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The Effects of the Covid-19 Period on Carbon Footprint in Sakarya University Esentepe Campus

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Abstract

Climate change, one of the biggest threat of global life, is continuously triggered by greenhouse gases released into the atmosphere due to human activities. Carbon dioxide (CO_2), one of the most important greenhouse gases, has revealed the concept of carbon footprint, and efforts to take mitigation measures by calculating it have become widespread. With sustainable campus studies, universities, where science and innovations are created, lead other institutions by creating the necessary database for measuring and managing greenhouse gas (GHG) emissions and calculating the corporate carbon footprint. This study calculated and compared the carbon footprints of Sakarya University Esentepe Campus for 2019 and 2020 when distance education was carried out during the Covid-19 pandemic. Greenhouse gas emissions resulting from activities on campus were calculated and converted to a CO_2 equivalent. GHG emission factors and the Tier-1 method of the Intergovernmental Panel on Climate Change (IPCC) were used in the calculations. As a result,the carbon footprint was 13273.38 tCO_2e in 2019 and 6338.72 tCO_2e in 2020. It was determined that the largest share of carbon emissions was due to the use of electrical energy. The results obtained for both years were compared, and a 47.7% reduction in total emissions was evaluated. In the light of current studies on carbon emission reduction, suggestions and measures need to be taken are summarized in this research.

Keywords: Carbon footprint, greenhouse gas emission, pandemic, Sakarya University, Esentepe Campus, Turkey.

1. INTRODUCTION

The world is faced with the threats posed by climate change arising from global warming. The gases that cause the Earth to warm are compounds that create a greenhouse effect in the atmosphere and have the property of retaining heat. When the effects of greenhouse gases on the worldare examined, it is very important to keep them at a certain level. Eighteen greenhouse gases with different global warming potentials cause climate change. Six greenhouse gases are calculated for the Carbon Footprint. The six greenhouse gases considered for carbon footprint calculation are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbon (HFC), perfluorocarbon (PFC), and sulfur hexafluoride (SF_6) [1]. In general, the amount of these

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greenhouse gases from human activities is calculated by converting them to equivalent carbon dioxide measurements [2].

The carbon footprint is the carbon dioxide equivalent (CO_2-e) of greenhouse gases emitted into the atmosphere due to the director indirect activities of an individual, organization, product, sector, city or even country. The carbon footprint is the measure of the share of individuals or institutions have in global warming. CO_2 emission, the most important greenhouse gas affecting global warming, is primarily caused by heating, transportation, electricity consumption, etc. Corporate or individual carbon footprint resulting from CO_2, CH_4, and N_2O gas emissions are evaluated under three scopes specified by the ISO 14040:2006 standard and theGreenhouse Gas Protocol determined by the IPCC. Emissions from directly burned fuelsare defined as primary, energy release is defined as secondary and emissions from outsourced services defined as tertiary-indirect carbon footprint [3].

The carbon footprint of human, which increases with various activities, is getting smaller as these activities decrease. The best indicator of this has been the decrease that occurred during the Covid19 pandemic period. COVID-19 was declared as global pandemic by the World HealthOrganization on March 11, 2020. Due to the pandemic, face-to-face education could notbe continued in schools, and it was decided to conduct distance and online education.On March 16, 2020, formal education was suspended at universities in Turkey, anddistance on-line education was started. This situation, which is experienced for thefirst time in both the world and education history, has reduced the carbon footprint caused by human activity on university campuses as an institution.

Many studies have been conducted on the measurement, monitoring and evaluation of corporate carbon footprint, especially on university campuses as large-public institution. Aroonsrimorakot et al. carried out the "Carbon Footprint of Mahidol University, Salaya Campus, Thailand, Faculty of Environmental and Resource Studies" in 2013 [4]. Sawant and Babaleshwar published the study titled A New Evaluation and Equation Method on Carbon Footprint, Sir Parshurambhau College, India in 2015 [5]. The study titled the carbon footprint of the University of theUnited Kingdom during the Covid-19,published by Filimonau et al., in 2020 showed that 2020 carbon footprint decreased by 29% during the quarantine when compared to that of 2019 [6]. The study conducted by Devandran and Dewika, which is titled "Sunway University's carbon footprint on electricity consumptionduring Covid-19" showed that the total carbon footprint decreased by 25% in 2020, and electricity consumption constituted thelargest share [7]. According to the 2020 Afe Babalola University report by Samuel S. et al., the carbon footprint was 15335.01 tCO_2, and 99.3% of the emissions are caused by electricity use in that campus [8].The study of "Sri Ramakrishna Engineering College carbon footprint in Coimbatore, India," published by Rahul et al. in 2020, determined that 27.89% of the annual total emissions are caused by electricity consumption [9]. Gökçek et al. Reported that the highest individual carbon footprint among nine faculties in the campus of Niğde Ömer Halisdemir University belongsto the students in the Faculty of Medicine (433 kgCO_2 /year) [10]. Iskandar et al. calculated the total emission of Trisakti University in Indonesia to be 999.5 tCO_2e/month in 2018 and determined that the largest share was transportation with 84.47% [11].

This study calculated and evaluated Sakarya University Esentepe Campus's institutional carbon footprint for 2019 and 2020 which is the pandemic period. With the announcement of the pandemic in Turkey on March 11, 2020, formal education was suspended, and distance education started. Most university staff worked remotely, except those who remained on campus for security andmaintenance purposes. By comparing the values of the two years in question, the difference and the reduction in emissions were determined, and new suggestions werepresented in the light of what has been doneuntil now to reduce carbon footprint of university campus.

2. METHOD

The related studies on monitoring, verification and reporting of greenhouse gas emissions are carried out based on ISO 14064-1 standard. The University Campus carbon footprint data included in Scope-1, Scope-2 and Scope-3 were calculated by using the Tier-1 method (2006 IPCC guidelines). The Tier 1 method is based on an estimate of the quantities of fuel combusted and average emission factors. The IPCC Global Warming Potential (GWP) was used to convert greenhouse gases to CO_2 equivalents (Table 1) [12].

Table 1 Global warming potential values relative to CO_2 [12]

CO_2	1
CH_4	28
N_2O	265

The university's total electrical energy consumption, natural gas consumption used for heating purposes, emissions from vehicles used by staff and students, emissions from wastewater, solid waste, and paper waste were considered while determining the carbon footprint. Additionally, according to the total population and area of the campus, the intensity of carbon emissions per capita andsquare meter was calculated.

2.1. Campus Area

The Esentepe Campus of Sakarya University is located in the east of the Marmara Region, between 40° 44′ 32.45" North latitudes and 30°19′ 55.12" East longitudes, and is 216 m above sea level. The main campus is 834444 m^2, and in this total, its closed physical area is 231780 m^2, consisting of educational, research, social, and administrative areas. There were 51533students and 2141 staff in 2019, and 52060 students and 2133 staff in 2020 [13].

2.2. Data

All data were obtained from Sakarya administrative units for 2019 and 2020. The distance between the university and the citycenter has been considered in determining the transportation emission values. In 2019 and 2020, 260 days were accepted as the education period for both years. Relevant emission factors and activity data specified in Tables 2 and 3 were used to calculate the campus's footprint.

Table 2 Emission factors for conversion

GHG Emissions Sources	**Emission Factors**	**Unit/Gases**
Bus, diesel	2.743243243	Kg/mile CO_2 [14]
Bus, diesel	0.0051	g/mile CH_4 [14]
Bus, diesel	0.0048	g/mile N_2O [14]
Minibus, diesel	0.62654321	Kg/mile CO_2 [14]
Minibus, diesel	0.001	g/mile CH_4 [14]
Minibus, diesel	0.0015	g/mile N_2O [14]
Passenger car, gasoline	0.391555556	Kg/mile CO_2 [14]
Passenger car, gasoline	0.0147	g/mile CH_4 [14]
Passenger car, gasoline	0.0079	g/mile N_2O [14]
Natural gas	1.88496	Kg/m^3 CO_2 [15]
Natural gas	0.000168	Kg/m^3 CH_4 [15]
Natural gas	0.00000336	Kg/m^3 N_2O [15]
Wastewater	0.3	(Kg/liter) CH_4 [16]
Wastewater	0.005	(Kg N_2O-N)N_2O [16]
Water supply	0.0014	Kg CO_2e/l [17]
Electricity	0.856	KgCO_2e/kWh [17]
Solid waste	0.021	Kg CO_2e/Kg [17]
Paper	0.928	Kg CO_2e/Kg [17]

Three scopes of direct and indirect greenhouse gas emissions were applied in the study. These are as follows: [18]

Scope 1: Direct emissions: On-campus fixed fuel supply (use of natural gas for heating and cooling)

Scope 2: Indirect emissions: Purchased electricity

Scope 3: Other indirect emissions: Student and employee transportation, wastewater, water supply, solid waste, and paper used

The different units are converted in the calculation as follows:

1 mile = 1.609344 km, $1m^3$= 1000 liters,
1g= 0.001kg, 1 ton = 1000 kg.

Table 3 Inventories and Activity data

Inventories	**Activity Data**	
	2019	**2020**
Campus area, m^2	834444	834444
Number of students	51533	52060
Number of employees	2141	2133
Distance of student and employee commuting,(Km)	7.1	7.1
Number of passenger cars (Student, employees, visitor)(Daily)	3204	1600
Number of buses (Daily)	232	75
Number of minibuses (Daily)	288	134
Natural gas used for heatingand cooling, m^3	1263360	174331
Amount of wastewater, liter	5397000	4458250
Amount of water supply, m^3	64769.9	17833
Amount of used electricity,Kwh	9042432	5653027
Amount of solid waste, (t)	1400	278
Paper usage, Kg	600000	8500

3. RESULTS

In 2019, the emission amount was determined as 2389.1 tons/year tCO_2e for the Scope 1, 7740.32 tons/year tCO_2e for the Scope 2 and 3143.96 tons/year tCO_2e for the Scope 3. In 2020, it was determined as 329.6 tons/year tCO_2e for the Scope 1 and 4838.9 tons/year tCO_2e for the Scope 2 and 1170.22 tons/year tCO_2e for the Scope 3 (Table 4)

Table 4 GHG emissions sources in tCO_2e

Scopes	**Directand Indirect Emissions**	**Emissions 2019 (tCO_2e)**	**Emissions 2020 (tCO_2e)**	**Difference between 2019 and 2020**	**Difference %**
Scope 1	Direct emissions from natural gas usage,	2389.1	329.6	2059.5	86
Scope 2	Indirect emissions from purchased electricity	7740.32	4838.9	2901.42	37
Scope 3	Otherindirect emissions	3143.96	1170.22	1973.74	62
	Studentand employee commuting	2349.73	1038.01	1311.72	55
	Water supply	94.87	25.04	69.83	73
	Wastewater	113.16	93.46	19.7	17
	Used paper	556.8	7.88	548.92	98
	Solid waste	29.4	5.83	23.57	80

In the Esentepe Campus, the total carbon footprint emission was 13273.38 tons, in 2019 and 6338.72 tons in 2020. In a study carried out in 2015, 12330.73 tons of CO_2e greenhouse gas emissions were reported [19].

When 2019 and 2020 are compared in terms greenhouse gas emissions, in 2020, the Scope 1 emissions decreased by 86%, the Scope 2 emissions by 37%, and the Scope 3 emissions by 62%. The total annual emission reduction rate was 47.7% (Table 4). These reduction rates are also seen in thegraph in Figure 1.

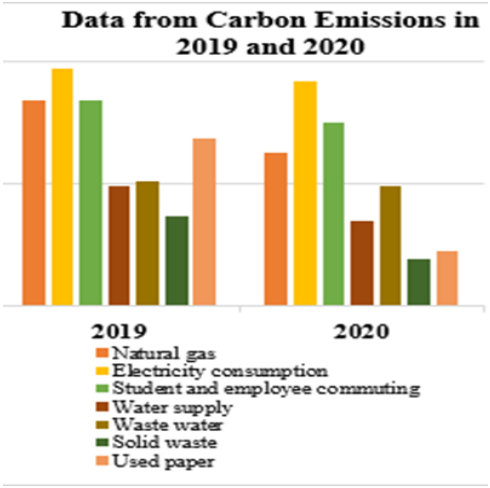

Figure 1 GHG emissions from major sources in tCO_2e

The source that created the most emissions in 2019 was electricity with 58.31%, followed by natural gas with 18%. Solid waste caused the least carbon emission (Figure 2).

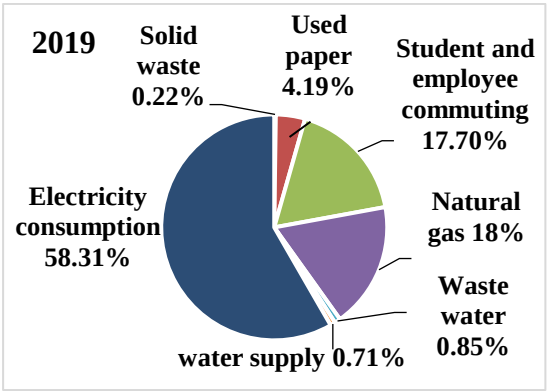

Figure 2 Contribution of major sources for the campus GHG emissions in percentage for 2019

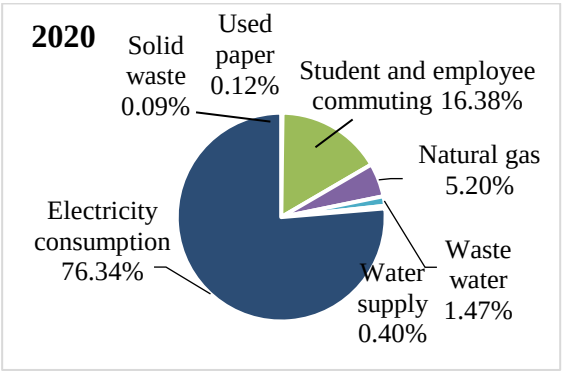

Figure 3 Contribution of major sources for the esentepe campus GHG emissions in percentage for 2020

The source that created the most emissions in 2020 was electricity with 76.34%, followed by transportation with 16.38%.Paper caused the least carbon emission among other emission sources. Detailed emission source percentages are shown in Figure 3.

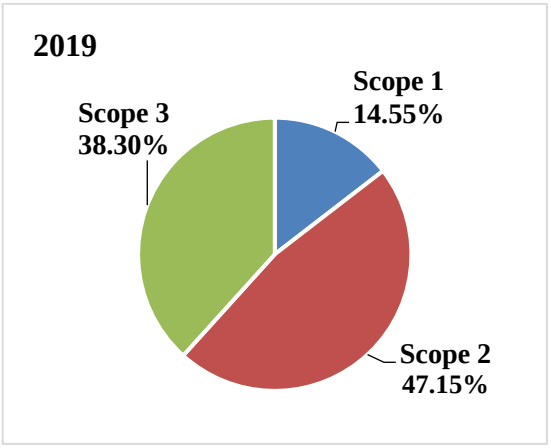

Figure 4 Breakdown of GHG emissionsby scopes in percentage

In terms of emission scopes, the Scope 2 created the highest carbon emission with 47.15% in 2019, followed by the Scope 3 with 38.30%. The scope 1 created the least carbon emission with 14.55% (Figure 4).

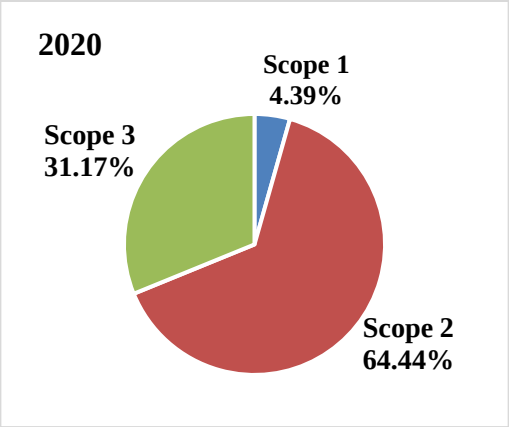

Figure 5 Breakdown of GHG emissions by scopes in percentage

Emission coverage percentages for 2020 are shown in Figure 5. In terms of emission scopes, Scope 2 created the highest carbon emission at 64.44%, followed by Scope 3 at 31.17%. Scope 1 created the least carbon emission at 4.39%.

The ratio of carbon emissions per square meter and per capita within the Esentepe Campus to the total amount of tCO_2e is given in Table 5.

Table 5 Intensity of carbon emissions

Intensity Metrics	2019	2020
Floor Area	834444	834444
Tons CO_2e/m^2	0.016	0.0076
Populations	53.674	54.193
Ton CO_2e/per person	0.25	0.12

In terms of intensity of carbon emissions, the emissions per square meter and per capita for 2019 are 0,016tCO_2e and 0.251tCO_2e, respectively and for 2020 are 0.0076 tCO_2e and 0.12 tCO_2e. Carbon emissions per capita decreased by approximately 50%.

4. CONCLUSION AND SUGGESTIONS

Since different scope criteria and emission factors have been used in the calculations of the total carbon footprint, a homogeneous comparison cannot be made between studies. Therefore, all campus footprint studies are evaluated on average. The carbon footprint the Esentepe Campus had a similar value to those of other university campuses. For example, while the carbon footprint of Trisakti University in Indonesia was 11994 tCO2e in 2018, the carbon footprint of Sakarya University in 2019 is 13273.38 tCO2e.

Other studies have observed a general decrease in total carbon emissions during the pandemic. A similar decrease in emissions also occurred at Sakarya University's Esentepe campus. The numberof staff and students on campus and the activities were minimal during the pandemic. For example, the carbon footprint, which decreased by 47.7% in Sakarya University, decreased by 29% in the United Kingdom University.

Additionally, when the study results are compared with different studies conducted in the same period, it is seen that electricityuse has the most important share, as in all studies. The reduction in electricity emissions between 2019 and 2020 was found to be 37%. When the reduction rates in other scopes are compared, the reduction of electricity emissions is low. The 37% reduction is a better result than a 25% reduction at Sunway University in terms of carbon footprint. Therefore, renewable energies should be used for basic needssuch as cooling and lighting. Some faculty building currently use an exemplary small-scale photovoltaic solar energy system and wind energy to meet their energy needs. These applications should be developed. Efficent use of energy also carries the use of LED bulbs and sensor lamps in lighting save approximately 50% of the electrical energy consumed for lighting. Additionally, in all buildings to be constructed and renovations, it should be attented that the design of buildings should be in a way that they benefit from natural daylight forenergy savings.

The 86% decrease in natural gas emissions during the pandemic shows that the carbon

footprint shrinks when fossil fuels are not used, suggesting that it is necessary to use and popularize alternative energies instead of fossil fuels for heating.

The 73% decrease in the amount of water used during the pandemic indicates that in case the technical measures on water saving are increased, it is possible to achieve this necessary decrease during normal education periods. The comprehensive water-saving program is implemented on total area of Sakarya University. New technics and new types of equipment (e.g. Photocell Faucet) are used for efficent waste water management in campus buildings [20].

There was a serious reduction in waste emissions by 80% during the pandemic.This decrease reveals that emission due to waste can be decreased though waste reduction efforts, especially recycling during normal education. According to zerowaste planning, university is supported recycling glass, plastic, metal, battery and electronic waste.

Constructing roads and parking lots thatwill reduce vehicle entry into the campus and encouraging the use of publictransportation and bicycle will significantly reduce emissions.

One of the best and most beneficial ways to prevent carbon emissions is afforestation. Green spaces must be expanded to achieve the goal of a carbon-neutral campus.

Awareness is one of the biggest steps in reducing carbon footprint. Organizing training and seminars to increase students, employees, and managers' awareness of carbon footprint and emission reduction and encouraging individuals to reduce their carbon footprints will be essential for this purpose.

Calculating corporate carbon footprints and planning and implementing designs and measures for their reduction within the framework of these results will be an essential step in reducing the carbon footprint locally and nationally.

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Authors' Contribution
The authors contributed equally to the study.

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No conflict of interest or common interest has been declared by the authors

The Declaration of Ethics Committee Approval
This study does not require ethics committee permission or any special permission.

The Declaration of Research and Publication Ethics
The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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