Original Research Article

CARBON FOOTPRINT ASSESSMENT AT HIMACHAL PRADESH UNIVERSITY SHIMLA: INSIGHT AND EVALUATION TOWARDS GREEN CAMPUS AND PROMOTION OF ENVIRONMENTAL SUSTAINABILITY

ABSTRACT

Carbon footprints (CFs) are used to calculate how much greenhouse gas (GHG) is released by a given organization or activity. A starting step towards adopting sustainable educational practices could be reporting the level of CFs on college campuses. The present study employs at calculating the carbon footprint of the Himachal Pradesh University Shimla campus for the first time as a first step towards implementing sustainable educational practices. This study was conducted for a comprehensive analysis of carbon footprints for the years 2020-2021, 2021-2022, and 2022-2023. It aims to estimate the trend of carbon emissions, specifically the change from the lockdown years 2020–2021 to the post-lockdown years 2021–2022 and 2022–2023. By analyzing these three discrete time periods, we aim to discern how carbon footprints have evolved in response to changes in human activities, providing valuable insights into the environmental impact of the COVID-19 pandemic and its aftermath.This study has calculated the carbon footprint of various energy sources including kerosene, petrol, diesel, and LPG under scope 1. Results depicts that kerosene has the largest CF among four activity sources with 342.26 t$CO_2e$for the Scope 1 emission.After evaluating the intensity of carbon footprint resulting from scope 1 emissions activity sources, this study suggested to limit the use of energy sources such as petrol, diesel, kerosene and LPG and transitioning to alternative options. Scope 2 emission calculations are conducted to estimate and compare the carbon footprint resulting from electricity consumption between coal-based electricity generation and hydropower generation.

Keywords: Carbon Footprint; Greenhouse Gases; Himachal Pradesh University Shimla; GHG Protocol; COVID-19

1. INTRODUCTION

Global warming is a fact that originates from a single scientific issue and spreads to encompass a wide variety of global issues about politics, business, society, technology, the environment, and ecology[1].The immediate and easily noticeable consequence of global warming is the rise in temperatures across the globe [1]. The planet has already warmed by 1.9 degrees Fahrenheit (1.1 degrees Celsius) since the start of the preindustrial era 250 years ago [2].

Experts caution that if we do not address the root causes of climate change, which are the burning of fossil fuels like coal, oil, and gas, the temperature may worsen to 4 degrees Celsius (7.2 degrees Fahrenheit) by the year 2100 [2]. Furthermore, the majority of the consequences of climate change that have been observed since the 1950s, such as warming oceans, melting glaciers, and increasing sea levels, are now attributed to human activity, according to experts, who are at least 95% positive of this. It was estimated that 7% of the total GHGs are emitted from anthropogenic sources [1].

In order to power factories, smelters, and steam engines during the Industrial Revolution, humans began burning coal and other fossil fuels, which increased the amount of greenhouse gases in the atmosphere. The world has been warming as a result of human activity ever since[3].

One of the main reasons for this is the excessive emission of greenhouse gases (GHGs) in the atmosphere leading to global warming and its consequences. First and foremost, the Kyoto Protocol was designed to restrict the increase of greenhouse gas emissions due to concerns about these emissions and their impact [4]. The Kyoto Protocol set a goal to use a variety of adaptable mechanisms, such as carbon trading, under which, industrialised nations committed to lowering their yearly hydrocarbon emissions by an average of 5.2% by 2012[5].

Global warming, which is determined by the amount of greenhouse gas emissions emitted into the atmosphere, is the primary cause of climate change. Determining an organization's present environmental performance in terms of its Carbon Footprint (CF) is the first step for those who want to help achieve the climate-neutral goal.The GHG Protocol (2004) is the most significant regulatory framework for GHG emission accounting. It defines the CF as the total quantity of GHG emissions produced by an organization's activities, either directly or indirectly, and typically expressed as the carbon dioxide equivalent (CO_2e)[6].

The organisationsengaged in education, research and community services, play an important role insustainable development and the fight against climate change. CF is a very useful toolfor exercising a greater degree of control over activities that impact the environmentand also provides a baseline on which to evaluate the effect of future mitigation effortson campus[7]. According to Cynthia Klein-Banai's study on[8] higher education institutes can take a leadership role by estimating their emissions, developing climate change plans, and identifying reduction potentials. Although, across the globe, these kinds of initiatives have been taken by several universities: The Universities of Leeds, UK [9]; the University of Illinois, Chicago (UIC) [10]; University of Cape Town (UCT) South Africa [11]Norwegian University of Technology and Science (NTNU) [12]; De Montfort University, UK [13]; USA[14]; etc.

The Cuajimalpa campus of the Autonomous Metropolitan University (UAM) is located in Mexico City conducted a study for achieving sustainability goal by computing the CF of the campus. The primary contributors to greenhouse gas (GHG) emissions were commuting via vehicles, which constituted 51%, and electricity usage, which accounted for 24%. This study serves as a reference point for setting mitigation goals for the institution and designing a comprehensive plan that includes assessing the emissions of the other four UAM campuses [15].

Another study published on Carbon footprint assessment at Universitas Pertamina from the scope of Electricity, Transportation, and Waste Generation being the main contributors in generating greenhouse gas emissions. The findings of this study indicated that the electricity sector accounted for the majority (92.3%) of CO2 emissions at the university, with per capita emissions reaching approximately 0.52 MTCO2 annually. This study emphasizes the need for an early and ongoing carbon footprint reduction plan at educational institutions [16].

So far the study of carbon footprint measurement of BITS Pilani, Pilani campus, situated in the semi-arid region of north-west India has been taken. Results show a total of 16500 tCO_2eq. of GHG emissions. 50% of GHG emissions are from scope 2 electricity generation and 48.9 % GHG emissions are from scope 3 sources. The rest 1.1 % emissions are the scope 1 GHG emissions from the petrol and diesel burned at BITS Pilani owned facilities like diesel-electric generator sets and vehicles. [17].

A study on Carbon Footprint in an Educational Institution in India focusing on the carbon footprint of Sri Ramakrishna Engineering College in Coimbatore, India. The study calculated the carbon footprint of the institution's campus from January 2018 to December 2019. The majority of carbon emissions come from other indirect sources, such as imported electricity, which accounts for approximately 27.89% of total carbon emissions [18].

The lack of comprehensive studies on carbon footprints in Indian universities is attributed to several factors, including the novelty of carbon footprint measurement in India, competing priorities, limited awareness, and insufficient institutional support for sustainability initiatives. Hence, Himachal Pradesh University has taken the initiative as an attempt to fill the research gap.This study compares the carbon footprint of Himachal Pradesh University produced during the COVID-19 lockdown in March onwards 2020, to that produced during the same period in years 2021-2022, and 2022-2023.Understanding environmental implications, creating accountability, and directing sustainability initiatives all depend on university research on carbon footprints. It equips students with useful problem-solving abilities and elevates universities to the position of sustainability leaders, fostering teamwork for a more sustainable future.

The present study is conducted to measure the carbon footprint of an HPU Shimla with the following objectives; to identify major sources and activities which emit CO2 and other greenhouse gases and reduce emissions over time; to manage the carbon footprint of the H.P. University Campus.

2. MATERIALS & METHODS

This section addresses the following topics: 1. Study Area 2. Justification for using Greenhouse Gas Protocol Corporate Standard as a research methodology for conducting the study 3. Data collection

2.1 Study Area

The Himachal Pradesh University was founded on July 22, 1970. It is located in Summerhill, Shimla district of Himachal Pradesh, India. The University campus occupies an area of 200 acres and has been designed to possess a distinctive architectural style.

Himachal Pradesh University, Summer Hill, Shimla homes Teaching Departments, properly-prepared Laboratories, Seminar Halls, and a Science Instrumentation Centre. It has 12 multi-storied buildings, which include Ambedkar Bhawan, Law Block, Science Blocks, Netaji Subash Chandra Bhawan, Multi-school Swami Vivekanand Bhawan, Gandhi Bhawan, and Main Library.

The University has 14 Hostels, a Faculty House, and an Auditorium that seats 800 persons. It additionally has residential colonies for coaching and non-coaching personnel. The University additionally has a playground, a put-up office, a bank, ATM, cyber cafes, eateries, and shops. It has its very own fleet of buses and is properly related through avenues and rail.

2.2 GHG Protocol

The methodology used in this study's GHG accounting and reporting adheres to the rules and guidelines outlined in the "greenhouse gas corporate accounting and reporting standards"**(GHG Protocol)**developed by World Resources Institute **(WRI)** and the World Business Council for Sustainable Development **(WBCSD)** developed in 2011, which specifies guidelines for measuring GHG emissions inside organisations covered by the Kyoto Protocol. This is the most widely used and accepted methodology for conducting corporate carbon footprints[19].

In terms of carbon dioxide equivalents, CF measures the amount of greenhouse gas emissions that an activity, or the accumulation of emissions over the course of a good or service's life cycle, directly or indirectly contributes to. Although the Intergovernmental Panel on Climate Change (IPCC) lists 18 greenhouse gases with varying global warming potentials, only carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) are taken into account for the carbon accounting under the United Nations Framework Convention on Climate Change [UNFCCC] and its Kyoto Protocol[20].

The GHG Protocol requires emissions to be reported against the three different "scopes" described below:

Scope 1: Scope 1 emissions are defined as direct emissions from sources under an organization's ownership or control. These emissions come from the burning of fossil fuels in the organization's boilers, furnaces, turbines, and other machinery, including kerosene and LPG (Liquified Petroleum Gas).

Scope 2: Indirect emissions associated with the generation of purchased electricity that the company consumed. Scope 2 accounts for the emissions produced during the generation of grid electricity. (*Explained with reference to thermal and hydropower plant*).

Scope 3: All other indirect emissions as a consequence of the activities of the company that occur from sources neither owned nor controlled by the company (*not mentioned in this study*).

<u>*2.3 Data Collection*</u>

Two types of data were collected namely activity data and EFs. Activity data were collected from scope 1 and scope 2 activities within defined organisational boundaries for 3 financial years i.e. 2020-2021, 2021-2022, 2022-2023.

Fuel consumption data was collected for LPG*(kg)*, and kerosene*(litre)* used for cooking and heating purpose on campus, and petrol*(litre)*, and diesel *(litre)*consumption for both on-site and off-site (paperwork or people) transportation as well as institutional buses.

<u>The different emission factors utilized to calculate the carbon dioxide, methane and nitrous oxide emission in tonnes:</u>

Table 1. Emission factors for different gases

Gases	EF for LPG (kg CO_2e / tonne fuel)	EF for Kerosene (kg CO_2e / litre fuel)	EF for Diesel (kg CO_2e / litre fuel)	EF for Petrol (kg CO_2e / litre fuel)
CO_2	2984.63	2.519376	2.676492	2.2717926

N_2O	0.00473	0.000021024	0.000021672	0.0000196692
CH_4	0.2365	0.0003504	0.0003612	0.00032782

3. RESULT & DISCUSSION

The following steps were followed to determine the GHG emissions related to each category:

1. Determine the energy consumption related to each activity source. The amount of activity that contributes to greenhouse gas emissions is measured by activity data or source (either directly or indirectly).
2. Find the updated GHG emissions factor associated with each activity source, defined in terms of CO_2/per unit of measurement (activity data for a certain source) and are unique to each source.
3. To find the quantity in each category, multiply consumption by the corresponding emission factor and global warming potential (GWP) add them together to get CF in kg and to obtain CF in tonnes the result wasdividiedby 1000[21].

The formula can be expressed as[22].

CF (tCO_2e) =$\sum g$ *A × Fg× GWPg*

A = Activity data

Fg = Emission factors of GHG

GWPg = Global warming potential (N_2O and CH_4)

After estimating the CF for each activity for three consecutive years following conclusions were made:

Analysis of CF in 3 consecutive years

The calculations represents the aggregated CF for emissions from petrol, diesel, kerosene, and LPG under Scope 1 for 3 consecutive years. The analysis revealed that the highest CF, accounting to 359.94 tCO2e, was recorded during the operational year of 2022-2023. In contrast, the CF during the year 2020-2021, which coincided with a lockdown period, was considerably lower, measuring only 156.6 tCO_2e. The impact of the lockdown was evident as most infrastructures and activities were inactive during that period. To visually represent the findings, Figure 1 illustrates the total annual CF estimates.It was found that there was a percentage increase of 135% from the period 2020-2021 to 2022-2023. Based on this limited study it can be concluded that the CF associated with working or studying from home, represents theenvironmentally friendly scenario. This is because it only includes the basic activities necessary for teaching and learning outside of a campus setting, such as using certain devices or energy consumption. Although this case of reduced CF during the lockdown period is contrasted by a study conducted at Bournemouth University, in Bournemouth and Poole, Dorset, UK, for the lockdown period of April–June 2020 [23]. Their study concluded that campuses will still consume huge quantities of utilities due to upkeep, while staff and students working/studying from home will contribute significant additional GHG emissions. Studies conducted at HPU Shimla reveals that even during lockdown periods, carbon footprint (CF) persists. It does not reduce to zero, resulting in additional carbon emissions due to online educational activities.

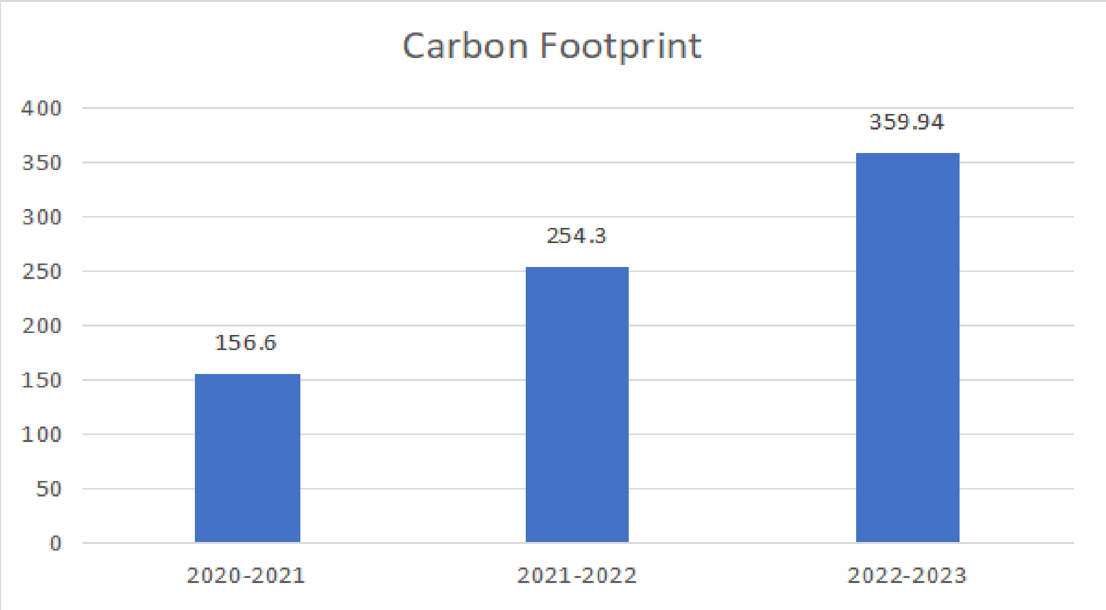

Fig.1: Total annual carbon footprint (CO_2e) *for 3 consecutive years in tons*

3.1 *Analysis of CF for Scope 1 emissions*

In our study, it was determined that among the emission sources falling under Scope 1, the highest Carbon Footprint (CF) was associated with the consumption of kerosene, totaling 342.26 tCO_2e even though kerosene is used only during four months of the year: November, December, January, and February. Therefore, It was mandated to reduce the consumption of kerosene at campus and adopt other sustainable measures such as HVAC systems. This finding is graphically presented in Figure 2, which illustrates the respective tons of CF attributed to each emission source.

Study revealed that the CF linked to diesel consumption is the smallest, making up just 5% of the total emissions. This is despite diesel having the highest emission factor among all four fuels. This outcome is due to the limited usage of diesel, with only five vehicles running on it within the university.

CF measured for petrol consumption at the university campus is 32% of total activity sources. However, This emission can be lowered by replacing petrol vehicles with ones that use fuel with lower emission factors, such as electric or natural gas vehicles, but the absence of infrastructure in Himachal Pradesh University Shimla, as well as the expenditure required, should be considered.

For LPG the CF is the second lowest over three consecutive years i.e. 148.30 tCO_2e. It is suggested to explore the possibility of replacing LPG with natural gas, as its EF is 12.5% lower than that for LP gas combustion(DOF) [DiarioOficial de la Federación], and potentially offers better prices in the market.

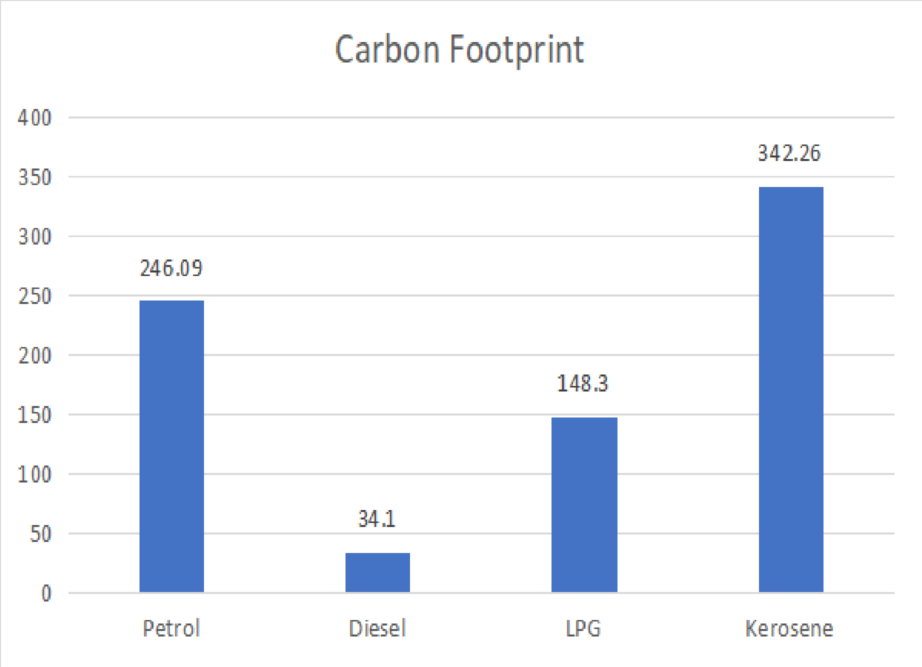

Fig.2: Carbon footprint (CO_2e)of each activity source in tons

3.2 Analysis of Electricity CF

Himachal Pradesh state mostly depends on hydroelectric power, for the generation of electricity. The hydropower plant is a sustainable and renewable source of energy. Most of the electricity consumption at University campus is from hydropower and a little is from solar panels installed at university campus. Therefore, Himachal Pradesh University Shimla is considered to be free from pollution from electricity generation.

The study calculated the scope 2 indirect emissions by assuming electricity generation from a thermal power plant with an emission factor of 0.85 kg per kWh obtained from **Central Electricity Authority (Indian government)**[24]. The study offers a comparison of greenhouse gas emissions if electricity generation comes from a thermal power plant instead of a hydropower plant, aiming to provide insights into the importance of adopting renewable energy resources.

The findings indicate that the cumulative carbon footprint attributed to electricity consumption from the thermal power plant over the course of three years would have amounted to 2735.526 tCO_2e.It would have been accounted for 41%of CF during the year 2022-2023 and 21% during the lockdown period of 2020-2021.

4. CONCLUSION

There are multiple methods for computing CF, according to empirical data on methodologies used at higher education institutions. The GHG protocol, on the other hand, is a widely recognised and well-known approach for calculating CF. This study aimed to calculate the carbon footprint of a university using the GHG protocol and data from three consecutive years. This research compares the GHG emissions produced by this institution of higher education during comparable operational periods in subsequent academic years to the carbon footprint during the COVID-19 lockdown. The findings revealed variations in the total carbon footprint across the observed period, specifically for scope. The highest carbon footprint was recorded during the operational year, indicating the impact of regular activities, totalling a significant amount. In contrast, the carbon footprint during the lockdown period was notably lower, reflecting the reduced impact of restricted operations. It is important to note that even during the (nearly) fully closed university campuses, the carbon footprint did not decrease to (near) zero. This implies that a substantial amount of energy is required to maintain the university's capital assets and infrastructure, regardless of their utilization. The study underscores the significance of energy consumption and its influence on the carbon footprint, emphasizing the need for sustainable energy practices within educational institutions.

In conclusion, the carbon footprint of a university, as demonstrated by this study, is shaped by a range of factors. Notably, HPU Shimla was observed to be free from electricity-related pollution due to its sourcing of electricity from a hydropower plant, which has an almost negligible carbon footprint highlighting the application of sustainable energy practices. Exploring alternatives to LPG, such as natural gas, and promoting the use of lower-emission vehicles can further reduce the university's carbon footprint. However, careful consideration of infrastructure requirements and associated costs is crucial in implementing these measures. By addressing these aspects, universities can play a vital role in mitigating carbon emissions and contributing to a more sustainable future. The university can drastically lower its carbon footprint and help climate change mitigation by implementing energy efficiency measures, using renewable energy sources, and supporting sustainable practices.

It is important to note, however, that the carbon footprint calculations reported here are based on the available data and the specific technique used. Further study and constant monitoring will be required to refine and update these estimations, allowing for a more thorough understanding of the university's carbon footprint and facilitating informed decision-making for sustainable practices.

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