Environment and Ecology Research 12(1): 40-53, 2024 http://www.hrpub.org
DOI: 10.13189/eer.2024.120105

Predictions and Policies on Carbon Footprint Release Data at the College of Vocational Studies, IPB University (SV IPB) Based on the Contribution of Campus Operational Activities

Aceng Hidayat[1,*], Rina Martini[2], Anita Ristianingrum[3], Wahyu Budi Priatna[4], Purana Indrawan[5], Doni Sahat Tua Manalu[3], Edi Wiraguna[6], Helianthi Dewi[7], Sari Putri Dewi[8], Agief Julio Pratama[9], Beata Ratnawati[10], Rachel Gavrila Hardian Putri[10], Irfan Manaf[10], Nur Balqis[10], Muhamad Hilmi Hanafi[10], Keyren Johana Ginting[10], Annisa Rizkialita[10], Raffael Yohanes Beckham Darma[10], Muhammad Danang Mukti Darmawan[11], Ridwan Siskandar[11]

[1]Department of Resource and Environmental Economics, Faculty of Economics and Management, IPB University, Indonesia
[2]Management of Food Service and Nutrition, College of Vocational Studies, IPB University, Indonesia
[3]Agribusiness Management Study Program, College of Vocational Studies, IPB University, Indonesia
[4]Department of Agribusiness, Economic and Management Faculty, IPB University, Indonesia
[5]Industrial Management Study Program, College of Vocational Studies, IPB University, Indonesia
[6]Technology and Management of Plantation Production, College of Vocational Studies, IPB University, Indonesia
[7]Department of Ecotourism, College of Vocational Studies, IPB University, Indonesia
[8]Livestock Management and Technology Study Program, College of Vocational Studies, IPB University, Indonesia
[9]Production Technology and Development of Agricultural Communities, College of Vocational Studies, IPB University, Indonesia
[10]Environmental Engineering and Management Study Program, College of Vocational Studies, IPB University, Indonesia
[11]Computer Engineering Technology Study Program, College of Vocational Studies, IPB University, Indonesia

Received November 14, 2023; Revised January 18, 2024; Accepted January 26, 2024

Cite This Paper in the Following Citation Styles

(a): *[1] Aceng Hidayat, Rina Martini, Anita Ristianingrum, Wahyu Budi Priatna, Purana Indrawan, Doni Sahat Tua Manalu, Edi Wiraguna, Helianthi Dewi, Sari Putri Dewi, Agief Julio Pratama, Beata Ratnawati, Rachel Gavrila Hardian Putri, Irfan Manaf, Nur Balqis, Muhamad Hilmi Hanafi, Keyren Johana Ginting, Annisa Rizkialita, Raffael Yohanes Beckham Darma, Muhammad Danang Mukti Darmawan, Ridwan Siskandar , "Predictions and Policies on Carbon Footprint Release Data at the College of Vocational Studies, IPB University (SV IPB) Based on the Contribution of Campus Operational Activities," Environment and Ecology Research, Vol. 12, No. 1, pp. 40 - 53, 2024. DOI: 10.13189/eer.2024.120105.*

(b): *Aceng Hidayat, Rina Martini, Anita Ristianingrum, Wahyu Budi Priatna, Purana Indrawan, Doni Sahat Tua Manalu, Edi Wiraguna, Helianthi Dewi, Sari Putri Dewi, Agief Julio Pratama, Beata Ratnawati, Rachel Gavrila Hardian Putri, Irfan Manaf, Nur Balqis, Muhamad Hilmi Hanafi, Keyren Johana Ginting, Annisa Rizkialita, Raffael Yohanes Beckham Darma, Muhammad Danang Mukti Darmawan, Ridwan Siskandar (2024). Predictions and Policies on Carbon Footprint Release Data at the College of Vocational Studies, IPB University (SV IPB) Based on the Contribution of Campus Operational Activities. Environment and Ecology Research, 12(1), 40 - 53. DOI: 10.13189/eer.2024.120105.*

Abstract Carbon footprint predictions have been used as indicators to help determine policy on the effects of contributions from the College of Vocational Studies at IPB University (SV IPB). The goal of this project is to lower emissions in the SV IPB environment by analyzing data on carbon footprint releases from campus activities. The objective is to project the distribution of the carbon footprint associated with each scope: scope 1 includes emissions from transportation and LPG purchases, scope 2 includes emissions from PLN electricity consumption, and scope 3 includes emissions from the use of PDAM and food (snacks and rice papers). The International Panel on

Climate Change's approach is used to calculate third-scope carbon footprints. The activities on the SV IPB campus have a carbon footprint of 369.8143 TonCO_2e. Of this, scope 1 contributes 6.917 TonCO_2e (LPG: 6.84 TonCO_2e and transportation: 0.0774 TonCO_2e), scope 2 makes up 362,584 TonCO_2e, and scope 3 makes up 0.550 TonCO_2e (PDAM: 0.22 TonCO_2e; snacks box: 0.138 TonCO_2e; rice box: 0.193 TonCO_2e). Minimizing the carbon footprint of SV IPB activities is carried out by implementing leadership policies regarding increasing the habit of turning off computers when they are not in use/have finished using them, turning off the AC and lights when they are not in use/have finished using them; as well as continuing to strive for online and hybrid-based learning processes/seminars/meetings in certain periods; changing transportation activities for leaders to walking; carrying out effectiveness in Study Program meeting activities; and reforestation by planting trees and ornamental plants that can help absorb CO_2. New behavior and efficiency must continue to be implemented and improved so that it becomes an effort to reduce the carbon footprint produced by the SV IPB Campus.

Keywords Carbon Footprint, College of Vocational Studies (SV IPB), Emission, Policies, Scope Activity

1. Introduction

Research related to carbon footprint studies is being hotly studied by researchers, especially studies of policy analysis due to the impact of the emissions produced [1]–[42].

Climate change that occurs continuously is a threat to the survival of all creatures on earth. It is human responsibility to repair any environmental damage in order to restore natural balance. Humans had little influence on the climate until they began to live sedentary lives and settle down. This has an impact on increasing the amount of carbon in the atmosphere from year to year. For example, the combustion process of the fuel used will continue to release CO_2 and result in an increase in the amount of carbon concentration in the atmosphere. This excessive concentration affects the increase in the temperature of the earth's surface which continues to rise due to heat from solar radiation trapped by the earth's mantle. This mechanism is called the greenhouse gas effect. Without the effects of greenhouse gases, the average temperature in the world could be -18 ℃. Unfortunately, because there are now too many greenhouse gases in the atmosphere, it captures too much heat. As a result, the Earth is getting hotter [43]–[48].

An indicator of an activity's environmental impact is its carbon footprint. The emission value produced increases with the number of actions performed [23], [31]. This indicates that there is a connection between atmospheric air quality and activity. The carbon footprint is a key indicator of the Greenhouse Gas Protocol (GHG Protocol) emissions that cause global warming. One of the first actions an institution may do to lessen global warming is to evaluate the direct and indirect GHG Protocol emissions resulting from its operations [22], [25].

The energy consumption of liquefied petroleum gas (LPG), power, telephone, internet, regional drinking water companies (PDAM), and heaps of trash accounts for the carbon footprint of the SV IPB campus as estimated by GHG Protocol emissions. Gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), CF4 and C2F6, hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF6) are anticipated to be released into the atmosphere and have an impact on carbon levels. This is expected given that SV IPB is developing and becoming more independent every year, as well as the fact that changes in infrastructure, natural resources, and human resources lead to SV IPB lifestyle modifications that raise carbon emissions in the SV IPB environment. If this is not addressed, SV IPB will negatively impact the global warming issue that is now receiving a lot of attention.

This study focuses on variables that are hypothesized to affect carbon emission disclosure in the SV IPB setting. Corporate governance is one of the elements expected to impact carbon emissions disclosure, according to [2], [12], [38], in order to satisfy the objectives of SV IPB and the expectations of IPB stakeholders, it is critical for SV IPB to have strong SV IPB governance and stringent oversight, as evidenced by the sustainability report's accountability and disclosure procedure.

According to [49], stakeholders play a number of roles, including: 1) preventing policies that "fail" because decision-makers are unaware of the information and interests of important stakeholders; 2) bringing together numerous parties involved on a global scale; 3) serving as a crucial component in problem solving; 4) enhancing organizational performance; 5) supporting public organizations in accomplishing their objectives; and 6) making a significant contribution to value creation through their influence on functions or activities in the management strategy. The second component is the agency's size, which may be determined by total assets and is equivalent to the size of an educational service. As a result, SV IPB contributes to carbon emissions.

Referring to the problem above, the researchers conducted research entitled "Predictions and Policies on Carbon Footprint Release Data at the College of Vocational Studies, IPB University (SV IPB) Based on the Contribution of Campus Operational Activities". The carbon footprint study at SV IPB was carried out in two scopes, namely scope 1 was emissions resulting from SV IPB operations (LPG, PDAM, food (snacks and rice boxes), and transportation); and scope 2 was emissions from electricity consumption from the State Power Plant (PLN).

Based on national GHG Protocol inventories, the

International Panel on Climate Change (IPCC) approach is used to quantify carbon footprint emissions from these three sectors. CO_2, CH_4, and N_2O emissions are computed and represented in TonCO_2. The GHG Protocol includes long-lived greenhouse gases such as CO_2, CH_4, and N_2O, which contribute to climate change in the SV IPB ecosystem. The aim of this research is to conduct a carbon footprint study and determine policies from the results of the study as a manifestation of IPB University's commitment to mapping the sources of GHG Protocol emissions that occur in the IPB University campus environment, especially SV IPB which can be the basis for efforts to reduce GHG Protocol in the future as part of SV IPB's contribution to the national GHG Protocol emission reduction target.

2. Research Methods

The research location for secondary data collection was carried out at the SV IPB campus, Jl. Cilibende number 14, Bogor, West Java. The time for data collection until data analysis is carried out is January - November 2023.

2.1. Activity Data Collection

Table 1. Activity Data, Carbon Footprint

Scope of Activity	Data Emission	Categories
Activity 1	Stationary Energy	1. Working unit gas (LPG)
	Transportation	2. Leader's operational car
Activity 2	PLN electricity consumption	1. SV IPB Building Electricity
		2. Wisma SV IPB Building Electricity
Activity 3	PDAM	1. PDAM
	Trash Heap	1. Meeting snacks
		2. Boxed rice

The data used is secondary data. The total carbon footprint analyzed consists of (i) scope 1: use of LPG gas and transportation activities by operational vehicles; (ii) scope 2: PLN electricity use activities, (iii) scope 3: use of PDAM, meeting snacks, and rice boxes. Secondary data in the research was obtained from archives or existing data at SV IPB. This secondary data was specifically obtained through the finance section of SV IPB. The data used is the period January-September 2023. The calculation does not include emissions from other IPB campus locations. More clearly, emission categories and activity data are shown in Table 1.

2.2. Carbon Footprint Calculation

Data quality is an important factor in the calculations of this study. The assumptions used in calculating carbon emissions are shown in Table 2.

Table 2. Assumptions for Estimating Emissions from Each Scope of Activity

No	Types of Assumptions	Assumption
1	Use of LPG	4.0797 mmBTU/month
2	Use of PDAM	972.62 m^3/month
3	Eat snacks at meetings	0.11 kgCO_2e/box
4	Consume rice boxes	0.15 kgCO_2e/box
5	Transportation	12.3 liter: 0 - 1000 cc: 20 km/liter 1000 – 2000 cc: 17 km/liter 2000 – up cc: 11 km/liter
6	Use of PLN electricity	39.769 TonCO_2e/month (SV IPB Building) 0,517 TonCO_2e/month (Wisma SV IPB Building)

The International Panel on Climate Change's techniques are used to compute the carbon footprints for the three scopes (IPCC). CO_2, CH_4, and N_2O emissions are computed and represented in TonCO_2. Table 3 displays the approach used to determine the GHG Protocol emissions from the SV IPB Campus's carbon footprint.

Table 3. Methodology for Calculating Carbon Footprint Emissions for the SV IPB Campus

Scope of Activity	Data Emission	Categories
Lingkup 1	LPG [13], [39]	Emission GHG = GHG $CO_2 + CH_4 + N_2O$, where FE CO_2 = 69.3 Ton/TJ; FE CH_4 = 0.033 Ton/TJ; FE N_2O = 0.0032 Ton/TJ
	PDAM [18], [19]	Emission $CH4 = \left[\sum_{i,j} . U_{i.} T_{IJ} . EF_J\right] (TOW - S) - R$ where, CH_4 emissions = CH_4 emissions in a year, kg CH_4/year I = Population income group j = Each type of waste processing Ui = Fraction of population in income group i in the inventory year Ti,j = Degree of utilization of the waste processing system, j, for each type of waste entering I in a year EFj = Emission factor, kg CH_4/kg BOD (0.3 kg CH_4/kg BOD) TOW = Total organic load in a year, kg BOD/year S = Organic components wasted as sludge in a year, Kg BOD/year R = Amount of CH_4 recovered in a year, kg CH_4/year
	Meeting snacks [30], [33]	Emisi $CH_4 = \Sigma ((M_i \times EF_i) * 10^{-3}) – R)$
	Boxed rice [28], [36]	Emisi $CH_4 = \Sigma ((M_i \times EF_i) * 10^{-3})$
	Transportation [21], [26]	GHG emissions = Amount of fuel consumed x FE where, FE CO_2 = 69.3 Ton/TJ; FE CH_4 = 0.033 Ton/TJ; FE N_2O = 0.0032 Ton/TJ
Lingkup 2	PLN electricity [3], [5]	GHG emissions = Electricity consumption (MWh) x FE electricity ($TonCO_2e$/MWh) Where, FE = 0.877 $TonCO_2e$/MWh

Table 4. Average Emission Factor Calculation Results

Month	Expenditure Costs (Rp)	Gas Use (mmBTU)	Energy Consumption (TJ)	Emissions			GHG			GHG Total ($TonCO_2e$)
				CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	
Jan	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Feb	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Mar	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Apr	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
May	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Jun	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Jul	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Aug	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76
Sep	215,000.00-	4.0797	0.0039	0.2215	0.0197	0.0004	0.2215	0.4146	0.1224	0.76

3. Results and Discussion

3.1. Scope 1

Scope 1 is carbon footprint emissions originating from SV IPB's operational use activities (use of LPG gas and leadership car transportation activities). Usage data for the two activities was obtained from secondary data/payment data during the January-September 2023 period.

3.1.1. LPG Gas

The total amount of CO_2 emissions from LPG gas is the result of calculating CO_2 emissions obtained through the use of LPG gas at SV IPB. Before calculating the carbon footprint during this period, the emission factor from the use of LPG gas each month is first calculated. The results of calculating the average emission factor for the period January - September 2023 are shown in Table 4.

Table 4 explains that the costs for using LGP gas every month are the same (Rp. 215,000.00-). Thus, the use of LPG gas and energy consumption can be calculated, namely 4.0797 mmBTU and 0.0039 TJ. From this data, the value of the GHG CO_2, CH_4 and N_2O emission factors for the period January - September 2023 can be seen, namely 0.2215 $TonCO_2e$; 0.4146 $TonCO_2e$; 0.1224 $TonCO_2e$.

According to Figure 1, the overall carbon footprint associated with gas usage activities during this time was 6.84 $TonCO_2e$, whereas the monthly carbon footprint associated with LPG gas consumption at SV IPB was 0.76 $TonCO_2e$. This is because the LPG gas supply and its consumption have been planned since SV IPB's users essentially already know their monthly demands. Figure 1 illustrates the whole monthly carbon footprint of LPG gas in more detail.

3.1.2. Transportation

The total amount of CO_2 emissions from operational car activities was calculated during the period January - September 2023. The vehicle in question is the leader's car. In this period, the total operational fuel consumption used in the SV IPB environment was 12.3 liters/month.

There are 3 types of cars used, namely 1000 - 1500 cc cars, 1500 - 2000 cc cars, and 2000 - up cc cars. The total energy consumption from transportation activities for each type of cc car is shown in Figure 2.

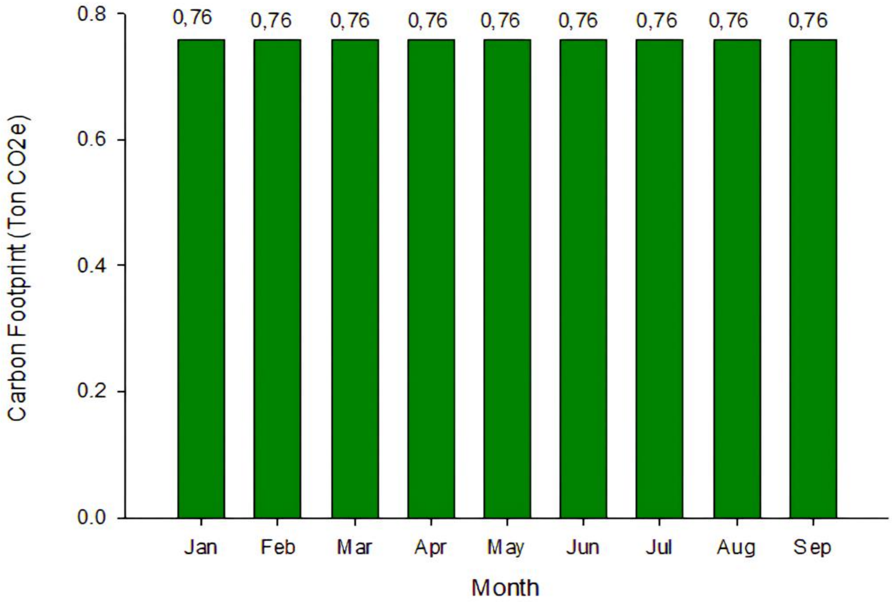

Figure 1. Total Carbon Footprint of LPG Gas Every Month

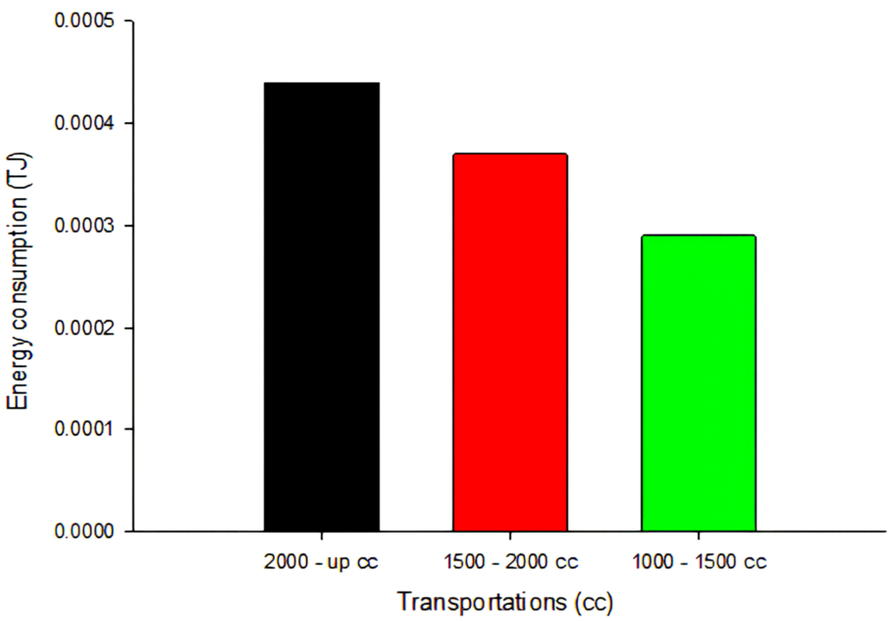

Figure 2. Energy Consumption Based on cc Type of Transportation

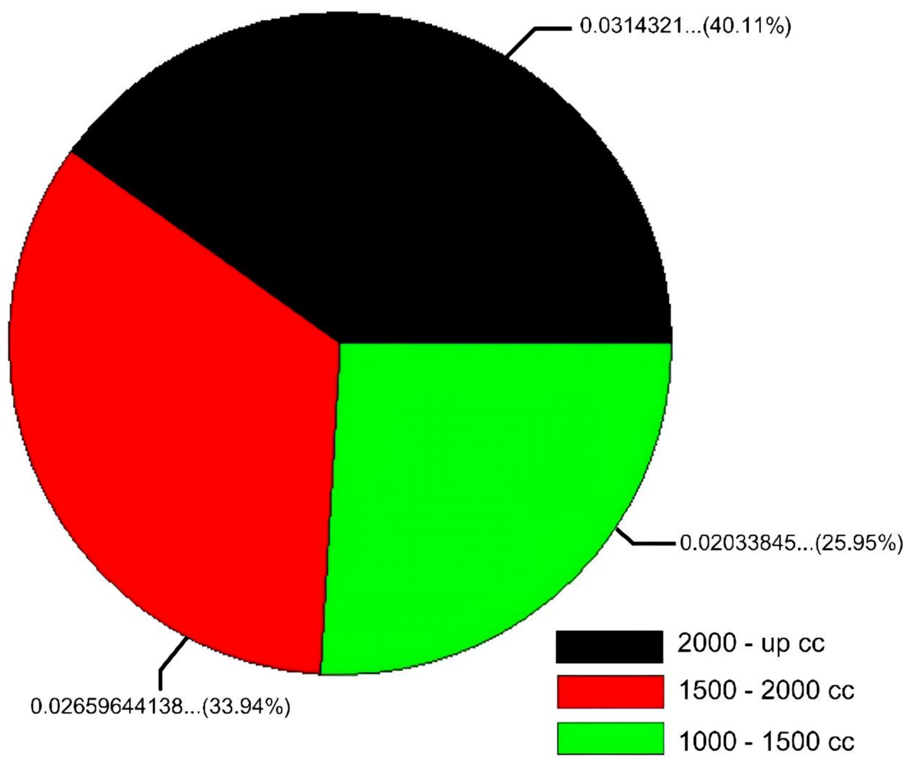

Figure 3. GHG Potential generated by cc type of transportation

Figure 3 explains that the distributed energy (fuel) consumption produced by the 3rd type of leader's operational car is 0.00044 TJ. The fuel consumption produced by the 2nd and 1st car types is 0.00037 TJ and 0.00029 TJ respectively. The engine capacity of the 1st type of car is 1000 - 1500 cc, the 2nd type of car is 1500 - 2000 cc, and the 2000 cc - up type of car. The results show that the vehicle engine capacity used affects fuel consumption. The larger the engine capacity, the greater the fuel required by the vehicle, so the emissions produced are greater.

The efficiency of fuel use, in this case, is a big problem for the threat of global warming. This is in accordance with the results shown in Figure 3 that the 3rd type of car contributes the largest GHG emissions compared to other types of car, namely 0.0314 TonCO_2e or 40.11%. The 1st and 2nd types of cars respectively contribute GHG emissions of 0.02 TonCO_2e or 25.95%, and 0.026 TonCO_2e or 33.94% to the environment at SV IPB.

3.2. Scope 2

Scope 2 is carbon footprint emissions originating from PLN electricity usage activities. Secondary data in this research was obtained from existing electricity usage data at SV IPB during the period January - September 2023. Emission calculations were carried out from PLN electricity usage in the College of Vocational Studies (SV) Building and the Guest House Building. More clearly, data on PLN electricity usage in each building during this period is shown in Table 5.

Table 5. Data on PLN Electricity usage for The Period January-September 2023 in The SV Building and SV Guest house

Building		kVa	mWh/Building								
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
SV	CA	105	0.2318	0.2111	0.3786	0.3764	0.2555	0.4095	0.2691	0.2223	0.5136
	CB	131	0.2892	0.2634	0.4724	0.4697	0.3187	0.5108	0.3357	0.2774	0.6408
	CC	164	0.3621	0.3298	0.5914	0.5880	0.3990	0.6395	0.4203	0.3473	0.8022
	Delta	197	0.4349	0.3961	0.7104	0.7063	0.4793	0.7682	0.5048	0.4172	0.9636
	K70	6600	14.5718	13.2716	23.7990	23.6623	16.0574	25.7372	16.9130	13.9757	32.2845
	Integrated	6600	14.5718	13.2716	23.7990	23.6623	16.0574	25.7372	16.9130	13.9757	32.2845
	TI	1040	2.2962	2.0913	3.7502	3.7286	2.5303	4.0556	2.6651	2.2022	5.0873
Guest House	Guest House	6600	0.5899	0.5899	0.5899	0.5899	0.5899	0.5899	0.5899	0.5899	0.5899

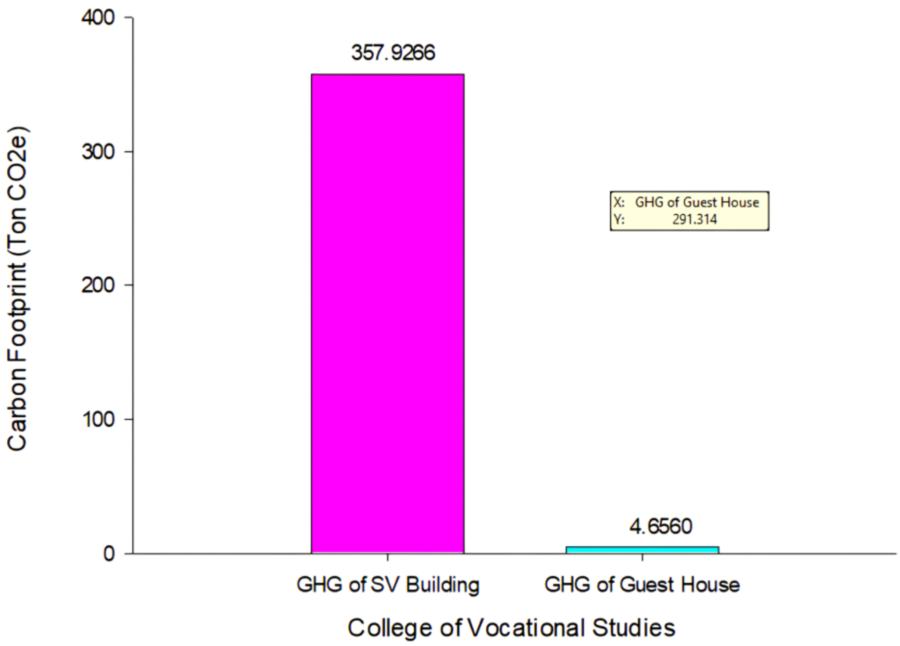

Figure 4. Total Emissions SV and Guest House

Table 5 explains that electricity usage in the SV building is much greater than in the Guest House building. This is because there are learning activities carried out every Monday to Saturday.

Actually, Sundays are often when student events take place. This is not the same as using the Guest House building, which is restricted to specific uses. Based on these activities, it is evident that the SV IPB electricity usage during the period of January to September 2023 produced a total carbon footprint emission value of 362.583 TonCO_2e, of which 357.927 TonCO_2e came from buildings in SV and 4.656 TonCO_2e from buildings Guest House. This is derived from the 413.4352 mWh of electricity used at SV IPB at that time, of which 408.1261 mWh were produced by using the SV Building and 5.3091 mWh were produced by using the Guest House Building. More clearly, the total emissions of the SV Building and Guest House are shown in Figure 4.

Clear details of the use of carbon footprint emissions from each SV building and Guest House are shown in Figure 5. Figure 5 explains that the average GHG CO_2 obtained by each building is different because each building has different electrical power and electricity usage.

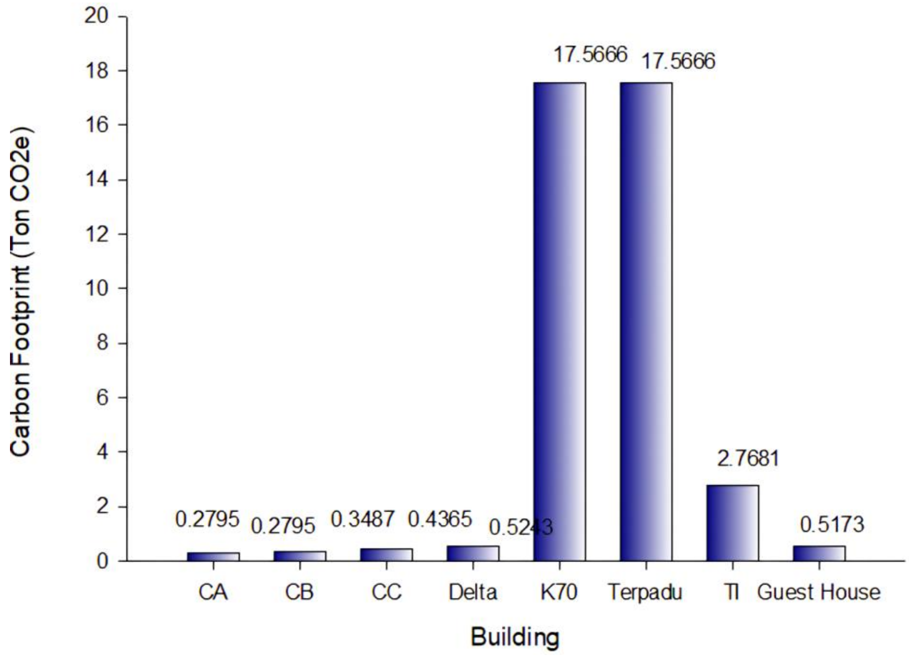

Figure 5. Details of Emissions usage per Building at SV IPB

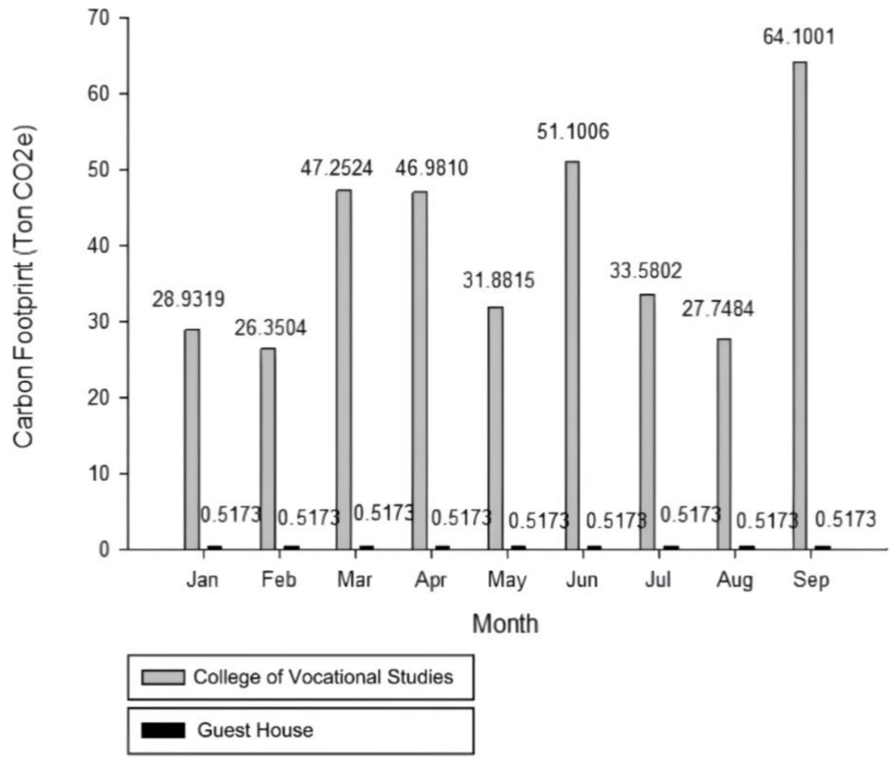

Figure 6. Electricity usage per Building per Month between January-September 2023

The K70 building and the integrated building have the largest electrical power, each at 6600 kVa. Then the CA building has the smallest electrical power, namely 105 kVa. This electrical power affects GHG CO_2. The greater the power used, the greater the GHG CO_2 produced. Based on this statement, the K70 building and the integrated building produce GHG CO_2 of 17.5666 TonCO_2e. Meanwhile, the CA building only produces GHG CO_2 of 0.2795 TonCO_2e.

The amount of GHG CO_2 is influenced by electricity consumption, the more electricity used, the greater the GHG CO_2 produced. The largest GHG CO_2 SV IPB is produced by the K70 building and the integrated building because in the K70 Building computer use and teaching and learning activities take place in large quantities every week, while the integrated building is dominated by the electricity use of lecturers' activities while in their respective work rooms. The CA building produces the smallest GHG CO_2 due to relatively less use of computers and teaching and learning activities.

Electricity usage per building per month during the January-September 2023 period is shown in Figure 6. The largest electricity usage was in September due to the increase in students (elevation from diploma 3 to diploma 4) which had an impact on increasing hours of teaching and learning activities and also increasing campus facilities, which of course requires more electricity.

3.3. Scope 3

Scope 3 is carbon footprint emissions originating from SV IPB's operational use activities (use of PDAM, meeting snacks and rice boxes). Usage data for the five activities was obtained from secondary data/payment data during the January-September 2023 period.

3.3.1. PDAM

Emissions calculated from the contribution of PDAM use are emissions originating from domestic liquid waste resulting from PDAM use. The assumption is that PDAM water that becomes domestic waste is 80% of the total water discharge used. More clearly, PDAM water is used during the period January - September 2023 is shown in Table 6.

The calculation of CH_4 emissions is based on the number of PDAM consumers served according to the liquid waste processing system. The system used at SV IPB includes a septic tank with an anaerobic process. Based on secondary data obtained from the civil service and academic departments, the total number of the SV IPB community is 2459 consisting of students, lecturers and staff. Assuming that the average SV IPB community still does not have its own income, it can be categorized as Urban Low Income. Thus, the total value of organic load in the period January - September 2023 is 3688.50 kg BOD/year.

Sludge production calculations to calculate the weight of organic components wasted in the septic tank in one month, assuming 1.2 Kg/person/month, the weight value of the organic components wasted in the septic tank during that period is 2950.8 Kg BOD/person/period. So the CH_4 emission value at SV IPB in the January-September 2023 period was obtained at 10.53 kg/month. The resulting emission value is influenced by the number of SV IPB residents, population income group, type of waste processing, type of incoming waste, emission factor, total organic material load, and the amount of CH_4 recovered by SV IPB. Thus, the total carbon footprint resulting from PDAM usage activities during this period is 0.22 TonCO_2e.

Table 6. Data on PDAM water and domestic waste for the period January - September 2023

Mount	Total Use (Rp)	Volume (m^3)	Domestic Waste (m^3)
Jan	3,214,800.00	1148.14	918.51
Feb	3,214,900.00	1148.18	918.54
Mar	3,248,700.00	1160.25	928.20
Apr	2,583,800.00	922.79	738.23
May	2,777,000.00	991.79	793.43
Jun	2,858,000.00	1020.71	816.57
Jul	2,588,000.00	924.29	739.43
Aug	2,547,500.00	909.82	727.86
Sep	1,477,400.00	527.64	422.11

3.3.2. Meeting Snacks and Rice Boxes

The total mass amount of consumption expenditure (meeting snacks and rice boxes) during the period January – September 2023 is shown in Table 7, while the total GHG from consumption expenditure is shown in Table 8. This calculation was carried out with the assumption that waste processing uses composting techniques.

Table 7 explains the meeting activities carried out by lecturers and staff to support campus activities which of course definitely produce waste. The waste in question is waste that comes from rice boxes and snack boxes ordered during meetings. Table 7 shows that the largest mass quantity of waste comes from rice box waste with a value of 1.0978 tons/year, while the mass quantity of waste from snack boxes is 0.777 tons/year.

Table 7. Total Mass of Meeting Activity Waste

No	Waste Category	User	Number of People	Assumed Consumption/Person (gr)	Mass Quantity of Waste (Tons)
1	Snackbox	Lecture	159	250	0.4770
2		Employee	100	250	0.3000
3	Ricebox	Lecture	159	350	0.6678
4		Employee	100	350	0.4200

Table 8. Total GHG from Consumption Expenditures

No	Waste Category	User	Emision CH_4	Emision N_2O	GHG CH_4 (Ton CO_2e)	GHG N_2O (Ton CO_2e)	Total GHG (Ton CO_2e)/year
1	Snackbox	Lecture	0.0019	0.0001	0.0401	0.0444	0.084
2		Employee	0.0012	0.0001	0.0252	0.0279	0.053
3	Ricebox	Lecture	0.0027	0.0002	0.0561	0.0621	0.118
4		Employee	0.0017	0.0001	0.0353	0.0391	0.074
Total							0.330

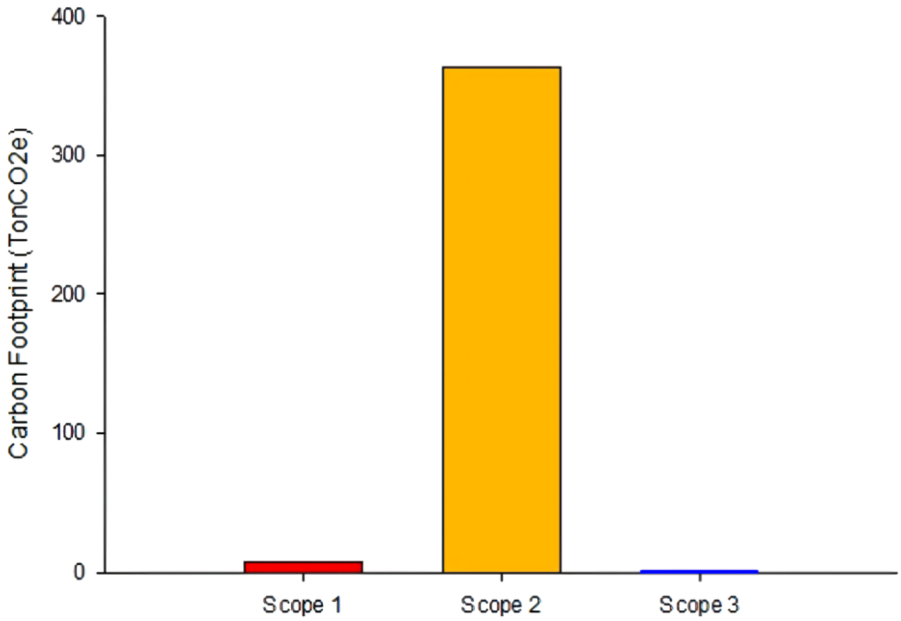

Figure 7. Total carbon footprint of the SV IPB campus based on scope

Table 8 explains the total value of carbon emissions from the two types of consumption calculated (meet snacks and rice boxes). This waste produces carbon emissions which will have an impact on the environment. Based on the calculation results, using the CH_4 emission factor value (g CH_4/kg) of 4 and the N_2O emission factor (g N_2O/kg) of 0.3, it was found that the largest waste emissions came from ricebox waste with a value of 0.193 $TonCO_{2e}q$/year while emissions from snack box of 0.138 $TonCO_2eq$/year. The total emissions from rice box and snack box waste are 0.330 $TonCO_2eq$/year.

3.4. Total Carbon Footprint of SV IPB and Policy Efforts

The results of the analysis of the total carbon footprint from scope 1, scope 2 and scope 3. Scope 1 during the January - September period is 6.917 $TonCO_2e$, 362.584 $TonCO_2e$, and 0.550 $TonCO_2e$ which are shown in Figure 7.

Figure 7 shows that the largest carbon footprint is produced from activities in scope 2, namely PLN electricity usage activities. Based on Figure 7, in general the carbon footprint produced from secondary data during the period January – September 2023 without realizing it is necessary to carry out various efficiencies which have an impact on reducing the carbon footprint on the SV IPB Campus, especially in scope 2 (the largest carbon footprint contribution). New habits, especially efficiency behavior, must continue to be implemented and improved so that they become an everyday culture. In an effort to reduce the carbon footprint produced by scope 2, the leadership of SV IPB can implement policies for users and employees related to scope 2 to further improve the culture and habit of turning off computers when they are not in use/have finished using them, turning off the AC and lights when they are not in use/ have completed use, installing energy-efficient lighting, and using renewable energy sources to generate the required electricity, as well as continuing to strive for online and hybrid-based learning processes/seminars/meetings in certain periods.

Furthermore, from scope 1, the policy effort that SV leaders can take is to change transportation activities for leaders to walking. This is because the SV campus area only reaches 11.2 Ha, so the distance between buildings can still be reached on foot. From the activity of consuming meeting snacks and rice boxes, SV leaders can provide policy efforts to the Study Program to make it effective in Study Program meeting activities. If this is not done, it is likely that in the following month, the activity of consuming meeting snacks and rice boxes will increase further.

In general, the leadership's policy of reforestation by planting trees and ornamental plants that can help absorb CO_2 can also be used as another policy. This is necessary, because the development of the SV IPB Campus which is becoming more advanced and independent every year, both infrastructure, natural resources and human resources, has resulted in changes in the SV IPB lifestyle which has an impact on increasing carbon emissions in the SV IPB environment. If this is left alone, then SV IPB will make a negative contribution to the issue of global warming which is currently being widely paid attention to. Through efficiency efforts and policies, it is hoped that this can contribute to maintaining global climate stability.

It should be noted that mapping interest groups that have an impact on the policy formulation process forms the roles of the actors who influence policy design regarding carbon footprint release data at the College of Vocational Studies, IPB University (SV IPB) based on the contribution of campus operational activities. Based on the contribution of campus operational activities, stakeholders identified in the development of policies regarding carbon footprint release data at the College of Vocational Studies, IPB University (SV IPB) are categorized as follows: (1) Primary stakeholders, or those who will be directly impacted by the policy's effects, both positive and negative; (2) Key stakeholders, or those who legally have authority, or who have significant influence and interest in the policy-making process and (3) Supporting stakeholders (secondary stakeholders), are stakeholders who act as intermediaries in the policy implementation process or parties who have no direct connection but are concerned about this policy decision. To identify stakeholders and their interests, and expert opinions, Focus Group Discussions (FGD) are used [49].

As a matter of fact, the COVID-19 lockdown strategy has contributed to a decrease in atmospheric greenhouse gas emissions. From an alternative perspective, societal or human limitations, which are a primary cause of environmental deterioration, have blessed and protected other living things on our planet. Due to the lockdown, which significantly reduced human movement and numerous everyday activities, good environmental signs, such as auro restoration, have emerged. Based on the findings of observations, it is at least thought that this has helped to improve air quality and lower greenhouse gas emissions in the atmosphere, even if it is still too early to draw any conclusions [50].

Thus, a broader policy analysis perspective needs to be considered in this case, especially in studying the design principles of policy formulation which can provide insight into collaborative approaches to create climate neutralization and resilience [51]–[53].

Obviously, it's important to consider the discussions around original mitigating techniques. A sustainable environment is defined by a number of criteria, including preserving life support systems, sustaining and enhancing ecosystem integrity, preserving and expanding biotic diversity, and creating and implementing rehabilitation plans for severely damaged ecosystems. Establishing and putting into practice preventive and adaptive energy-related methods to combat the threat of global environmental change is another concept that emphasizes sustainability. As a result, the following recommendations are given to start reducing sustainability: The utilization of renewable resources must not surpass standards; (2) the production of waste must not surpass the ability of the environment to absorb it (sustainable waste management); and (3) the exhaustion of non-renewable resources must require the creation of comparable renewable alternatives [54].

4. Conclusions

The results of research on projections and policies regarding carbon footprint release data at SV IPB based on the contribution of campus operational activities show that the total carbon footprint from SV IPB campus activities from January to September 2023 is 369.8143 $TonCO_2e$. This is calculated in three ways: (i) Scope 1 produces a carbon footprint of 6.917 $TonCO_2e$, which is spread out between LPG usage activities of 6.84 $TonCO_2e$ and transportation of 0.0774 $TonCO_2e$; (ii) Scope 2 produces a carbon footprint of 362,583 $TonCO_2e$ due to the use of PLN electricity, and (iii) Scope 3 contributed 0.550 $TonCO_2e$ (PDAM: 0.22 $TonCO_2e$; snacks box: 0.138 $TonCO_2e$; rice box: 0.193 $TonCO_2e$).

Campus operational data indicates that the activity that most contributes to the SV IPB campus's carbon footprint emission statistics is the use of PLN electricity. Leadership guidelines about the habit of shutting off computers, air conditioners, and lights when not in use or finished can be implemented to lessen this. It is also important to keep up with seminars, meetings, and online and hybrid learning procedures at certain periods. A policy is required to carry out reforestation by planting trees and ornamental plants that can help absorb CO_2. Other policies, related to the implementation of new habits, can be shifted to walking, to carry out effectiveness in Study Program meeting activities, and, in general, regarding changes in the SV IPB lifestyle caused by the development of the SV IPB campus, which is becoming more advanced and independent every year, both in infrastructure, natural resources, and human resources. As a tangible way for SV IPB to contribute to the decline in national GHG emissions, new behaviors and efficiency must continue to be adopted and enhanced so that it becomes an endeavor to lessen the carbon footprint generated by the SV IPB Campus.

From additional information (carbon footprint release data contributed to campus operational activities), policy implications that can be drawn to date include a shift in the good habits displayed by staff, instructors, and students regarding the carbon footprint resulting from the use of PLN electricity and the presence of strong communication links improved communication about the policy of implementing new habits of transport efficiency behavior for SV leaders who have switched to walking with lecturers, staff, and students; efficient use of vehicle fuel and energy as a result of the ongoing adoption of online/hybrid learning activities.

This research is part of a major stage of SV IPB's research road map towards a green campus. Currently the research is at the stage of focusing on secondary data sources (carbon footprint release data contributing to campus operational activities). This is certainly not enough to be claimed as an SV process towards a green campus. SV IPB's current advice is to continue conducting research in order to carry out the sustainable stages. This includes predicting carbon release data derived from primary data, conducting alternative and innovative studies using a variety of methods to obtain accurate information regarding carbon footprint release data at SV IPB, analyzing various policies for making decisions regarding carbon mitigation, and analyzing current perspectives and relevance regarding the analyses to be carried out. Consequently, it is envisaged that this would broaden the research path towards green IPB SV and boost its legitimacy.

Acknowledgements

This research was funded by the 2023 Dean's Assignment Research Grant at the College of Vocational Studies, IPB University, with assignment letter number 19972/IT3. S3/RT.01.00/M/B/2023 dated October 12, 2023

REFERENCES

[1] A. R. Yuliani, M. M. Sari, and I. W. K. Suryawan, “Carbon Footprint Assessment of LPG Gas Usage in Small Industries: A Case Study of Sami Laris Swalayan Shopping Center,” *J. Earth Mar. Technol.*, vol. 3, no. 2, pp. 98–103, 2023, doi: 10.31284/j.jemt.2023.v3i2.4509.

[2] C. C. Chang, Y. T. Liao, and Y. W. Chang, “Life cycle assessment of carbon footprint in public transportation - A case study of bus route no. 2 in Tainan City, Taiwan,” *Procedia Manuf.*, vol. 30, no. 2018, pp. 388–395, 2019, doi: 10.1016/j.promfg.2019.02.054.

[3] D. L. Setyowati, P. Hardati, T. Marhaeni, P. Astuti, and M. Amin, “Energy Consumption, Emission Absorption and Carbon Emission Reduction on Semarang State University Campus,” *Int. J. Energy Environ. Eng. 13(7), 505-509.*, vol. 13, no. 7, pp. 505–509, 2019.

[4] V. T. Le and A. Pitts, “A survey on electrical appliance use and energy consumption in Vietnamese households: Case study of Tuy Hoa city,” *Energy Build.*, vol. 197, pp. 229–241, 2019, doi: 10.1016/j.enbuild.2019.05.051.

[5] H. Liu, X. Wang, J. Yang, X. Zhou, and Y. Liu, “The ecological footprint evaluation of low carbon campuses based on life cycle assessment: A case study of Tianjin, China,” *J. Clean. Prod.*, vol. 144, pp. 266–278, 2017, doi: 10.1016/j.jclepro.2017.01.017.

[6] G. Pinto, M. S. Piscitelli, J. R. Vázquez-Canteli, Z. Nagy, and A. Capozzoli, “Coordinated energy management for a cluster of buildings through deep reinforcement learning,” *Energy*, vol. 229, 2021, doi: 10.1016/j.energy.2021.120725.

[7] X. Li, C. Zhang, T. Zhao, and Z. Han, “Adaptive predictive control method for improving control stability of air-conditioning terminal in public buildings,” *Energy Build.*, vol. 249, p. 111261, 2021, doi: 10.1016/j.enbuild.2021.111261.

[8] I. Araújo, L. J. R. Nunes, and A. Curado, “Preliminary Approach for the Development of Sustainable University Campuses: A Case Study Based on the Mitigation of Greenhouse Gas Emissions,” *Sustain.*, vol. 15, no. 6, 2023, doi: 10.3390/su15065518.

[9] Q. Xu, K. Hu, X. Wang, D. Wang, and M. T. Knudsen, “Carbon footprint and primary energy demand of organic tea in China using a life cycle assessment approach,” *J. Clean. Prod.*, vol. 233, pp. 782–792, 2019, doi: 10.1016/j.jclepro.2019.06.136.

[10] L. T. Doulos, A. Kontadakis, E. N. Madias, M. Sinou, and A. Tsangrassoulis, “Minimizing energy consumption for artificial lighting in a typical classroom of a Hellenic public school aiming for near Zero Energy Building using LED DC luminaires and daylight harvesting systems,” *Energy Build.*, vol. 194, pp. 201–217, 2019, doi: 10.1016/j.enbuild.2019.04.033.

[11] J. Liu, X. Chen, S. Cao, and H. Yang, “Overview on hybrid solar photovoltaic-electrical energy storage technologies for power supply to buildings,” *Energy Convers. Manag.*, vol. 187, no. February, pp. 103–121, 2019, doi: 10.1016/j.enconman.2019.02.080.

[12] B. Ridhosari and A. Rahman, “Carbon footprint assessment at Universitas Pertamina from the scope of electricity, transportation, and waste generation: Toward a green campus and promotion of environmental sustainability,” *J. Clean. Prod.*, vol. 246, 2020, doi: 10.1016/j.jclepro.2019.119172.

[13] A. Quintili and B. Castellani, “The energy and carbon footprint of an urban waste collection fleet: A case study in central Italy,” *Recycling*, vol. 5, no. 4, pp. 1–18, 2020, doi: 10.3390/recycling5040025.

[14] D. A. Ahmad and G. A. Kristanto, “Estimation of household greenhouse gas emissions from different activities in Bintang Alam, Karawang Regency, Indonesia,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 724, no. 1, 2021, doi: 10.1088/1755-1315/724/1/012062.

[15] S. Chen, Y. Tan, and Z. Liu, “Direct and embodied

energy-water-carbon nexus at an inter-regional scale," *Appl. Energy*, vol. 251, no. May, p. 113401, 2019, doi: 10.1016/j.apenergy.2019.113401.

[16] K. H. Chen *et al.*, "The application of footprints for assessing the sustainability of wastewater treatment plants: A review," *J. Clean. Prod.*, vol. 277, p. 124053, 2020, doi: 10.1016/j.jclepro.2020.124053.

[17] P. Zawartka, D. Burchart-Korol, and A. Blaut, "Model of Carbon Footprint Assessment for the Life Cycle of the System of Wastewater Collection, Transport and Treatment," *Sci. Rep.*, vol. 10, no. 1, pp. 1–21, 2020, doi: 10.1038/s41598-020-62798-y.

[18] X. Shi, X. Liao, and Y. Li, "Quantification of fresh water consumption and scarcity footprints of hydrogen from water electrolysis: A methodology framework," *Renew. Energy*, vol. 154, pp. 786–796, 2020, doi: 10.1016/j.renene.2020.03.026.

[19] Y. Sandang and S. Cole, "Using a human rights approach to improve hotels' water use and sustainability," *J. Sustain. Tour.*, vol. 31, no. 10, pp. 2337–2355, 2022, doi: 10.1080/09669582.2022.2108041.

[20] N. C. Onat and M. Kucukvar, "Carbon footprint of construction industry: A global review and supply chain analysis," *Renew. Sustain. Energy Rev.*, vol. 124, no. January, p. 109783, 2020, doi: 10.1016/j.rser.2020.109783.

[21] P. Zhao *et al.*, "China's transportation sector carbon dioxide emissions efficiency and its influencing factors based on the EBM DEA model with undesirable outputs and spatial Durbin model," *Energy*, vol. 238, p. 121934, 2022, doi: 10.1016/j.energy.2021.121934.

[22] J. Hu, R. Wood, A. Tukker, H. Boonman, and B. de Boer, "Global transport emissions in the Swedish carbon footprint," *J. Clean. Prod.*, vol. 226, pp. 210–220, 2019, doi: 10.1016/j.jclepro.2019.03.263.

[23] L. Huang, Q. Liao, J. Yan, Y. Liang, and H. Zhang, "Carbon footprint of oil products pipeline transportation," *Sci. Total Environ.*, vol. 783, p. 146906, 2021, doi: 10.1016/j.scitotenv.2021.146906.

[24] J. Liu, S. Wang, N. Wei, X. Chen, H. Xie, and J. Wang, "Natural gas consumption forecasting: A discussion on forecasting history and future challenges," *J. Nat. Gas Sci. Eng.*, vol. 90, no. March, p. 103930, 2021, doi: 10.1016/j.jngse.2021.103930.

[25] J. Liu, S. Li, and Q. Ji, "Regional differences and driving factors analysis of carbon emission intensity from transport sector in China," *Energy*, vol. 224, p. 120178, 2021, doi: 10.1016/j.energy.2021.120178.

[26] Q. Lv, H. Liu, D. Yang, and H. Liu, "Effects of urbanization on freight transport carbon emissions in China: Common characteristics and regional disparity," *J. Clean. Prod.*, vol. 211, pp. 481–489, 2019, doi: 10.1016/j.jclepro.2018.11.182.

[27] G. P. Peters, "Carbon footprints and embodied carbon at multiple scales," *Curr. Opin. Environ. Sustain.*, vol. 2, no. 4, pp. 245–250, 2010, doi: 10.1016/j.cosust.2010.05.004.

[28] A. Scipioni, A. Manzardo, A. Mazzi, and M. Mastrobuono, "Monitoring the carbon footprint of products: A methodological proposal," *J. Clean. Prod.*, vol. 36, pp. 94–101, 2012, doi: 10.1016/j.jclepro.2012.04.021.

[29] S. González-García, R. González-García, L. González Vázquez, M. T. Moreira, and R. Leis, "Tracking the environmental footprints of institutional restaurant service in nursery schools," *Sci. Total Environ.*, vol. 728, p. 138939, 2020, doi: 10.1016/j.scitotenv.2020.138939.

[30] M. Lombardi, E. Laiola, C. Tricase, and R. Rana, "Assessing the urban carbon footprint: An overview," *Environ. Impact Assess. Rev.*, vol. 66, no. June, pp. 43–52, 2017, doi: 10.1016/j.eiar.2017.06.005.

[31] A. Ciurzyńska, W. Marczak, A. Lenart, and M. Janowicz, "Production of innovative freeze-dried vegetable snack with hydrocolloids in terms of technological process and carbon footprint calculation," *Food Hydrocoll.*, vol. 108, no. May, 2020, doi: 10.1016/j.foodhyd.2020.105993.

[32] X. Esteve-Llorens, C. Darriba, M. T. Moreira, G. Feijoo, and S. González-García, "Towards an environmentally sustainable and healthy Atlantic dietary pattern: Life cycle carbon footprint and nutritional quality," *Sci. Total Environ.*, vol. 646, pp. 704–715, 2019, doi: 10.1016/j.scitotenv.2018.07.264.

[33] A. E. Fenner *et al.*, "The carbon footprint of buildings: A review of methodologies and applications," *Renew. Sustain. Energy Rev.*, vol. 94, no. March, pp. 1142–1152, 2018, doi: 10.1016/j.rser.2018.07.012.

[34] R. Aichele and G. Felbermayr, "Kyoto and the carbon footprint of nations," *J. Environ. Econ. Manage.*, vol. 63, no. 3, pp. 336–354, 2012, doi: 10.1016/j.jeem.2011.10.005.

[35] M. Namazkhan, C. Albers, and L. Steg, "A decision tree method for explaining household gas consumption: The role of building characteristics, socio-demographic variables, psychological factors and household behaviour," *Renew. Sustain. Energy Rev.*, vol. 119, no. November 2019, p. 109542, 2020, doi: 10.1016/j.rser.2019.109542.

[36] M. S. Mancini *et al.*, "Ecological Footprint: Refining the carbon Footprint calculation," *Ecol. Indic.*, vol. 61, pp. 390–403, 2016, doi: 10.1016/j.ecolind.2015.09.040.

[37] R. Chen, R. Zhang, and H. Han, "Where has carbon footprint research gone?," *Ecol. Indic.*, vol. 120, no. August 2020, p. 106882, 2021, doi: 10.1016/j.ecolind.2020.106882.

[38] P. Yañez, A. Sinha, and M. Vásquez, "Carbon footprint estimation in a university campus: Evaluation and insights," *Sustain.*, vol. 12, no. 1, pp. 1–15, 2020, doi: 10.3390/SU12010181.

[39] R. Mendoza-Flores, R. Quintero-Ramírez, and I. Ortiz, "The carbon footprint of a public university campus in Mexico City," *Carbon Manag.*, vol. 10, no. 5, pp. 501–511, 2019, doi: 10.1080/17583004.2019.1642042.

[40] S. A. Sharif and A. Hammad, "Developing surrogate ANN for selecting near-optimal building energy renovation methods considering energy consumption, LCC and LCA," *J. Build. Eng.*, vol. 25, no. April, p. 100790, 2019, doi: 10.1016/j.jobe.2019.100790.

[41] M. Montané, L. Ruiz-Valero, C. Labra, J. G. Faxas-Guzmán, and A. Girard, "Comparative energy consumption and photovoltaic economic analysis for residential buildings in Santiago de Chile and Santo

Domingo of the Dominican Republic," *Renew. Sustain. Energy Rev.*, vol. 146, no. April, 2021, doi: 10.1016/j.rser.2021.111175.

[42] H. Nabipour Afrouzi, J. Ahmed, B. Mobin Siddique, N. Khairuddin, and A. Hassan, "A comprehensive review on carbon footprint of regular diet and ways to improving lowered emissions," *Results Eng.*, vol. 18, no. March, p. 101054, 2023, doi: 10.1016/j.rineng.2023.101054.

[43] V. Bozoudis and I. Sebos, "The Carbon Footprint of Transport Activities of the 401 Military General Hospital of Athens," *Environ. Model. Assess.*, vol. 26, no. 2, pp. 155–162, 2021, doi: 10.1007/s10666-020-09701-1.

[44] G. L. Kyriakopoulos, I. Sebos, E. Triantafyllou, D. Stamopoulos, and P. Dimas, "Benefits and Synergies in Addressing Climate Change via the Implementation of the Common Agricultural Policy in Greece," *Appl. Sci.*, vol. 13, no. 4, 2023, doi: 10.3390/app13042216.

[45] G. L. Kyriakopoulos and I. Sebos, "Enhancing Climate Neutrality and Resilience through Coordinated Climate Action: Review of the Synergies between Mitigation and Adaptation Actions," *Climate*, vol. 11, no. 5, 2023, doi: 10.3390/cli11050105.

[46] I. Sebos, A. G. Progiou, and L. Kallinikos, "Methodological framework for the quantification of ghg emission reductions from climate change mitigation actions," *Strateg. Plan. Energy Environ.*, vol. 39, no. 3–4, pp. 219–242, 2020, doi: 10.13052/spee1048-4236.391411.

[47] I. Sebos and L. Kallinikos, "Greenhouse gas emissions in Greek agriculture: Trends and projections," *E3S Web Conf.*, vol. 436, p. 02007, 2023, doi: 10.1051/e3sconf/202343602 007.

[48] V. Bozoudis, I. Sebos, and A. Tsakanikas, "Action plan for the mitigation of greenhouse gas emissions in the hospital-based health care of the Hellenic Army," *Environ. Monit. Assess.*, vol. 194, no. 3, 2022, doi: 10.1007/s10661-022-09871-3.

[49] I. Sebos, I. Nydrioti, P. Katsiardi, and D. Assimacopoulos, "Stakeholder perceptions on climate change impacts and adaptation actions in Greece," *Euro-Mediterranean J. Environ. Integr.*, vol. 8, no. 4, pp. 777–793, 2023, doi: 10.1007/s41207-023-00396-w.

[50] S. Papadogiannaki *et al.*, "Evaluating the Impact of COVID-19 on the Carbon Footprint of Two Research Projects: A Comparative Analysis," *Atmosphere (Basel).*, vol. 14, no. 9, 2023, doi: 10.3390/atmos14091365.

[51] Z. Liang, "Assessment of the construction of a climate resilient city: An empirical study based on the difference in differences model," *Int. J. Environ. Res. Public Health*, vol. 18, no. 4, pp. 1–20, 2021, doi: 10.3390/ijerph18042082.

[52] M. F. Leone and G. Zuccaro, "Climate-resilient urban transformation pathways as a multi-disciplinary challenge: the case of Naples," *Techne*, vol. 2, pp. 159–164, 2021, doi: 10.13128/techne-10702.

[53] C. Lomba-Fernández, J. Hernantes, and L. Labaka, "Guide for climate-resilient cities: An urban critical infrastructures approach," *Sustain.*, vol. 11, no. 17, 2019, doi: 10.3390/su11174727.

[54] L. Losada-Puente *et al.*, "Cross-Case Analysis of the Energy Communities in Spain, Italy, and Greece: Progress, Barriers, and the Road Ahead," *Sustain.*, vol. 15, no. 18, pp. 1–20, 2023, doi: 10.3390/su151814016.