorying CO2 emission data released in the campus area. The methods used in this study are IPCC and UI GreenMetric. The calculation of CO2 emissions both before and during the Covid-19 pandemic is divided into two sectors which are primary CO2 emissions and secondary CO2 emissions. The analysis of CO2 emission calculation data before and during the Covid-19 pandemic is as follows:

2.1.1 Primary CO_2 Emissions

Calculation of primary carbon emissions using the IPCC method is carried out using the equation 2.1 and 2.2

Energy Consumption (L)
= Number of Vehicles/year x Mileage (Km) x Specific Energy Consumption (L/Km)
= 996.715 x 0,5 x 0,1179
= 58.756,35 L/year
Energy Consumption (TJ)
= Energy Consumption (L) x Calorific Value (TJ/L)
= 58.756,35 x $33x10^{-6}$
= 1,94 TJ/year
Primary CO_2 Emissions (TonsCO_2-eq/year)
= (Energy Consumption (TJ) x Emission Factor (Kg/TJ)) / 1000
= (1,94 x 69.300) / 1000
= 134,37 tons of CO_2-eq/year

As for calculations using the UI GreenMetric formula is carried out using the equation 2.6.

Primary CO_2 Emissions (Tons CO_2-eq/tahun)
= (Number of Vehicles/day x 2 x Mileage x 240 x 0,02) / 100
= (3,834 x 2 x 0,5 x 240 x 0,02) /100
= 184,03 tons of CO_2-eq/year

Based on the calculations, the results of primary carbon emissions at Universitas Airlangga before and during the Covid-19 pandemic can be seen in Table 1, Figure 1, and Figure 2

Table 1. Universitas Airlangga Primary CO2 Emissions Before and During the Covid-19 Pandemic

Vehicles	Before the Covid-19 Pandemic		During the Covid-19 Pandemic	
	IPCC	UI GreenMetric	IPCC	UI GreenMetric
Car	296,44	593,37	66,04	117,44
Motorcycle	329,25	561,49	69,14	104,8
Bus	0,23	0,10	0,00	0,00
Total	625,92	1154,96	135,18	222,24

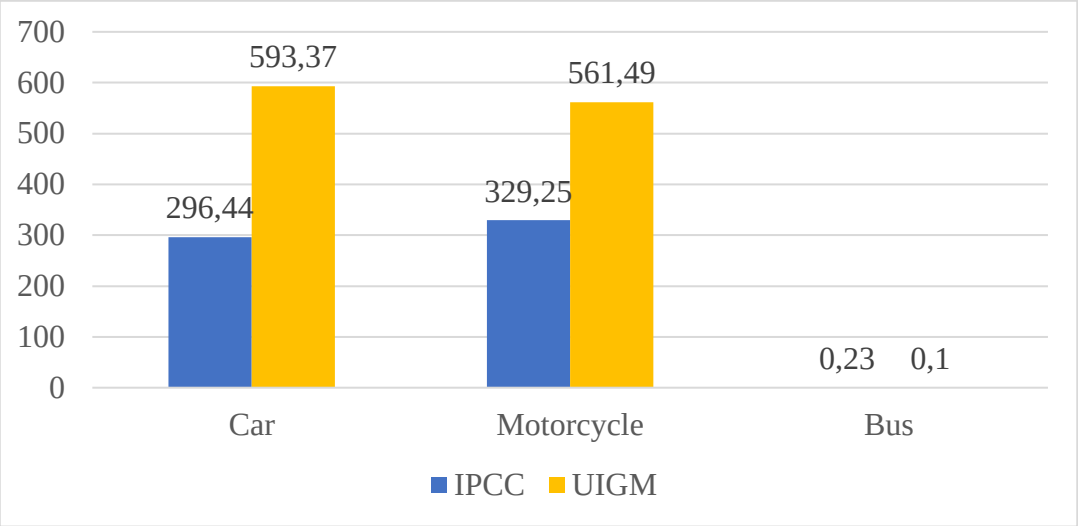


Figure 1. Primary CO2 Emissions of Universitas Airlangga Before the Covid-19 Pandemic

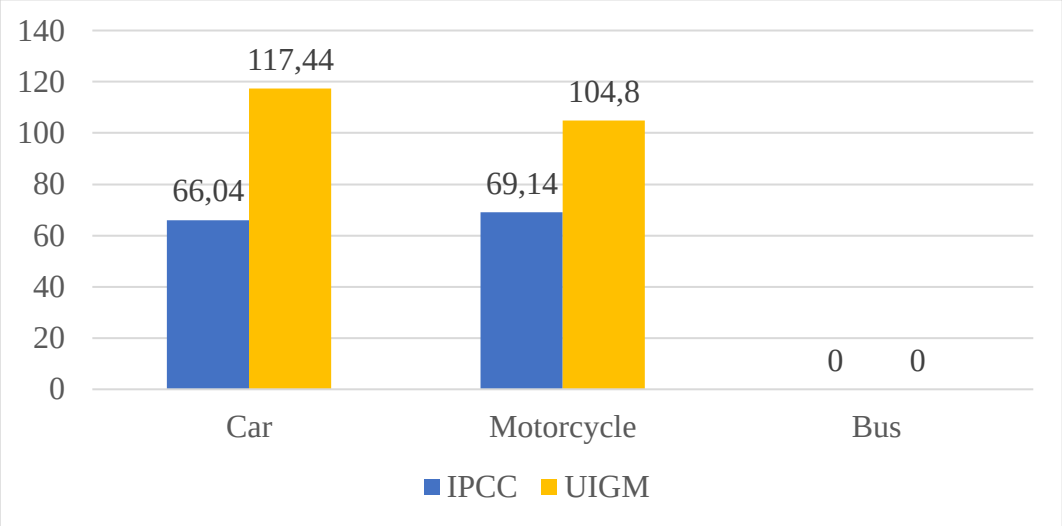


Figure 2. Universitas Airlangga Primary CO2 Emissions During the Covid-19 Pandemic

Figure 1 and 2 show that the primary carbon emissions produced by two-wheeled motorized vehicles using the IPCC method before the pandemic were 329,25 tons of CO2-eq/year and during the pandemic were 69,14 tons of CO2-eq/year while for the UI GreenMetric

calculation before the pandemic was 561,49 tons CO2-eq/year and during a pandemic of 104,8 tons of CO2-eq/year. The primary carbon emissions produced by four-wheeled vehicles using the IPCC method before the pandemic were 296,44 tons of CO2-eq/year and during the pandemic were 66,04 tons of CO2-eq/year while the results of UI GreenMetric calculations before the pandemic were 561,49 tons of CO2-eq/year and during a pandemic of 104.8 tons of CO2-eq/year. Apart from motorbikes and cars, there were campus buses operating during the pre-pandemic period. Campus operational buses themselves produce primary carbon emissions calculated by the IPCC method of 0.,23 tons of CO2-eq/year and for the UI GreenMetric method they produce emissions of 0.,10 tons of CO2-eq/year.

2.1.2 Secondary CO2 Emissions

Calculation of secondary carbon emissions using the IPCC method was carried out using the equation 2.3.

Secondary CO2 Emissions (Tons CO2-eq)
= (Electricity Consumption (KWh) x Emission Factor (Kg/KWh)) / 1000
= (1.861.063 x 0,774) / 1000
= 1.441,19 tons of CO_2-eq/year

Whereas the calculation of secondary carbon emissions using UI GreenMetric method is carried out using the equation 2.8

Secondary CO2 Emissions (Tons CO2-eq)
= (Electricity Consumption (KWh) x 0,84) / 1000
= (1.861.063 x 0.84) / 1000
= 1.563,29 tons of CO_2-eq/year

Based on the calculations above, the results of secondary carbon emissions at Universitas Airlangga before and during the Covid-19 pandemic are in Table 2, Figure 3, and Figure 4

Table 2. Universitas Airlangga Secondary CO2 Emissions Before and During the Covid-19 Pandemic

Unit	Before the Covid-19 Pandemic		During the Covid-19 Pandemic	
	IPCC	UI GreenMetric	IPCC	UI GreenMetric
Universitas Airlangga Hospital	5.078,91	5.509,23	6.395,32	6.937,97
Rectorate Building	1.791,75	1.943,56	911,96	989,34
Faculty of Mediciness	1.621,72	1.759,12	739,48	802,13
Faculty of Economic and Business	1.441,19	1.563,29	479,6	520,23
Institute of Tropical Disease	953,35	1.034,12	1.346,07	1.460,28
Airlangga Convention Center	863,58	936,74	544,75	590,98
Faculty of Pharmacy	815,35	884,43	1.378,49	1.495,46
Faculty of Veterinary Medicine	792,31	859,44	805,47	873,81
Faculty of Social and Political Sciences	765,62	830,49	343,56	372,67
Universitas Airlangga Dental Hospital	718,40	779,27	440,35	477,66

Unit	Before the Covid-19 Pandemic		During the Covid-19 Pandemic	
	IPCC	UI GreenMetric	IPCC	UI GreenMetric
Faculty of Psychology	696,22	755,21	275,81	299,18
Faculty of Science and Technology	675,79	733,05	404,67	439,01
Faculty of Fisheries and Maritime Affairs	631,46	684,96	505,71	548,62
Faculty of Public Health	610,60	662,34	179,38	194,60
Faculty of Dentistry	587,78	637,58	360,29	390,81
Kahuripan Hall	581,71	631,00	625,99	679,1
Airlangga Medical Education Center	556,23	603,36	375,32	407,12
Faculty of Law	524,16	568,57	208,53	226,19
Faculty of Humanity	468,54	508,24	199,33	216,22
Faculty of Nursery	433,17	469,87	317,02	343,92
Nuruzzaman Mosque	426,94	463,11	139,4	151,21
Library	411,93	446,84	196,08	212,69
Former Faculty of Pharmacy	310,76	337,09	129,83	140,83
Postgraduate	305,41	331,29	159,47	172,98
Faculty of Vocational	229,30	248,73	80,01	86,79
Universitas Airlangga Dorm	172,00	186,57	418,47	453,97
Seagrass and Seaweed Research	163,07	176,89	275,7	299,09
Student Center	162,39	176,09	174,69	189,52
Ulul Azmi Mosque	158,59	172,02	97,31	105,56
Universitas Airlangga Press	91,21	98,95	104,36	113,21
Sport Center	74,63	80,95	85,38	92,63
Health Service Center	45,18	49,01	22,14	24,02
Airlangga Corner	45,17	48,99	63,66	69,06
Syariah Tower	0,00	0,00	908,23	985,18
Faculty of Advanced Technology and Multidiscipline	0,00	0,00	679,68	737,35
Total	23.204,42	25.170,40	20.371,51	22.099,39

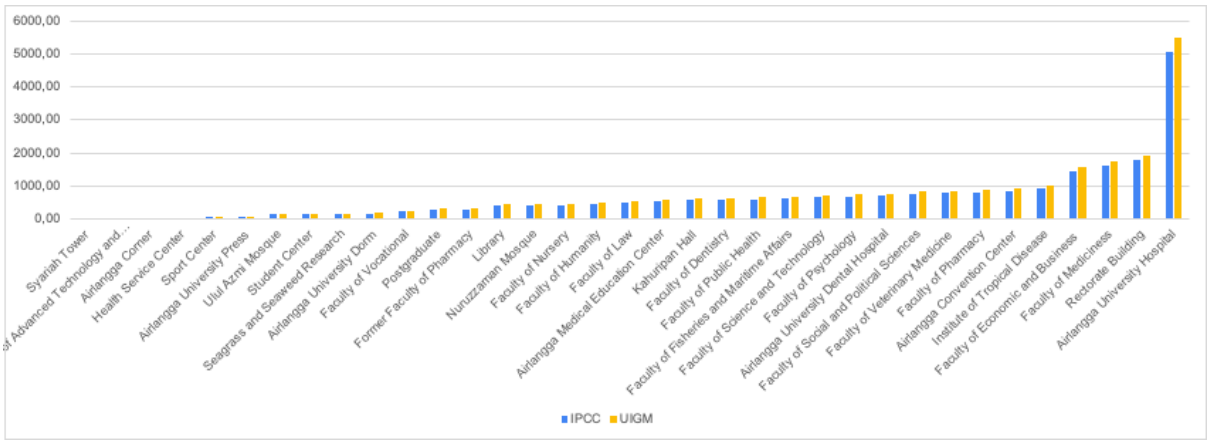


Figure 3. Secondary CO2 Emissions of Universitas Airlangga Before the Covid-19 Pandemic

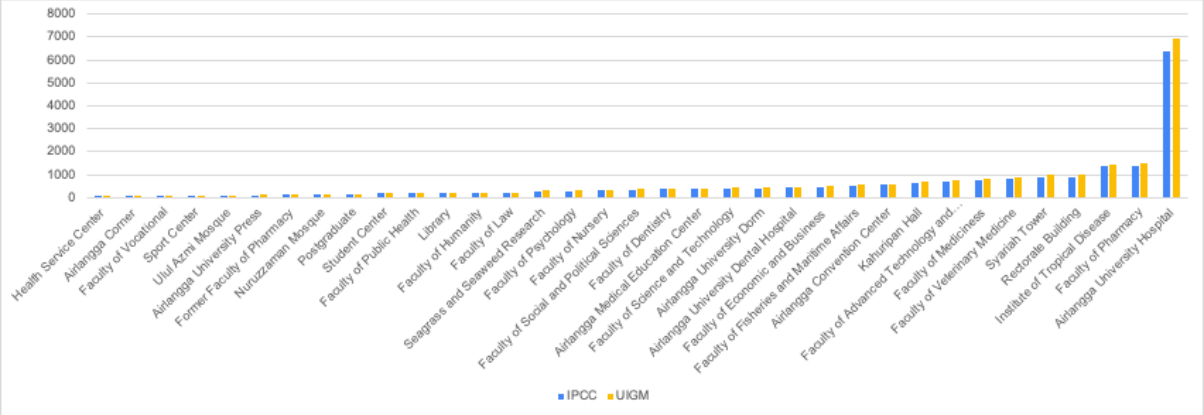


Figure 4. Universitas Airlangga Secondary CO2 Emissions During the Covid-19 Pandemic

Figure 3 and 4 show that the Universitas Airlangga Hospital unit is the largest contributor to secondary carbon emissions. Secondary carbon emissions from the Universitas Airlangga Hospital using the IPCC method before the pandemic was 5.078,91 tons CO2-eq/year and during the pandemic was 6.395,32 tons CO2-eq/year, while for the UI GreenMetric calculation before the pandemic was 5.509,23 tons CO2-eq/year and during the pandemic of 6.937,97 tons of CO2-eq/year. This is because the Universitas Airlangga Hospital consumes the great amount of electricity. So it can be concluded that the higher the electricity consumption, the more CO2 emissions that are produced. The same thing is also found on greenhouse gas emissions at the Faculty of Law of the Islamic University of Indonesia which was conducted by Akli. [5] The highest greenhouse gas emissions were contributed by UII and also came from electricity consumption that resulted a total of 176.931.825 Kg CO2-eq from 227.667 KWh electricity usage. The least contributors to secondary carbon emissions at Universitas Airlangga before the pandemic were the Sharia Building and the Advanced and Multidisciplinary Faculty of Technology because during this time period they were still under construction so that carbon emissions from electricity use had not been recorded, whereas during the pandemic the least contributor to the secondary carbon emissions was the Health Service Center with secondary carbon emissions with the IPCC method of 22,14 tons CO2-eq/year and with the UI GreenMetric method of 24,02 tons CO2-eq/year.

2.1.3 Total CO2 Emissions

Based on the results of the calculation of primary and secondary carbon emissions, the total carbon emissions of the Universitas Airlangga can be determined by adding up the total primary and secondary carbon emissions to the total carbon emissions. The results of calculating total carbon emissions are in Table 3, Figure 5, and Figure 6

Table 3. Total CO2 Emissions of Universitas Airlangga Before and During the Covid-19 Pandemic

Emisi	Before the Covid-19 Pandemic		During the Covid-19 Pandemic	
	IPCC	UI GreenMetric	IPCC	UI GreenMetric
Primary CO_2 Emission	625,92	1.154,96	135,18	222,24
Secondary CO_2 Emission	23.204,42	25.170,4	20.371,51	22.099,39

Total CO_2 Emission	23.830,34	26.325,36	20.506,69	22.321,63

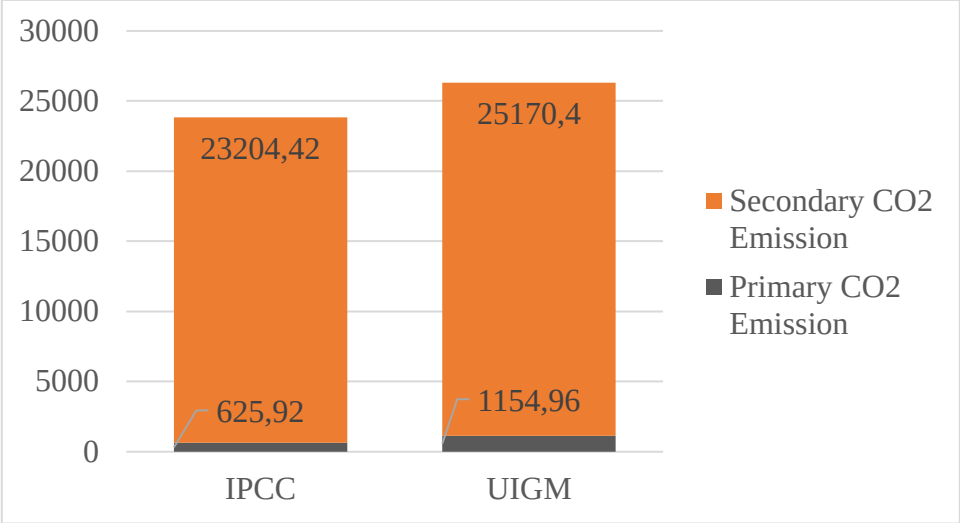


Figure 5. Total CO2 Emissions of Universitas Airlangga Before the Covid-19 Pandemic

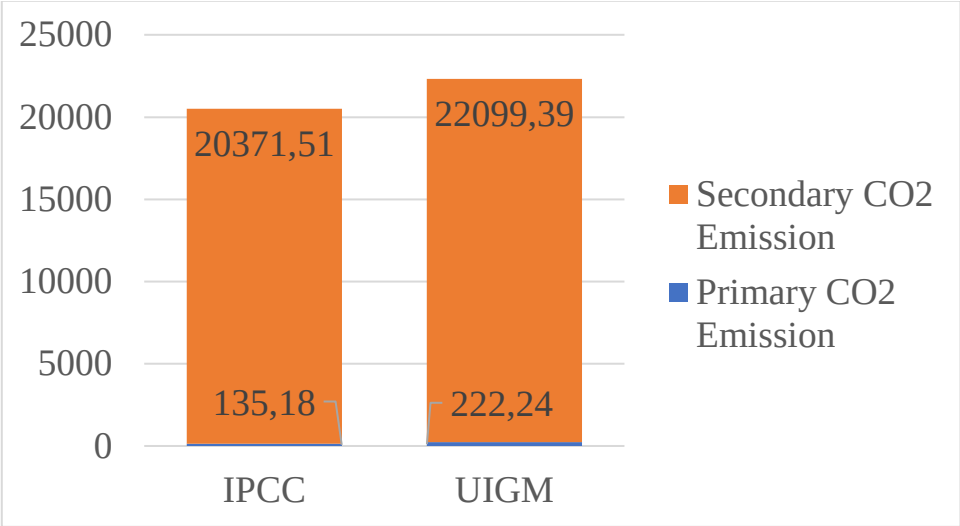


Figure 6. Total CO2 Emissions of Universitas Airlangga During the Covid-19 Pandemic

Figure 5 and 6 show that before the pandemic the total carbon emissions based on the IPCC calculation was 23.830,34 tons of CO2-eq/year of which 625,92 tons of CO2-eq/year came from the primary sector, namely the projection of vehicles entering the campus area and 23.204,42 tons of CO2-eq/year came from the secondary sector, namely the use of electricity in the campus area. Meanwhile, based on the UI GreenMetric method, a total carbon emission of 26.325,36 tons of CO2-eq/year was obtained, of which 1.154,96 tons of CO2-eq/year came from the primary sector and 25.170,4 tons of CO2-eq/year came from the secondary sector. As for the time period during the pandemic, Universitas Airlangga's total carbon emissions based on the IPCC calculation was 20.506,69 tons of CO2-eq/year, of which 135,18 tons of CO2-eq/year came from the primary sector and 20.371,51 tons of CO2-eq/year came from the secondary sector. Meanwhile, based on the UI

GreenMetric method, a total carbon emission of 22.321,63 tons of CO2-eq/year was obtained, of which 222,24 tons of CO2-eq/year came from the primary sector and 22.099,39 tons of CO2-eq/year came from the secondary sector.

Calculations show that the secondary sector which came from electricity plays a large role as a major contributor to carbon emissions at Universitas Airlangga. This is also shown by research on previous carbon footprints by Oja [6] who calculated carbon footprints from campus activities at the Faculty of Engineering, Hasanuddin University. In this study, the largest carbon footprint-producing sector also comes from the secondary sector from the use of electricity in the campus area. The calculation showed that the carbon emissions produced by the sector were 1.315.429,63 kg.CO2/year or equivalent to 1.315,43 tons CO2-eq. Haseeb's research also proves that the secondary sector was the largest producing sector during the Covid-19 pandemic. In research on carbon footprints at the University of Punjab Quaid e Azam, as much as 98% of the total carbon emissions during the pandemic came from the secondary sector of electricity use. Emissions from the secondary sector produce as much as 7.664,06 tons of CO2-eq. [7]

The reduction in carbon emissions was due to the large-scale social restrictions (PSBB) during the Covid-19 pandemic. In accordance with the Letter from the Minister of Education and Culture Number 36962/MPK.A/HK/2020 dated 17 March 2020 concerning, Online Learning and Working from Home in the Context of Preventing the Spread of CoronaVirus Disease (COVID-19), large-scale social restrictions also caused the transition from face-to-face learning to online learning at Universitas Airlangga with the issuance of the Chancellor's Circular Number 736/UN3/HK/2020 concerning Teaching and Learning Activities. Restrictions on activities in the campus have resulted in a decrease in the number of activities in the last two years so that the carbon emissions produced by the activities of the academic community decreased.

2.2. Mapping the Secondary Carbon Footprint

Mapping was carried out on the secondary CO2 emissions from Universitas Airlangga activities before and during the Covid-19 pandemic. Mapping aims to determine the distribution of secondary CO2 emissions. Mapping was carried out using ArcGis software and was carried out on secondary sector emissions because in the primary sector vehicles were observed entering in the campus gate so that each building unit could not be mapped. Calculation of the number of classes, ranges and intervals is done as the first step in the mapping process. Interval calculations in the frequency distribution were carried out for each carbon emission calculation result from the IPCC and UI GreenMetric methods both before and during the Covid-19 pandemic, so that two frequency distribution tables were produced for each IPCC and UI GreenMetric calculation results.

Based on the results of the frequency distribution, 7 classes of secondary carbon emission categories are classified into very low (dark green), low (yellow), rather low (orange), medium (dark orange), rather high (red), high (dark red), and very tall (brown). The range of carbon emission values in each category based on the calculation results of the IPCC method is as follows: 22,14-932,14 tons CO2-eq/year in the very low category; 933,14-1.843,12 tons of CO2-eq/year in the low category; 1.844,14-2.754,14 in the low category; 2.755,14-3.665,14 tons of CO2-eq/year in the rather low category; 3.666,14-4.576,14 tons of CO2-eq/year in the rather high category; 4.577,14-5.487,14 tons of CO2-eq/year in the high category; and 5.488,14-6.398,14 tons of CO2-eq/year in the very high category. While the range of carbon emission values in each category based on the calculation of the UI GreenMetric method are as follows: 24,02-1.012,02 Ton CO2-eq/year in the very low category; 1.012,02-1.999,02 tons

of CO2-eq/year in the low category; 2.000,02-2.987,02 in the low category; 2.988,02-3.975,02 tons of CO2-eq/year in the rather low category; 3.976,02-4.963,02 tons of CO2-eq/year in the rather high category; 4.964,02-5.951,02 tons of CO2-eq/year in the high category; and 5.952,02-6.939,02 tons of CO2-eq/year in the very high category.

The results of secondary carbon footprint mapping of Universitas Airlangga before and during Covid-19 pandemic can be seen in Figure 7-Figure 9:

Before the Covid-19 Pandemic	During the Covid-19 Pandemi
	
(IPCC)	(IPCC)
(UI GreenMetric)	(UI GreenMetric)
	

Figure 7. Secondary Carbon Footprint Mapping of Universitas Airlangga Campus A

Before the Covid-19 Pandemic	During the Covid-19 Pandemi
(IPCC)	(IPCC)
	
(UI GreenMetric)	(UI GreenMetric)
	

Figure 8. Secondary Carbon Footprint Mapping of Universitas Airlangga Campus B

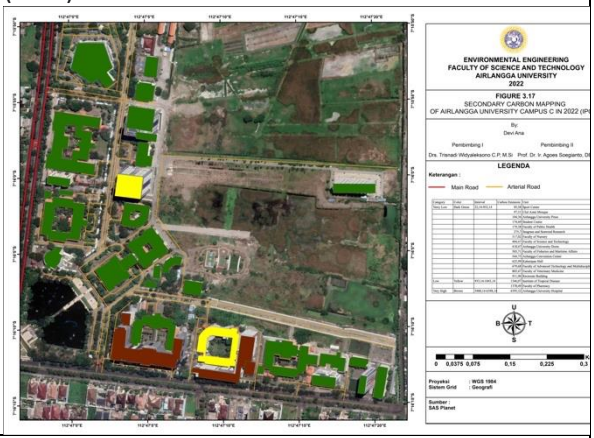
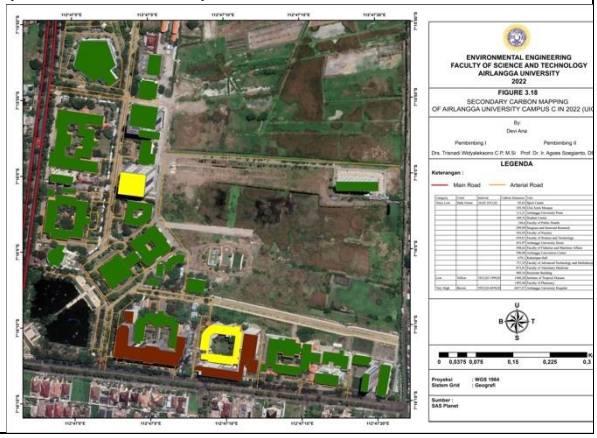
Before the Covid-19 Pandemic	During the Covid-19 Pandemi
(IPCC)	(IPCC)
	
(UI GreenMetric)	(UI GreenMetric)
	

Figure 9. Secondary Carbon Footprint Mapping of Universitas Airlangga Campus C

Figure 7 to Figure 9 shows that secondary carbon footprint mapping using the IPCC and UI GreenMetric methods before the Covid-19 pandemic resulted in three different categories, which are very low, low, and high. There are 28 units categorized as very low (dark green), 4 unit categorized as low (yellow), and 1 unit categorized as high (dark red). Meanwhile, the secondary carbon footprint mapping using the IPCC and UI GreenMetric methods during the Covid-19 pandemic resulted in three different categories, which are very low, low, and very high. There are 32 units categorized as very low (dark green), 2 units categorized as low (yellow), and 1 unit categorized as very high (brown). The highest secondary carbon footprint both before and during the Covid-19 pandemic came from the Universitas Airlangga Hospital.

3. Conclusion

Our results show that in the period before the pandemic that total carbon emissions, based on the IPCC calculation, were 23.830,34 tons of CO_2-eq/year. Meanwhile, based on the UI GreenMetric method, a total carbon emission of 26.325,36 tons of CO_2-eq/year was obtained. As for the time period during the pandemic, Universitas Airlangga's total carbon emissions based on the IPCC calculation method were 20.506,69 tons of CO_2-eq/year. Meanwhile, based on the UI GreenMetric method, a total carbon emission of 22.321,63 tons of CO_2-eq/year was obtained. Secondary carbon footprint mapping was carried out to see the distribution of secondary CO_2 emissions produced by Universitas Airlangga. The secondary

carbon footprint both before and during the Covid-19 pandemic was mostly generated by the Universitas Airlangga Hospital.

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