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Study and Comparison of Carbon Footprint Emissions at a Higher Education Institute in India

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Abstract

This study involves in the assessment and comparison of carbon footprint emissions at a higher education institute in India. The key factors considered were the contributions of electricity usage, canteen facility operations, and transportation. The institute considered for study had an average population of 5871 students and 601 staff members, aims to assess the environmental impact of its activities. For the academic year finishing in 2023, the assessed CO2 discharges was found to be at 2081 tons, bringing about a per capita fossil fuel by-product of 0.321 tons, which were altogether lower than those revealed by higher education institutions outside India. Findings of the energy utilization uncovered that power use represented a significant piece of the CO2 discharges, contributing roughly 55% of overall carbon footprint. In view of these outcomes, strategy suggestions were made to control CO2 discharges by creating awareness among the staff and students. Also, proposals were made to the management for initiating greener environment in the campus. The objective of such measures is to reduce dependency on grid-supplied electricity and nurture a sustainable future. By calculating the carbon footprint and identifying significant contributors, this study provides valuable insights for higher education institutes in India seeking to assess and improve their environmental impact.

Keywords: carbon footprint, higher education institute, sustainable future, environmental impact, carbon reduction.

1.0 Introduction

In recent decades, the imperative role of education in promoting sustainable development has garnered increasing attention worldwide. Higher education institutions have responded to this call by undertaking numerous initiatives to contribute to sustainability and foster environmentally responsible practices. This technical paper draws insights from the publication titled "Experiences from the implementation of sustainable development in higher education institutions: Environmental Management for Sustainable Universities" [1]. Comprising 33 papers presented at the European Roundtable on Sustainable Consumption and Production - Environmental Management for Sustainable Universities conference in 2013, this publication exemplifies the concerted efforts made by higher education institutions to embrace sustainability.

Amidst growing concerns about climate change and its far-reaching environmental impacts, the higher education industry has emerged as a sector of interest in the global quest to mitigate carbon emissions. Understanding the carbon footprint of higher educational institutions is pivotal for crafting effective strategies and policies to minimize their environmental impact. Drawing inspiration from studies on carbon footprints in various domains, our technical paper draws insights from "The Carbon Footprint of Australian Tourism." This research employed multiple approaches to calculate the direct and indirect carbon costs of the Australian tourism industry over a specific period. By adapting and applying similar methodologies to the context of a higher educational institute, we aim to provide valuable insights into the carbon emissions associated with educational activities. The findings will enable us to identify potential areas for improvement and promote sustainable practices on campuses.

In this context, our study focuses on estimating the carbon footprint resulting from energy and fuel consumption at M S Ramaiah Institute of Technology, a higher education institution in India. The institute has already taken initial measures to address global warming since 2021. Therefore, this paper presents the findings of the carbon footprint estimation for the academic year ending in 2023, contributing to the institution's ongoing efforts in mitigating climate change and reinforcing its commitment to sustainability.

2.0 Literature

With the increasing concerns about climate change and its impact on the environment, there is a growing interest in understanding and reducing carbon footprints associated with various activities. The literature review in this technical paper encompasses a wide range of studies focused on carbon footprints and their estimation in various sectors, including cooking practices and household emissions, electricity usage as well as specific insights into higher educational institutions' sustainability efforts. Druckman and Jackson [2] socio-economic framework for attributing CO2 emissions to high-level functional needs emphasizes lifestyle aspirations' role in driving household carbon emissions, providing insights into targeting segments with high carbon footprints. Padgett et al. [3] examination of carbon calculators reveals a lack of consistency, particularly in household electricity consumption estimates, and calls for improved transparency and standardization. Johnson [4] study on charcoal and LPG grilling methods highlights the significance of fuel efficiency in cooking processes and the potential impact on carbon footprints.

Robinson et al. [5] showcase methodologies for calculating carbon footprints in different contexts, emphasizing the importance of accurate accounting and standardization in footprint calculations. By exploring the carbon footprints of different activities and considering factors that influence emissions, the study seeks to shed light on sustainable practices and inform strategies for reducing the environmental impact of higher education institutions. Kenny and Gray [6] comparison of carbon footprint models for household emissions reveals challenges in accurate estimation, emphasizing the need for consistency and transparency in carbon footprint calculators. Jain and Pant [7] proposed environmental management model for higher educational institutions underscores the significance of addressing environmental concerns, such as energy consumption and waste generation, in the university setting. Lin et al. [8] provides valuable insights into various sustainability aspects in higher education. James [9] identifies critical factors associated with environmental sustainability in universities, which can guide future campus sustainability efforts. The technical paper's focus on estimating the carbon footprint at a higher educational institute represents a critical step in addressing the environmental impact of educational institutions and identifying opportunities for sustainability improvements.

3.0 Methodology

The carbon footprint of the higher education institution located in India was estimated using a general methodology commonly employed for such assessments [10] as shown in Figure 1. The key steps involved in the process included: a) choosing the greenhouse gases to be evaluated, b) defining the study boundaries, c) gathering the required data, and d) converting the data into carbon footprint measurements.

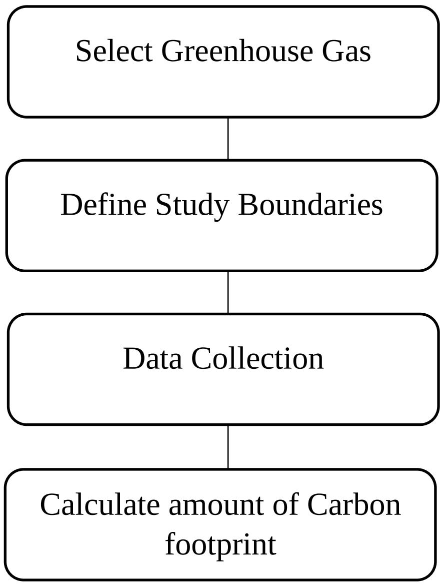

Figure 1: Method adopted to estimate CO2 emission

In this study, carbon dioxide (CO2) was selected as the primary greenhouse gas for assessment, and the study boundaries were established to focus on the estimation and analysis of carbon dioxide emissions. The institution was situated in Bengaluru, the Information Technology capital of India, considered to have moderate climate with mild summers and winters, without extreme temperatures. The annual weather report of Bengaluru [11], summarized in Table 1, provided important parameters for the analysis.

Table 1. Annual weather report of Bengaluru

Parameter	Unit	Range
Altitude	m	934
Max Temperature	^{0}C	25.7 to 32.8
Humidity	%	41 to 79
Precipitation	mm	125 to 147 (May to October)
Avg. Sun hours	hours	6 to 10 (longest during March April)

To determine the carbon footprint of the educational institution, various potential contributors were considered, including transportation, electricity usage, solid waste, diesel power generators, solar power, and food preparation in the canteen. The process began with defining the project location, duration, data sourcing, analysis, greenhouse gas emission calculations, comparison with other higher education institutions, and ultimately proposing measures to reduce CO2 emissions. Both direct emissions from activities within the institute's control and indirect emissions from electricity, LPG purchases, and personal transport were taken into account. The study period aligned with the institute's academic calendar, spanning from July to June. The human factors considered included students, faculty, support staff, and all individuals present within the institute premises.

The institute encompassed a 15-acre campus, housing various building blocks dedicated to different programs and facilities. On an average working day, the institute had a total of 5871 students and 601 staff members. Key parameters such as electrical and fuel consumption, as well as solid waste disposal, were considered for the carbon footprint estimation. Additionally, the institute had initiated small-scale solar power generation starting in 2021. The factors considered for estimating the carbon footprint are presented in Table 2.

Table 2: Factors considered for estimating carbon footprint.

Factor	Electrical	Petrol	Diesel	Solar	Gas	Solid Waste
Electricity consumption	*			*		
Canteen	*				*	*
Transport facility		*	*			
Private transport		*	*			
Generator			*			

Data required for the estimation was collected from energy audits, fuel purchase records, and electricity bills maintained at the administrative office, maintenance department, and canteen of the institute. The data collection process was time-consuming, ranging from 3 to 5 months, as the maintenance department sections maintained records in a decentralized manner. Various sections within the institute served as data sources, as listed in Table 3.

Table 3. Data source

Data about	**Source**
Number of Students	Admission section
Number of Staff	Administration section
Diesel consumption by generator	Generator section
Electricity	The electricity board issued bills from the Accounts section
Solar energy generated	Electrical section of the maintenance section
Private transport (bikes/cars) of students, staff, and visitors	Parking bay attendant
Public (institute's bus) transport facility	Administration section
LPG consumption	Canteen In-charge and hostel warden
Solid waste	Canteen In-charge and hostel warden
Building area and type	Administration and Maintenance sections

The collected data was then converted into CO2 emissions using standard emission factors presented in Table 4. These factors provided the conversion rates for different emission sources, such as human factors, petrol, diesel, electricity, solid waste and LPG.

Table.4 Standard emission factor

Emission Source	**CO_2 emitted**
Human factor	1.14 kg per person per day
Petrol	2.3 kg per liter
Diesel	2.7 kg per liter
Hydroelectricity	0.68956 kg per kW h

Solar based electricity	0.05 kg per kW h
Solid waste	0.125 kg per kg
LPG	1.5 kg per kg

By following this methodology and utilizing the appropriate emission factors, the carbon footprint of the higher education institution was estimated, enabling a comprehensive analysis of its environmental impact.

3.1 Transportation activity

The carbon footprint analysis of transportation activities comprised of emissions from various vehicles used for commuting by students, staff, different sections of the institution, college buses, and visitor vehicles. Since the institution was located within the city limits and well-connected by public transport, no transportation facility was provided by the institution. A survey was conducted to gather data on transportation modes, vehicle fuel economy, and daily commuting distances of individuals to and from the institution. The survey revealed that around 90% of students, faculty, and staff used their own vehicles, with 90% using petrol-run vehicles and the remaining using diesel-run vehicles. Physical counts of vehicles entering the premises were conducted on all days of the week. The campus witnessed a total of 5809 two-wheelers owned by students and staff, along with 272 petrol cars and 116 diesel cars.

The institution-owned vehicles were not uniformly utilized, with some department vehicles being sparingly used. The administration office maintained a monthly usage report and fuel bills for these vehicles, which served as the basis for determining average fuel consumption. Three parking areas were accessible inside the institute's grounds, with separate parking for bikes and four-wheelers. The number of visitor vehicles entering the campus was counted on a weekly basis and averaged to calculate the CO2 emissions associated with visitor transportation.

By considering these factors and conducting a comprehensive analysis of transportation-related emissions, the carbon footprint associated with transportation activities at the higher education institution was accurately assessed. To estimate the CO2 emissions, the transport usage data was directly converted using emission factors of 2.3 kg per liter for petrol vehicles and 2.7 kg per liter for diesel vehicles.

3.2 Electrical Activity

The electrical activity of the higher education institution played a significant role in its carbon footprint. Electricity was utilized for various purposes, including lighting, air-conditioning, heating, and operating machinery such as furnaces and lathes in laboratories. During the semester term days, electricity consumption was notably high. The institution's electricity needs were fulfilled by the state-run electricity board's power grid, in-house diesel generators, and a new solar power plant installed on the rooftops of different building blocks.

A single substation supplied power to all the building blocks, including the sports complex and the boy's and girl's hostels. The monthly electricity consumption bills issued by the state electricity board were available in the maintenance department. Higher usage levels were seen from March to May due to the peak summer season, achieving extended month to month kilowatt-hour (kWh) use.

To determine the carbon foot print related to power drawn from the power structure, how much power consumed in kWh was obtained by the CO2 release factor of 0.68956 kg per kWh. This determined the emissions resulting from electricity usage in the institute.

The institution also employed two diesel generators to ensure uninterrupted power supply during unscheduled power cuts. Although the actual power produced by these generators was not recorded, the amount of diesel consumed consistently was utilized to work out the carbon foot print, taking into account a factor of 2.7 kg of CO2 discharges per liter of diesel.

Recently, the institution made a proactive step towards manageable energy by introducing a solar power plant on different structure blocks, including the Engineering Science Block, Apex Block, Lecture Hall Complex, and Division of Electrical Science Block. Data on electricity generated by the solar plant was available in the maintenance department. This data was used to calculate the CO2 emissions associated with solar energy production, employing a multiplication factor of 0.05 kg per kWh.

By considering these factors related to the institution's electrical activity, an accurate estimation of the carbon footprint arising from electricity consumption was achieved.

3.3 Food preparation and solid waste management

Food preparation and solid waste management activities significantly contribute to the institution's carbon footprint. The presence of three canteens and separate hostels for boys and girls results in an average of 650 kg of solid waste generated daily. This waste is collected by city corporation trucks on a daily basis, and data regarding the waste transported is available in the maintenance department. The conversion of this waste data into CO2 emissions utilizes an emission factor of 0.125 kg of carbon per kilogram of waste.

In terms of cooking, the institute's three canteens and mess rely primarily on liquefied petroleum gas (LPG) as the cooking fuel. Portable commercial gas cylinders, each weighing 19 kg, are purchased from the state-owned petroleum corporation. While there is no daily measurement of LPG consumption in the canteens, records maintained by the canteen managers and wardens indicate an average consumption of thirteen cylinders per week. This consumption translates to the release of 1.5 kg of CO2 per kilogram of LPG consumed.

By considering the emissions associated with food preparation and solid waste management activities, a comprehensive assessment of the carbon footprint attributed to these areas is achieved.

4.0 Results and Discussion

The carbon footprint percentages produced by each criterion and energy source considered in the study are presented in Table 5 and visualized in Figure 2. To calculate the emissions, certain assumptions were made regarding vehicle travel distances and fuel economy. It was assumed that all vehicles travelled approximately 400 meters within the campus, with an average mileage of 16 km/l for diesel cars, 19 km/l for petrol cars, and 40 km/l for two-wheelers. The fuel consumption for diesel and petrol vehicle was calculated separately for six working days in a week. The calculated fuel consumption for 400 metres was 0.025 liter, 0.01 liter and 0.0211 liter for diesel cars, petrol cars and two wheelers respectively.

Table 5. The carbon footprint of each criterion

Factor	Standard Emission factor	Electrical (kW h per year)	Petrol (liters per year)	Diesel (liters per year)	Gas (kg per year)	Waste (kg per year)	Avg. No. of human per year	CO_2 emission (kg/year)	%
Electricity consumption	0.68956	1666092						1148870	55%
LPG	1.5				11856			17784	1%
Diesel vehicles	2.7			905				2443	0%
Private transport (Petrol)	2.3		19915					45804	2%
Generator	2.7			17473				47177	2%

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Solar based electricity	0.05	439881			21994	1%
Human contribution	1.14 (0.38/8hrs)			2019264	767320	37%
Solid Waste	0.125		237250		29656	1%
Total					**2081048**	**100.00%**

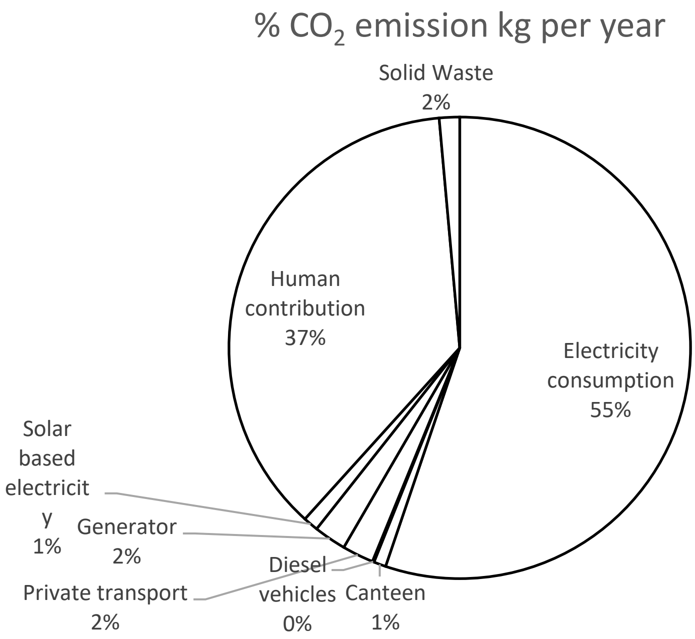

Figure 2: Factors contributing to carbon footprint

The analysis revealed that the institution produced approximately 2081.0 tons of CO2 emissions in a given year. Electricity consumption was identified as the principal contributor, accounting for 55% of the total carbon footprint. Comparatively, emissions from diesel usage in transportation and generator operations were higher than those from petrol-run vehicles. The carbon emissions of the institution were then compared with those of other higher education institutions worldwide, as shown in Table 6.

Table 6: CO_2 emission of various higher education institutions

University	Country	Total Annual CF (CO_2 in t)	CF per capita (CO_2/person in t)
Yale University[12]	United States	817000	
University of Illinois[13]	United States	275000	7.5
Louisiana State University[14]	United States	162742	
Leeds University[15]	United Kingdom	161819	2.36

Qassim University[16]	South Africa	123997.47	
Clemson University[17]	United States	95418	3.57
Norwegian University Techn/ Science[18]	Norway	92000	3.61
University of Cape Town[19]	South Africa	84925.5	
University Technology Malaysia[20]	Malaysia	57576	2.1
De Montfort University[21]	United Kingdom	51080	2
Pusan National University[22]	South Korea	33629.83	0.99
Massey University[23]	New Zealand	26696	
University of Castilla-La Mancha[24]	Spain	23000	
University of Sydney[25]	Australia	20100	
St. Edward's University[26]	United States	18541.7	3.7
Birla Inst of Technology & Science Pilani[27]	India	16500	3.7
University of Diponegoro[28]	Indonesia	16345.83	
Keele University[29]	United Kingdom	14393	1.27
University of Diponegoro[30]	Indonesia	13945.55	5.55
Trisakti University[31]	Indonesia	11994.86	
Technical University of Pereira[32]	Colombia	8969	0.4
Mea Fah Luang University[33]	Thailand	7330.72	0.52
Fed University of Agriculture Abeokuta[34]	Nigeria	5935	
Talca University[35]	Chile	5472.89	0.72
Escuela Superior Politécnica del Litoral[36]	Ecuador	5009.22	0.356
University Autonomous Metropolitan[37]	Mexico	2956.28	1.06
Polytechnic University of Madrid[38]	Spain	2147	1.55
M S Ramaiah Institute of Technology	India	2081.0	0.321
Talca University[39]	Chile	1568.6	0.95
Universitas Pertamina[40]	Indonesia	1351.98	0.52
Autonomous Baja California University[41]	Mexico	706.52	4.74
Valaya Alongkorn Rajabhat University[42]	Thailand	663.6	
University of the Basque Country[43]	Spain	597.15	0.558
University of Haripur[44]	Pakistan	578.9	0.14

The comparison highlighted that the carbon emissions of the study institute were notably lower than those of institutions in developed countries. This suggests that the institution has made significant progress in managing its carbon footprint. However, there is room for further improvement. Based on the study findings, several suggestions were proposed for each category considered in the study.

Under the transport sector, it was recommended to encourage the use of vehicles that adhere to emission norms, promote the use of public transportation, encourage carpooling, and promote walking for short-distance travel [45]. In the electricity category, suggestions included using electricity effectively, utilizing LED lights, avoiding lower temperature settings in air conditioners, harnessing solar energy, reducing and reusing paper, adopting effective waste management techniques in hostels and canteens, minimizing food waste, and planting more trees on campus.

The management of the institution should focus on awareness programs to educate all individuals on campus about energy-saving policies [46]. Encouraging innovative ideas to conserve electricity and promoting responsible usage should also be emphasized. Because of the review, the institution has proactively initiated steps, for example, by instructing housekeeping staff to visit classrooms to switch off unattended fans or lights, introducing LED lights all through the campus, and setting temperature limitations for air conditioners below 22°C. Furthermore, the organization has increased harvesting solar power generation by adding new panels on all structures.

All in all, the assessment highlighted the institution's carbon foot print, which was viewed as lesser than that of numerous other advanced education institutions, especially in developed nations. However, there is opportunity to get better through the execution of different measures across various classifications. By implementing the proposed ideas and proceeding to bring issues to light and carry out energy-saving strategies, the institution can additionally reduce its carbon foot print and add to a more sustainable future.

5.0 Conclusion

In conclusion, this study utilized the standard emission factors method to estimate the carbon footprint, specifically in terms of CO2 emissions, within a higher education institution in India. The findings revealed that the institution produced approximately 2081 tons of CO2 per year. The analysis identified that electrical energy consumption alone contributed 1148.8 tons, accounting for about 55% of the total emissions. The human factor was responsible for 37% of the emissions, while the usage of petrol vehicles and diesel generators accounted for the remaining portion. Contributions from the LPG, transportation facility, solar-based electricity, and solid waste were around 1% of the total carbon footprint. These results helped in knowing the extent of pollution within the campus and provided insights into the primary causes of rising CO2 levels in the environment. Recognizing the importance of this issue, the institution's authority is committed to setting an example of environmental responsibility. This commitment involves implementing sound policies and practices, as well as investing in green technologies that can considerably reduce the institution's dependency on electricity and support an environmentally sustainable future.

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