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Carbon Footprint Determination: An Empirical Study at the PES Campus

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Abstract: Carbon dioxide is the primary greenhouse gas produced by human activity that contributes to global warming and climate change. The quantity of emissions from various emission sources can be determined by carbon footprint and can be used as an environmental indicator, which is helpful in calculating the effect of human activity on the environment and global climate. The purpose of this is to evaluate the emissions of greenhouse gases (GHGs) using several emission inventories. A carbon footprint disclosure of any educational institution is very important to understand such that its key emission sources can be identified and necessary mitigation measures can be adopted for carbon reduction. The Scope 1, 2, and 3 emissions of the scope site are included in the study. Three scopes—scope 1, scope 2, and scope 3—have been taken into consideration in the computation. It highlights the top 2 areas of emissions within the campus i.e., purchased electricity consumption (61.87% of total emissions), mobile source emission (21.81% of total emissions). The total emission computed for the campus is 971120.16 kg of CO_2 equivalent, out of which the major contribution is from Scope 2 (61.87%) emissions, followed by Scope 1 (31.87%), and the least contribution by Scope 3 (6.26%). Through the acquired results, it was noticed that annual emissions per individual is 0.2 tCO2 equivalents, while the annual allowable limit is 18 tCO_2 equivalents per individual. This can further be reduced using the recommended measures and through obtained results. Based on emissions below allowable levels, it is concluded that the chosen study area is Green Campus, and additionally, this empirical study raises staff and student knowledge of the carbon footprint in a fair way.
Keywords: Carbon footprint, Greenhouse gases, green campus

1. Introduction

Environmental conservation nowadays has become a major concern, especially following the significant negative consequences involved by the economic development promoted since the industrial revolution. People become progressively aware of their activity's implications on the environment, and are increasingly interested in reducing and correcting the adverse effects. The potential climatic effect of greenhouse gases released either directly or indirectly as a result of institutional activity is referred to as the "carbon footprint." A carbon footprint disclosure of any educational institution is very important to understand such that its key emission sources can be identified and necessary mitigation measures can be adopted for carbon reduction.

Academic institutions play a significant and vital role in helping society address the climate and environmental challenges put forth by international frameworks such as Green Deal (COM 640 2019) and Climate neutrality (COM 80 2020), which focus on achieving climate neutrality in the short /medium term [1].

In today's date, very few colleges disclose their carbon emissions. PES Campus, Shivamogga has taken initiative to compute its carbon footprint and set a Bench mark for other colleges/universities.

Over the last decennium, reporting on sustainability has grown in significance in both profit and nonprofit organizations. Sustainability reporting provides information to decision- makers and acts as a channel for organizational change. Furthermore, the International Association of Universities has prioritized sustainable development in higher education [2]. Products, events, people, and organizations can all have their footprints calculated. An organization's net carbon footprint calculates the greenhouse gas emissions from all of its operations, including the energy needed for buildings, industrial processes, and company automobiles [3].

Education is the pillar of the growth of a nation. An educational establishment serves as the foundation for a society that propels national development. So, it is essential to bring awareness about the cause and effect of emission of CO_2 among the students rather than other citizens. This will make them to find alternative ways and solutions for reducing the CO_2 emission. In this study, the carbon-producing hotspot is found out and analyzed for carbon footprint and was recorded. By analyzing the hotspot some effective measures were suggested to lower the carbon emission.

Driving more fuel-efficient cars (or ensuring that the ones you already own are maintained properly), taking public transportation, using energy-efficient appliances, insulating the houses to lower heating and cooling costs, eating less meat which has a higher carbon footprint than fruits and vegetables and consuming food that requires less transportation are just a few ways to lessen your carbon footprint.

Carbon offsets are another way for individuals and companies to reduce their carbon footprint. Carbon credits can be purchased with money that can then be used for projects such as planting trees or investing in green energy sources.

The estimate of net carbon emission is a topic covered in a large number of scholarly publications.

Karen Valls-Val et al. carried out a comprehensive review of the present situation of CF assessment in academic institutions through the examination of several important components, including the time frame, calculation tools, methodology and practices, emission sources, emission factors, and reduction plans. The review methodology took into account articles that were published up until March 2021. Thirty-five of the reviewed publications focused on determining the carbon footprint of higher education institutions; the remaining articles were reviews, CF assessments that were activity-specific, or studies that addressed GHG emission mitigation. Comparison of the data for the normalized CF (average of 2.67 t CO2e/student, ranging from 0.06 to 10.94) revealed distinct discrepancies. They came to the conclusion that the carbon footprint in higher education institutions needs more advancements and answers to several issues, such as defining representative emission sources, building a reliable emission factor database, and developing tools and procedures that meet all organizational requirements [1].

Pablo Yanez et al. documented the emissions on the Talca campuses that are related to Scopes 1, 2, and 3. After a thorough analysis of the data, recommendations for improvements were made on the aspects most influencing the carbon footprint. In scopes 1 and 2, the estimated carbon footprints were 20.03 tCO2e and 0.25 tCO2e per person annually, respectively. Findings revealed that Scope 3, which tracks indirect emissions from activities like human transportation, had the largest impact, coming in at 0.41 tCO2e per person. One of the primary sources of stress, according to the report, is the commute of staff and students to and from university. [4].

Shibu et al. evaluated the greenhouse gas (GHG) emissions from a variety of emission inventories at the Energy Management Centre, Trivandrum. By multiplying activity data by the appropriate emission factor, the "consumption-based approach" was used to estimate the carbon footprint from various sources. Using the emission parameters given by the Department for Environment, Food, and Rural Affairs, UK (DEFRA) and the Central Pollution Control Board, India (CPCB), emissions from different inventories were calculated. The transportation sector was determined to be the source of the largest emissions, while human respiration was shown to be the source of the smallest emissions. The chosen stocks' net carbon footprint was calculated to be 4851.25 kg CO2e/year [5].

Tao Gao et al. concentrated on the procedures and research techniques needed to conduct investigations on various kinds of carbon footprints. A comparison analysis was conducted to determine the commonalities, distinctions, and shortcomings among various carbon footprint assessment standards. Aspects of an

organization's and a product's carbon footprint, including goals, concepts, boundaries of the research, calculating techniques, data selection, and other factors, were examined. The organization's and the product's carbon footprint assessment standards—PAS2050, TSQ0010, ISO14047, and the product and supply chain GHG Protocol—as well as the Greenhouse Gas (GHG) protocol and ISO14064 were compared. . They saw that, over the course of any product's or activity's life cycle, the carbon footprint has started becoming synonymous with a comprehensive GHG account [6].

The objective of this study is to identify major sources of emissions in the supply chain and inform relevant stakeholders so that actions can be taken to reduce emissions.

2. Description of the study area

PES CAMPUS is located in Shimoga district of Karnataka State in India. It belongs to BANGALORE division. The location's latitude is 13"57'41.4' N and the longitude is 75 30'29.5'E, at mean altitude of 640 meters above the sea level. The average temperature is around 27°C and about the annual rainfall of 624mm (24.57 ") for an average of 182.8 days.

Fig 1. Study area

3. Methodology

The Calculation of GHG emissions from the unit of activity data requires emission factors for various greenhouse gases (Specifically CO_2, CH_4 and N_2O). These factors enable GHG emissions to be estimated from a unit of available activity data (e.g., Kg of fuel consumed, Kg of product produced etc.). These are multiplied with their respective conversion factors to be expressed in terms of Kg CO; equivalent ($KgCO_2e$). These emission factors were researched and extracted from various national and international norms.

Table 1. Carbon Emitters and Their Respective Emission Factors

Car bon Em itter s	Emi ssio n Fa ctor
Elec tri ci ty	0 . 8 5 k g C O 2 /K W H
Pet ro l	2 . 2 9 6 k g C O 2 /l iter
Die se l	2 . 6 5 3 k g C O 2 /l iter
LPG	2 . 9 8 3 k g C O 2 /k g

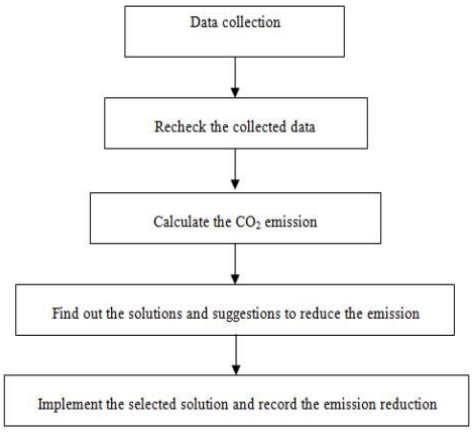

Fig 2. Methodology Flow Chart

4. Data Collection

Scope 1- Direct GHG Emissions: Sources that the organization owns or controls are the source of direct greenhouse gas emissions. For instance, emissions resulting from combustion in owned or controlled boilers, furnaces emissions from combustion of fuels in automobiles.

Scope 2- Indirect GHG Emissions (Electricity): The GHG emissions from the production of the purchased electricity that the organization uses are covered by scope 2.

Scope 3- Other Indirect GHG Emissions: It includes emissions from outsourced activities i.e. from the commuter activities of members of the organization. It's the activity of teaching staff, non-teaching staff and students commuting to and from college.

Table 2. Types of Data Collected for Academic Project

GHG accounting activity	Activity subset	Data collection sources	Units
Stationary Combustion	LPG consumption in Canteen & Chemistry Lab	Offline survey with respective department	Kg/year
Stationary Combustion	Diesel used in Diesel Generator	Record books	Litres/year
Mobile Combustion	Fuel used in College Bus during academic year 2021-2022	Transport Record Books	Litres/year
Purchased Electricity	electricity usage in units during the academic year 2021-2022	Monthly Electricity Bills	KWh/year
Employee Commuting	Mode of Transport used and fuel consumed during commuting.	Online survey and offline survey	Litres/year

5. Calculations

The strength of the campus, including students, teaching staff, and supporting staff, has been collected through the survey.

The survey details are as follows:

- Students - 4350

- Teaching staff – 221
- Non-teaching staff – 71

Calculation of Carbon Footprint was done through three scopes:
Scope 1 (Direct GHG Emissions),
Scope 2 (Indirect GHG Emissions),
Scope 3 (Other Indirect GHG Emissions)

The scope wise breakdown is analyzed as follows:

Scope 1 Data Analysis: Required data for Scope has been collected through face-to-face survey and through resource person in the required area.

Table 3. No of LPG's used across the year

LPG Consumption	No of LPG Cylinders used per year
College canteen No 1	425
College canteen No 2	24
Boys hostel mess	408
Girls Hostel Mess	645
Staff Quarters	80
Chemistry Lab	3
Total LPG Consumed per Year	1584

LPG consumed in kg/year is calculated as follows
No of Cylinders/year * Weight of Cylinder in Kg
1584 Cylinders/year * 19kg =30096 kg/year ≈ 30100kg/year
Therefore, GHG Emissions ($kgCO_2e$/year) = 30100 kg/year * 2.983 $kgCO_2e$/kg (emission factor for LPG)
= 89788.3$kgCO_2e$/year = Say 89790 $kgCO_2e$/yr.

Diesel Generator Emission:
Diesel used in Diesel Generator per year = 3000 liters/year
Emission ($kgCO_2e$/year) = Diesel Consumed/year *emission factor (2.653 $kgCO_2$/year).
Therefore, emission = 3000 liters/year * 2.653 $kgCO_2$/liters = 7959 $kgCO_2e$/year.

Mobile Source Emission (Institution Vehicles):
Diesel Consumed in Institutional Vehicles per year = 79840 liters/year
Emission ($kgCO_2e$/year) = Diesel Consumed liters/year * emission factor (2.653 $kgCO_2$/liters)
Therefore, Emission = 79840 liters/year * 2.653 $kgCO_2$/liters = 211815 $kgCO_2$ e/year.
Total Scope 1 GHG Emission = 89790+7959+211815 = 309564 $kgCO_2$ e /year.

As indicated in the fig 3, the maximum GHG emissions were contributed by mobile source emissions i.e diesel used in institutional vehicles i.e. 68.42% of the overall Scope 1 emissions. These mobile sources were utilized for the commuting of the students, teachers and non-teaching staff for to and from college. A total of 31 institutional vehicles including includes 29 buses, 1 tempo traveler and 1 winger were used for commutation. The total emission computed for mobile source combustion was 211815 $kgCO_2e$/year

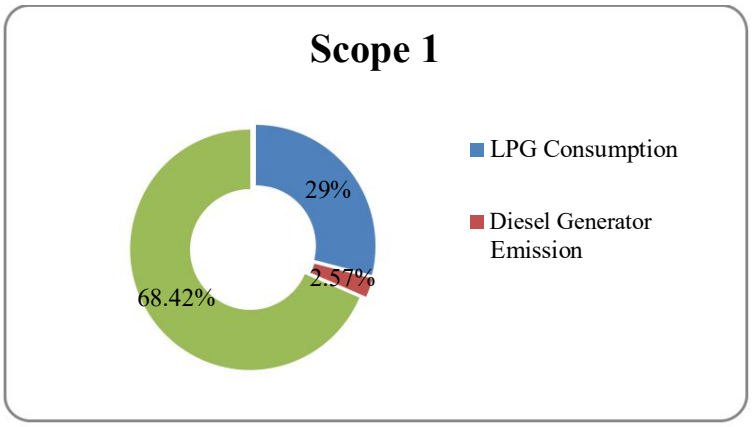

Fig 3. Figure Showing Scope 1 Emission (%) for Various Emission Sources

This was followed by consumption of LPG i.e. 29.01% of total Scope 1 emissions. The LPG cylinders were used in the canteen for food preparation and in the chemistry lab for research purposes. It was projected that during the fiscal year 2021–2022, the canteen used a total of 1584 commercial cylinders (19 kilogram capacity). Hence, the overall emission computed for LPG cylinders is 89790 kg CO_2e/year

The minimum emission is contributed by diesel consumption through the diesel generator, i.e 2.57 % of overall Scope 1 emissions. Diesel generators (DG) are provided for power backup to the whole campus during power cuts to sustain ongoing operations across campus. The total emission computed by Diesel generator is 7959 $kgCO_2e$/ year

Scope 2 Data Analysis: The requisite data has been collected through the electrical bills of the institution for the academic year 2021-2022.

Table 3. Electricity Consumption of the Campus for the Academic Year 2021-2022

Month	Units Consumed	kWh	$kgCO_2e$
Apr-21	52870	52870	44939.5
May-21	26347	26347	22394.95
Jun-21	27495	27495	19120.75
Jul-21	41270	41270	35079.5
Aug-21	59295	59295	50400.75
Sep-21	56187	56187	47758.95
Oct-21	62620	62620	53227
Nov-21	62473	62473	53102.05
Dec-21	75237	75237	63951.42
Jan-22	54890	54890	72156.5
Feb-22	62870	62870	53439.5
Mar-22	84890	84890	72156.5
Total	**666444 units/ year**	**666444 kWh/year**	**587727.4 $kgCO_2e$/year**

Therefore, Emission ($kgC0_2e$/year) = Electricity consumption (kWh /year) * Emission Factor (0.85 $kgCO_2$/kWh)

= 666444 kWh /year * 0.85 $kgCO_2$/ kWh

Scope 2 GHG Emission = 566477.4 $kgCO_2e$/year

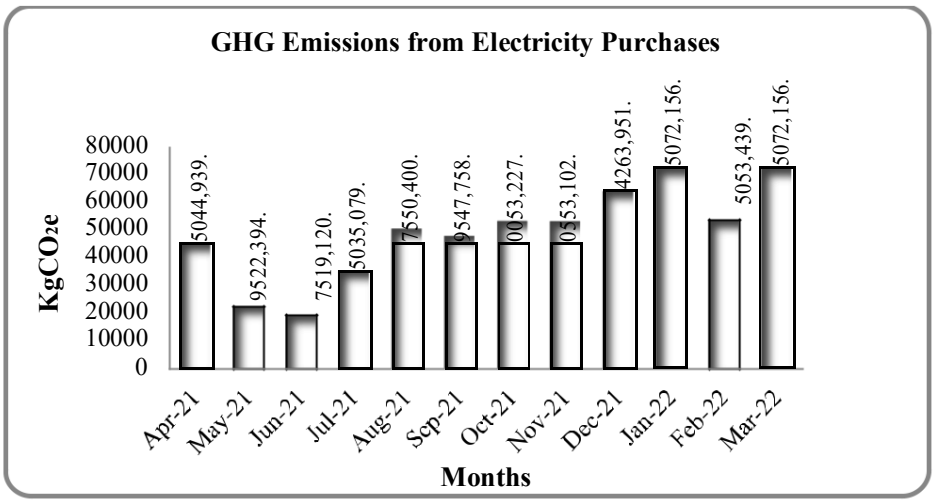

Fig 4.4 Figure Showing Monthly GHG Emissions ($kgCO_2e$) due to Electricity Consumption under Scope 2

It was noted that the maximum emissions were made in the months of January and March of the year 2022 followed by December of the year 2021. Minimum emissions were reported in the months of May, June, and July of year 2021. This trend analysis suggests that emissions were increasing during the active months of the year and least during COVID-19 lockdown period.

Scope 3 Data Analysis: Data was gathered via an online survey using a Google form by name "Vehicle Survey for Academic Project" and also by face-to-face interviews. It involves employee commuting through their owned vehicles. Scope comes with a combination of combustion of fuels i.e., both Petrol and Diesel.

Therefore, Emission ($KgCO_2e$/year) is equal to,

Emission = [(Total Petrol Consumption in liters/year) * (Emission Factor 2.296 $kgCO_2$/liters) + (Total Diesel Consumption in liters/year) * (Emission Factor 2.653 $kgCO_2$/liters)]

= [(22080 liters/year) * (2.296 kgCO2/liters) + (5640 liters/year) * (2.653 kgCO2/liters)]

Scope 3 GHG Emissions = 65658.6 $KgC0_2e$/year.

The Scope 3 emissions for PES Campus were computed to be 65658.6 kgCO2e or 65.65 tCO2e. The maximum emissions are due to commuting of the teaching and non-teaching staff through their own vehicles. Since waste leaves release less greenhouse gas than food waste, the emissions from garden waste have been disregarded in the scope 3 data analysis. Also, since there is no food disposal on campus, carbon emissions are disregarded, and emissions from employee commuting are considered a major source of emissions for Scope 3.

Total GHG Emissions = (Scope 1 + Scope 2 + Scope 3) GHG Emissions

= (309564 + 566477.4 + 65658.6) $kgCO_2e$/year

Therefore, overall total emissions = 941700 $kgCO_2e$/year.

= 941.700 tons of CO2e

or carbon intensity as 0.2 tCO_2e per individual

6. Results

Table 4. Summary of the Estimation of Carbon Emission of PES College for the Reporting Year 2021-2022

GHG Emissions	**Scope 1**			**Scope 2**	**Scope 3**	**Total**
Total $kgCO_2e$/ year	LGP Consumption	Diesel Consumption	Emission due to Mobility	Purchased Commuting	Employee Commuting	
	89790	7959	211815	566477.4	65658.6	**941700**

As indicated in above table 4, for financial year 2021-22, Carbon Footprint of PES Campus was computed to be 941.170 tons of CO_2e or carbon intensity as 0.2 tCO_2e per individual for identified GHG emission sources. The primary source of emissions was noted from Scope 2 emissions i.e., 566.477 tCO_2e followed by Scope 1 which is 309.564 tCO2e. The minimum contribution is by Scope 3 which is computed to be 65.66 tCO_2e.

7. Conclusions

The present study computes the carbon footprint of PES CAMPUS Shivamogga, for the Reporting Year 2021-2022. It is a trailblazing step undertaken by the college amongst other colleges to report and reduce its carbon emissions, which includes Scope 1, Scope 2, and Scope 3 emissions of the scope location. It highlights, the top 2 areas of emissions within the campus i.e., electricity consumption (60.15% of the total GHG emissions) and mobile source emissions (22.49% of total GHG emissions). The study highlights negligible emissions from garden waste, mobile source and fugitive emissions. The total GHG emissions computed for the college is 941700 kg of CO_2 equivalent, out of which the major contribution is of Scope 2 (60.15%) emissions, followed by Scope 1 (32.87%) and least contribution by Scope 3 (6.97%).

By this it can be said that calculating the carbon footprint of either individual or organizations is very crucial for the well sustainability of the environment. By calculating carbon footprint of an individual or organizations brings the awareness among themselves and others about the environmental sustainability. For an organization, it is important to find the major emission sources and the mitigation measures for reducing emissions for its future well-being. Overall, this study or initiative is a step towards contributing to India's nationally determined goals and achieving carbon neutrality by PES Campus.

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