Quantifying Carbon Footprints within Higher Education Institutions: A Case Study of Sri Lanka Technological Campus

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***Abstract*—In response to the imperative of reducing greenhouse gas emissions, organizations are progressively taking steps to quantify their carbon footprint. The purpose of this paper is to present a comprehensive analysis of the carbon footprint of Sri Lanka Technological Campus, including direct and indirect emissions as well as a discussion about the commonly used method. Emissions are presented in two scopes (scope 1 reports direct process emissions, scope 2 reports emissions from purchased energy) to identify carbon emission hotspots within the university's operations. Direct sources and indirect sources of greenhouse gas emissions in the university are identified and relevant activity data are collected. The carbon footprint of the University was calculated using collected activity data followed by the hybrid model, combining approaches of Environmentally Extended Input-Output Analysis and Life-Cycle Assessment. In 2022, the institution's emissions inventory tallies to 196.89 metric tons of CO_2e, with the majority attributed to the indirect emissions of the campus. Approximately 72% of the University's carbon footprint is attributed to indirect emissions. This underscores the imperative for adopting environmentally conscious procurement practices and transitioning to renewable energy sources for purchased electricity as a means of offsetting this impact. The study revealed that significant impediments are associated with information availability for cover up all categories and the absence of established data collection strategies. Effective mitigation actions involve the adoption of energy conservation policies and enhancements to procurement practices to reduce carbon footprint of the university.**

Keywords—Carbon footprint, higher education institutes, greenhouse gas emissions, indirect emission

I. Introduction

Climate change concerns have led to an increased focus on evaluating emissions and quantifying a carbon footprint. This has become particularly significant as a first step toward minimizing one's environmental impact and ultimately reaching carbon neutrality. Currently, there is a considerable gap between the capacity of natural carbon sinks to capture carbon and the global emissions being discharged [1]. Reduction of greenhouse gas (GHG) emissions identified as one of the most crucial steps in mitigating climate change. Therefore, numerous organizations, institutions, countries, and other groups in the national and international levels are actively involving to reduce emissions and achieve carbon neutrality. As higher education institutes for learning and research, universities also have the potential to make advancements independently, separate from national regulations or mandatory requirements [2]. Adopting innovative technologies and methods supported by their research, while raising a sense of sustainability and climate-friendly in younger generations, represent feasible approaches. Universities making official pledges toward achieving carbon neutrality would be help in conveying the message to other entities, including governments, demonstrating a hands-on action in the battle against climate change [3]. The quantification of carbon footprints, which measure greenhouse gas emissions, offers higher education institutes to establish a starting point when targeting forcarbon neutrality.

The carbon footprint evaluates all greenhouse gas emissions resulting from and associated to the activities of a system. This involves emissions originating directly from the system, along with specific indirect emissions caused by the selected system boundaries [4]. Besides carbon dioxide, methane, nitrous oxides, and fluorocarbons (HFC and PFC) are the main other greenhouse gases that are included. To address this, emission inventories mainly use the term 'CO2 equivalents' (CO2e). The result of such an assessment can assist in identifying the primary emission sources, serving as a baseline for designing efficient strategies to reduce greenhouse gas emissions [IPCC, 2014]. At the organizational level, it's essential to pay special consideration to standards like the GHG Protocol Corporate Standard [5]or ISO 14064-1 [6] when quantifying the carbon footprint. Usually emissions are assigned to scopes and categories in carbon footprint calculation. Guidelines of GHG Protocol Corporate Standard anticipated the division of the released greenhouse gases into three scopes. The first category represents to emissions directly caused, such as those resulting from on-site fossil fuel combustion. Scopes 2 and 3incorporate the indirect emissions]. Scope 1 and 2 only reflects energy-related, indirect emissions, which are resulting from the generation of the energy procured by the institution. Scope 3 includes all other non-energy-relatedindirect emissions, which incorporate emissions from activities like business travel and waste management [2].

Higher education institutions are insisted to set objectivesto become carbon neutral sooner in order to set an example for future generations of learners. The carbon footprint can act as a crucial instrument, not just for identifying the major sources of emissions but also for increasing awareness among both staff and the student community. Generally usedapproach for determining a university's carbon footprint is a hybrid model that combines two distinct methods for evaluating environmental effects: Life-Cycle Assessment (LCA) and Environmentally Extended Input-Output Analysis (EEIOA). Using this approach, emissions from scope 1 and 2 would primarily be calculated using activity data and suitable Emission Factors [EFs], whereas categories related to procurement and acquired equipment would depend on financial records and relevant EFs, particularly [2].

Universities, which are frequently swarming with varied people and energy-intensive businesses, have a big impact on local and global carbon footprints. In case of this, our study aimed to clarify Sri Lanka Technological Campus carbon footprint as well as the complex procedure involved in estimating and measuring emissions in accordance with Scope 1 and Scope 2 categories to the calendar year 2022. As the significance of this study has increased because of concerns about climate change and a worldwide dedication to reducing greenhouse gas emissions, having a thorough and precise understanding of carbon emissions on the campus is essential. The results of this study will not only benefit for Sri Lanka Technological Campus but will also serve as a reference for other institutions motivated to reduce their carbon footprint and engage in responsible environmental stewardship.

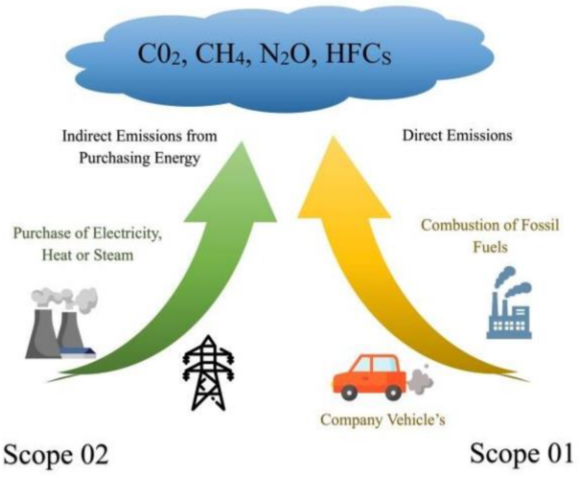

Fig. 1. Scopes of emissions of the university used for the study

II. Material and Methods

A. Sri Lanka Technological Campus

Sri Lanka Technological Campus (SLTC) is situated in western province of Sri Lanka and had around 4000 registered students plus about 300 staff members in 2022. Two main campuses are situated in the western province, splitting the city campus at the TRACE Expert city in Colombo and main campus at the Padukka premises. This study focused main campus which is located at Padukka spanning an area of 46.3 Acres. The university offers study programs on many levels, for example the university has five faculties: technology, engineering, computing and IT, science and music.

Fig. 2. Map of the study area. The mark indicates the Sri Lanka Technological Campus

B. Calculation Approach

The calculation of the University carbon footprint followed by the Greenhouse Gas Protocol Corporate Standard [5], Data related to the consumption of energy and the up keeping of the properties were mainly calculated and provided by the University's facility management. Information needed for the remaining emission categories was gathered by the university's carbon footprint research group. The carbon footprint will be presented in tonnes of CO_2 equivalents, following the global warming potential reported by the IPCC, 2014 [1] for all greenhouse gases (GHG). The choice of measuring emissions in accordance with scope 1 and 2 categories for the calculation of carbon footprint is influenced by the data availability of the university. Obtaining quantified solid waste data for the year 2022 within the university posed a significant challenge.

C. Scope 1: Direct Emissions

All emissions (E_{GHG}) assigned to scope 1 were determined using a life-cycle assessment (LCA) method, involving the multiplication of activity data (AD_{S1}) by the suitable emission factors (EFs). The calculation employed the following formula:

$$E_{GHG} = AD_{S1} \times EF \quad (1)$$

The activity data for direct emissions referred here incorporates information gathered from greenhouse gas emissions that originate directly from sources within the university premises. Direct emission sources were identified by conducting a physical survey and walk through assessment within the university. Suitable EF is chosen through IPCC (2014) and Greenhouse Gas Protocol Corporate Standard. Following table shows the direct emission sources within the university as identified in this study.

TABLE I. DIRECT SOURCE EMISSIONS WITHIN THE UNIVERSITY

Direct Emission Sources	**Type**
Diesel Generator	Point
Liquefied Petroleum Gas	Point
Grass Cutter	Point
Air Conditioners	Non point - Fugitive
Fire Extinguishers	Non point - Fugitive

D. *Scope 2: Indirect, energy related emissions*

Scope 2 includes the indirect emissions (E_{GHG}) resulting from the utilization of purchased electricity. The primary method employed for the calculation involves multiplying consumption data (CD_{S2}) by suitable emission factors, which also take into consideration the local conditions. The following equation was used for the calculation:

$$E_{GHG} = CD_{S2} \times EF \qquad (1)$$

Consumption data for indirect emissions within the university is acquired from the facility management of the campus to the year 2022. Appropriate EF is chosen through Sustainable Energy Authority of Sri Lanka.

III. RESULTS AND DISCUSSION

The total amount of emissions associated with the Sri Lanka Technological Campus sums up to 196.89 t CO_2e for the year 2022. To enhance comparability with other universities, the carbon footprint can also be expressed as 0.04 tons of CO_2 equivalent per person, considering the total number of students and staff members (4800). Fig. 3 shows the visualization of the carbon footprint and Table 2 displays the results in greater detail.

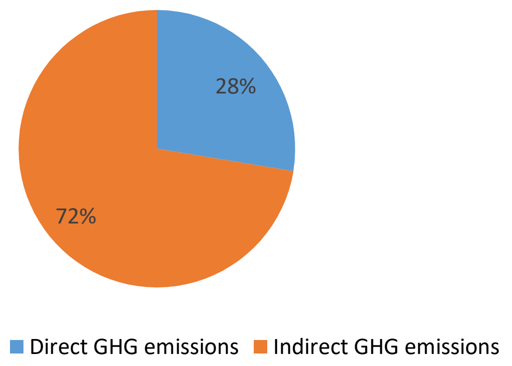

Fig. 3. The carbon footprint of SLTC in 2022

Based on the findings, scope 2 indirect emissions contribute significantly more to the university's carbon footprint, making up 72% of the total. This indicates that the electricity purchased for the campus contributes more to greenhouse gas emissions in the atmosphere than emissions from direct sources. Also, electricity sourced from renewable energy is considered carbon-neutral, it's important to not overlook energy efficiency and conservation in the future. This is because the carbon footprint is not the single sustainability metric that a higher education institution should take into account. Therefore, the university's carbon footprint can be reduced by implementing renewable energy sources for electricity procurement or generation. With regard to renewable electricity, the SLTC could further extend the deployment of solar photovoltaic (PV) systems on the roofs of its main campus areas to contribute to the broader energy transition.

TABLE 2. CARBON FOOTPRINT ESTIMATION IN SLTC

EMISSIONS - SLTC Padukka Premises			**Function of the campus**	**CO2-e TOTAL (Tonnes p.a)**	**Carbon (CO_2)**	**Methane (CH_4)**	**Nitrous (N_2O)**
	Scope 01 - Direct GHG emissions and removals in tonnes CO2-e			**54.32**	**39.39**	**0.44**	**0.06**
1	Direct emissions from Stationary Combustion	Generator	Teaching and learning	19.75	19.69	0.02	0.04
	Direct emissions from Stationary Combustion	LPG	Other	13.89	13.88	0.01	0.01
	Direct emissions from Stationary Combustion	Grass cutter	Other	6.13	5.70	0.41	0.01
	Direct fugitive emissions from the release of GHGs in anthropogenic systems.	AC	Teaching and learning	14.43	-	-	-
	Direct fugitive emissions from the release of GHGs in anthropogenic systems.	Fire Extinguishers	Safety	0.12	0.12	-	-
2	**Indirect emissions in tonnes CO2-e - Category 2**			**142.57**			
	Scope 02 - Indirect GHG emissions from imported energy			**142.57**			
	Indirect emissions from imported electricity		Teaching and learning	142.57			
TOTAL EMISSIONS SCOPE 1 and 2				**196.89**			

Furthermore, new procurement policies should be introduced at the university, favouring more energy-efficient or sustainable products within the bounds of economic feasibility. For instance, the campus can purchase inverter air conditioning systems, which can lead to a decrease in direct fugitive emissions. The University of Jyvaskyl in Finland¨ reported a carbon footprint of 40,873 t CO_2e in 2019 [7] and University of Olu, Finland reported carbon footprint as 19,072 t CO_2e in 2019 [2]. These universities in Europe are characterized by their substantial size, with approximately 20,000 students and a greater demand for electricity, especially during the winter heating season. Also, due to the presence of numerous components, laboratories, and facilities, these universities exhibit a higher carbon footprint compared to the one observed at this campus. These universities included scope 3 emissions in their carbon footprint calculations, whereas the current study exclusively concentrated on scope 1 and 2 emissions. Consequently, the current findings indicate a somewhat lower value. While the significance of higher education institutions striving for carbon neutrality is widely acknowledged today, it's equally important to closely examine the methods and strategies through which a university should attain this goal. Offsetting, compensation measures, or merely procuring renewable energy are straightforward and quickly implementable actions, but they may not result in enduring carbon neutrality in the long run [2]. Scope 3 indirect non-energy-related emissions encompass staff members' business travel, fuel consumption for rented vehicles, procurement activities, and waste management data. These data play a substantial role in determining the university's ultimate carbon footprint. Therefore, it is important to quantify carbon footprint by accounting all 3 scope emissions. Despite the global trend among higher education institutions toward sustainability, SLTC has not yet developed a sustainability or carbon-neutral plan for the university. This study emphasizes the importance of embracing carbon neutrality as a responsible higher education institution in Sri Lanka. Additionally, the measured carbon footprint presented in this study can inform decision-making processes related to adopting sustainable alternatives and green procurement etc.

This calculation of the carbon footprint provides an appropriate starting point for the university to start considering the reduction of environmental impacts by its operations. Based on this, university can implement sustainable policies such as energy saving policies, and kind of mitigation measures can be adopted. affiliations as succinct as possible. As stated before, scope 2 emissions significantly contribute more to this study. If only purchased electricity produced by renewable energy sources the institution’s carbon footprint could be reduced by over 142.57 t CO2e, lowering the share of Scope 2. Depending on the chosen categories, the results of educational organizations can vary greatly. Recognizing the substantial influence of indirect, non-energy related emissions on the carbon footprint is crucial, and there should be a strong endorsement for the compulsory incorporation of the principal categories within this scope. Recognizing the Offsetting is generally not a significant factor in the calculation of a higher education institution's (HEI) carbon footprint. Offsetting is typically viewed as a potential option following the carbon footprint calculation and is mainly contingent on the outcomes of that calculation. Furthermore, one could contemplate how to factor in the beneficial influence of a university's research when assessing environmental and sustainability objectives. So it is acceptable to employ methods like the carbon footprint to quantify the possible reductions in emissions facilitated by research and education. The findings of this study emphasize the necessity for the university to validate sustainable strategies as part of its commitment to a more sustainable future, aligning itself as a responsible higher education institution.

IV. CONCLUSION

Carbon footprint of Sri Lanka Technological Campus for the year 2022 was quantified and results indicate a total of 196.89 tons of CO_2e emissions under scope 1 and scope 2 emissions. Notably, a significant portion of this figure, approximately 72%, is attributed to the purchased electricity, a finding that deviates from the patterns observed in other documented case studies. This underscores the importance of tailoring mitigation measures to the unique local characteristics of the higher education institution (HEI). Adopting for purchasing renewable energy would be considerably reduce the carbon footprint of the campus. Therefore, authors see a need for better-investigated input data and more specific emission factors to use scope 3 emissions and include ultimate carbon footprint quantification of the study. It will enhance the comprehensiveness and accuracy of this study. Therefore, this case study can serve as educational resources in this context, and by comparing the methods employed, best practices can be developed.

REFERENCES

[1] IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC; WMO, Geneva, Switzerland.

[2] Kiehle, J., Kopsakangas-Savolainen, M., Hilli, M. and Pongrácz, E., 2023. Carbon footprint at institutions of higher education: The case of the University of Oulu. Journal of Environmental Management, 329, p.117056.)

[3] Gomez, ´ N., Cadarso, M.A., ´ Monsalve, F., 2016. Carbon footprint of a university in a multiregional model: the case of the University of Castilla-La Mancha. J. Clean. Prod. 138, 119–130. https://doi.org/10.1016/j.jclepro.2016.06.009.

[4] Harangozo, G., Szigeti, C., 2017. Corporate carbon footprint analysis in practice – with a special focus on validity and reliability issues. J. Clean. Prod. 167, 1177–1183.

[5] WRI, WBCSD, 2004. In: The greenhouse gas protocol. World Resources Institute; World Business Council for Sustainable Development, Geneva, Switzerland; Washington, DC R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[6] ISO, 2018. Greenhouse Gases - Part 1: Specification with Guidance at the or Ganization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals.

[7] El Geneidy, S., Alvarez Franco, D., Baumeister, S., Halme, P., Helimo, U., Kortetmaki, ¨ T., Latva-Hakuni, E., Makel ¨ a, ¨ M., Raippalinna, L.-M., Vainio, V., Kotiaho, J.S., 2021. Sustainability for JYU: Jyvaskyl ¨ an ¨ Yliopiston Ilmasto- Ja Luontohaitat. Jyvaskyl ¨ an ¨ Yliopisto, JYU.Wisdom - School of Resource Wisdom, Jyvaskyl