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ORIGINAL PAPERS

THE IMPORTANCE OF CALCULATING THE CARBON FOOTPRINT OF EGYPTIAN UNIVERSITIES AND THEIR ROLE IN SUSTAINABLE DEVELOPMENT: PORT SAIED UNIVERSITY AS CASE STUDY

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Abstract: Implementation of sustainability policies is a must to improve the environmental indicators of universities. One of these indicators is tracking the carbon footprint (CFP). Port Said University started tracking CFP in 2023 for Faculty of Science campus as a pilot study. Three operational limits (scopes) were established, based on the GHG protocol methodology, namely, Scope 1 (direct emissions e.g. fuel consumption in mobile sources), scope 2 (indirect emissions e.g. electrical energy consumption), and Scope 3 (other indirect emissions e.g. daily mobility). Scope 1, Scope 2, and Scope 3 revealed that their CFP annually were 49/5, 199.8, and 8443.6 tCO_2e, in 2023 and were 43.5, 166.8, and 8708 tCO2e respectively. It could be concluded that transportation is the main cause for the higher CFP, as scope 3 represented 97.1%, and 97.6% of the total emissions in the years 2023 and 2024, respectively. Moreover, this study showed that CFP of Scope 1 and 2 were reduced in 2024 when compared with 2023. This reduction (12.2 and 16%, respectively%) could be attributed to the environmental strategies imposed by the administration for wise management of resources and using clean transportation within the campus. On the other hand, the increment in GHG emission in Scope 3 was attributed to the increase in emission of students commuting due to the increase in their admission in 2024 compared to 2023. Universities serve as innovation hubs where data from carbon footprint assessments can drive new research in clean technologies, climate adaptation, and environmental policy. Collaboration between academia, industry, and government can produce scalable sustainability solutions relevant to Egypt's socio-economic context. This study could be a valuable reference for implementing emission reduction strategies in other nations, especially in the developing countries where universities share similar characteristics and face limitations in environmental data availability.

Keywords: Carbon footprint; Scopes; sustainability; emissions; universities

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1. Introduction

Universities are not only centers of learning and research but also significant consumers of energy and resources. In Egypt, where the higher education sector is rapidly expanding, calculating the carbon footprint of universities is an essential step toward achieving the nation's sustainable development goals (SDGs) and aligning with Egypt's Vision 2030 and commitments under the Paris Agreement [1, 2]. Universities play a pivotal role in shaping societal values and behavior. Through carbon footprint assessment and reduction initiatives, Egyptian universities can model sustainable practices, educate students on environmental stewardship, and promote responsible citizenship within academic communities. The higher education sector contributes to Egypt's national climate strategies by aligning campus sustainability actions with the National Climate Change Strategy 2050 (NCCS 2050). Accurate carbon accounting enables universities to report progress, participate in carbon reduction programs, and support Egypt's transition toward a low-carbon economy.

SDGs provide clear guidelines and targets for all countries to adopt in accordance with their own priorities and the environmental challenges of the world at large [3]. Mitigation of climate changes through awareness campaigns is a fundamental target of goal 13 (Climate Action).

Quantifying the carbon footprint allows universities to identify the major sources of greenhouse gas (GHG) emissions—such as electricity consumption, transportation, waste generation, and laboratory activities [4]. This helps in understanding how institutional operations contribute to climate change and highlights areas where improvements can yield the greatest environmental benefits. By calculating emissions, universities can pinpoint inefficiencies in energy use, water management, and waste handling [6]. Implementing corrective measures—such as renewable energy systems, energy-efficient buildings, and sustainable mobility—reduces both carbon emissions and operational costs, creating long-term financial and environmental benefits.

Universities are committed to Sustainable Practices by promoting more sustainable lifestyles through greening their campuses and reducing the environmental footprint (United Nations Conference on Sustainable Development, 2012; cited [6]). Consequently, universities are a relevant case study organization to assess the relevance and applicability of carbon management standards [7]. However, this commitment should not only be based on educating students in sustainable practices but also on the report of sustainability indicators, such as the carbon footprint (CFF). It is believed that hundreds of higher education Institutions have reported their GHG emissions inventory. However, there is an urgent need that more institutions to be committed to Sustainable Development (SD) and CFF reporting worldwide [6 - 8].

Over the past few years, interest in global warming and climate change has grown exponentially and people now realize that it is time to act. Our aim was to expand and incorporate the concepts and principles of sustainable development in the educational, research and service fields, thus estimating the carbon footprint, to meet environmental challenges and to help mitigate climate change. To the best of our knowledge this is the first study investigating carbon footprint of higher education institutions in Egypt.

2. Methodology

The carbon footprint of Faculty of Science, Port Said University (Figure 1), was determined during 2023 and 2024. The site was selected as both academic and administrative activities of the institution are concentrated in one building. Business and operational units that are owned or controlled by the university as well as the direct and indirect emissions generated within the campus boundaries were identified according to international standers [4 – 6, 9].

Figure 1. Location of the studied campus.

Three types of emissions (Scopes) were considered. Scope 1 (Direct emissions) are those that come from sources that are owned or controlled by the university. Scope 2 (indirect emissions) are associated with water and electricity energy consumption, while Scope 3 (other indirect emissions) are those that are not owned or controlled by university (paper consumption, travelling). Types of emission were summarized in Figure 2.

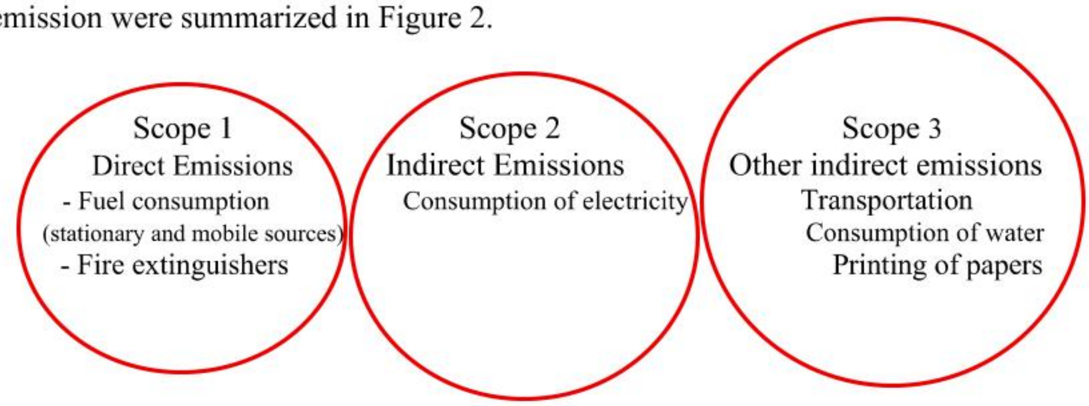

Figure 2. Types of emissions (operation limits) of the research.

The annual distances traveled by staff, employees and students were estimated [1, 3]. Moreover, private cars were recorded (frequency and type of fuel, brand, sharing the vehicle with other people when traveling, etc.). All the data were calculated using and the QGIS geographic software [1, 6].

3. Results and discussion

The carbon footprints of the campus were 8692.9 and 8918.27 tCO_2-eq., in 2023 and 2024, respectively (Table 1). The direct emissions (Scope 1) due to fuel consumption (stationary and mobile sources) in 20203, yielded 49.50 tCO_2-eq., the indirect emissions due to electrical energy consumption (Scope 2) was199.8 tCO_2-eq., while the other indirect emissions (Scope3) were 8443.6 tCO2-eq., representing the highest proportion of the total emissions.

Regarding indirect emissions not associated with electricity, these occurred mainly due to the daily committing of students and staff (77.2 and 13.1% in 2023 and 83and 10.4% in 2024, respectively), and travel of officials (8.4 and 5%, in both years, respectively) (Table 1).

It was observed that the daily mobilities of students were the most representative (75 and 81% in 2023 and 2024, respectively), followed by daily travel of staffs (12.7 and 10.1% in the same years, respectively), travel of officials (8.1 and 5.1%, in 2023 and 2024, respectively), and electrical consumption (2.3 and 1.9% in both years, respectively) (Figure 3).

Table 1 Greenhouse gases (GHG) emissions (tCO^2-eq.) during 2023 and 2024

Scope	Emission Source	2023		% in the total	2024		% in the total
		tCO^2-eq.	%		tCO^2-eq.	%	
Scope 1 (Direct) **Total**	Fuel Consumption: - Mobile Sources -Stationary Sources - Fire extinguishers	 33.5 15.3 0.7 **49.5**	 67.7% 31% 1.3% **100%**	0.6%	 31.07 11.6 0.8 **43.47**	 71.5% 26.7% 1.8%	0.5%
Scope 2 **Total**	Electrical energy consumption	199.8 **199.8**	100% **100%**	2.3%	166.8 **166.8**	100%	1.9%
Scope 3 Other indirect Total	- Travel of students - Travel of staff - Travel of officials - Paper consumption - water consumption - Waste management	6511.8 1109.4 703.7 98.2 11.8 8.7 **8443.6**	77.2% 13.1% 8.4% 1.1% 0.1% 0.1	97.1%	7229.5 903.3 459.4 98.4 10.1 7.3 **8708**	83% 10.4% 5% 1.1% 0.1% 0.4%	97.6 %
Total emissions		**8692.9**	**100**	**100**	**8918.27**	**100**	**100**

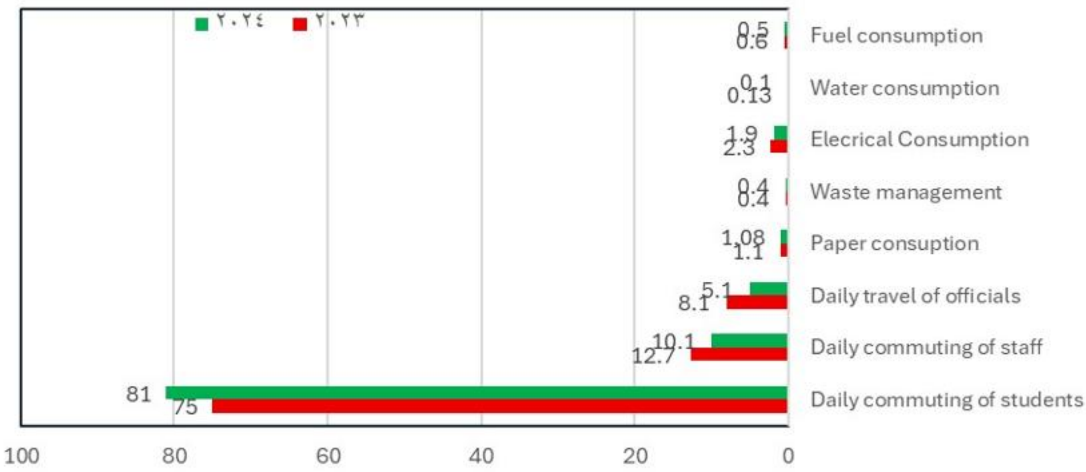

Figure 3. % of each source of emission measured to total emissions.

Table 2 shows that the indirect emissions of scope3 have the highest participation in the total GHG emissions worldwide except Canada, Australia and some universities in the UK.

Table 2. The contribution of different scopes in total emissions worldwide.

Country	% contribution of each scope			Reference
	Scope 1	Scope 2	Scope 3	
Egypt	1.1	2.1	97.3	The present study (averaged between 2023 and 2024)
India	1.1	50	48.9	Sangwan et al. 2018 [10]
Colombia	0.9	2.5	96.6	Varón-Hoyos et al., 2021 [3]
Chile	16	16	68	Vásquez et al. 2015[1]
Chile	5	35	60	Yañez, et al. 2020 [2]
Brazil	1.5	0.2	98.3	Carvalho et al. 2011 [11]
Mexico	4	24	72	Mendoza-Flores et al., 2019 [12]
UK	6	15	79	Ozawa-Meida et al., 2013 [13]
UK	27.9	49.4	22.8	University of Bristol report, 2018 [14]
UK	20	58	22	University of Cambridge report, [15]
Spain	3.6	16.9	79.4	Hermosilla et al. 2014 [16]
Spain	24.6	30.2	45.2	Universidad de Valladolid 2014 [17]
Spain	6.3	20	73.6	Puchades et al. 2011 [18]
The Netherlands	44.2	28.1	27.7	Wageningen University report, 2018 [19]
Turkey	16.3	65.4	18.3	Sreng & Yigit, 2017 [20]
Canda	52	40	8	University of Alberta report, 2014 [21]
USA	63.2	3.7	33.1	Colgate University Report, 2018 [22]
USA	44.2	28.1	27.7	University of California-Berkeley, 2016 [23]
New Zealand	22.1	18.1	59.7	Victoria University of Wellington, 2017 [24]
Australia	4	69	27	Favacho, 2016 [25]
Indonesia	11.6	1.8	86.6	Rahayuningsih et al., 2021 [26]

There were notable decreases in GHG emissions in fossil fuel consumption in stationary and mobile sources (Scope 1) (12%) and electricity consumption (Scope 2) (16.5%) between 2023 and 2025. (Table 3). However, there was a slight increase in GHG emission in Scope 3 (%), although there were significant decreases in waste management, water consumption, and travel of officials and staff. Nevertheless, there was a significant increase in emissions from commuting of students.

Table 3. Variation in GHG emissions (tCO^2-eq.) between 2023 and 2024.

Scope	2023	2024	% difference
Scope 1 (Direct)	49.5	43.47	- 12.2%
Scope 2 (Indirect)	199.8	166.8	-16.5%
Scope 3 (Other indirect)			
- Travel of students	6511.8	7229.5	**11%**
- Travel of staff	1109.4	903.3	-18.6
- Travel of officials	703.7	459.4	-34.7
- Paper consumption	98.2	98.4	-0.2
- water consumption	11.8	10.1	-9.0
- Waste management	8.7	7.3	-16
Total of Scope 3	8443.6	8708	**3%**
Total	**8692.9**	**8918.27**	**2.6%**

Discussion

The highest proportion of the total emissions in the present study was recorded for Scope 3 (8576 t CO_2-eq., representing 97.35% of the total emission of the campus, averaged between 2023 and 2024), while the indirect emissions associated with electricity (Scope 2) were 183.3 tCO_2-eq. (representing 2.1% of the total emission averaged between 2023 and 2024). The emissions directly produced by the campus (Scope1) yielded a total of 46.5 tCO_2-eq., representing 0.55% of the total emission (averaged between 2023 and 2024).

The consumption of fossil fuels from stationary sources and mobile sources are the main sources of direct emissions (Scope 1). The highest participation of the indirect emissions of scope 3 in the total GHG emissions is in agreement with the results from different Universities in the UK, USA, Europe, Asia, Australia and Latin America [1 – 4, 10 – 26]. Moreover, our results are very comparable to those obtained from Colombia, Brazil and Indonesia [3, 11, 26]

Direct and indirect GHG emissions decreased by 12.2 and 16.5% between 2017 and 2018, mainly due to reductions in emissions from sources such as fossil fuel consumption in stationary and mobile sources and electricity consumption (Table 3). However, there was a slight increase (3%) in Scope 3 in 2024 when compared with GHG emissions in 2023, although commuting and travel of staff and officials as well as water and paper consumptions were reduced significantly. This increment could be attributed to the increase in GHG emissions due to transport of students (+11%). Increment of carbon emissions from travel of students could be ascribed the increase of their admission and consequently their increased use of mechanized means [2]. Likewise, in the framework of Scope 3 emissions, most of this type of emissions are attributed to the daily commuting of students [1, 2, 3, 11, 16, 18, 26]. However, some universities, especially in

Canada, Northern USA and Europe, have the Scope 1emissions are the dominant and Scope 3 is less representative [19, 21, 22, 23]. The considerable increase in Scope 1 emissions could be attributed to the extensive usage of fuels for heating in sever winter period. In contrast, the weather in Egypt and most of developing countries is not harsh in winter.

In general terms, the reductions in emissions of fossil fuel, electricity, water and paper consumption, as well as the restrictions on the travel of officials were successful in reducing GHG emissions between 2023 and 2024. Therefore, it is necessary to reduce the admission of undergraduates to reduce and control their carbon footprint. Among the emission reductions mentioned, those that would have been presented in relation to travel of officials and commuting of staff stand out, since strategies enforced by the government have involved reductions in their GHG emissions by 19 and 35%, respectively, despite the fact that in 2024 the emission factors showed an increase of 3% on average compared to those of 2024 due to a greater emissions from travel of students (115), which indicates the increase in use of mechanized means.

4. Conclusions

Assessing and calculating the carbon footprint of Egyptian universities goes far beyond simple measurement; it serves as a strategic mechanism for embedding sustainability into campus governance, academic programs, and public engagement. By taking a proactive role in this field, Egyptian universities can become influential drivers of national progress, helping steer the wider community toward a more sustainable and climate-resilient future.

The GHG emissions reported in this study are comparable to those observed at many universities globally, largely because community mobility typically represents the dominant contributor to total emissions. The findings can also be attributed to the fact that the university neither produces its own electricity nor relies on heating during any time of the year.

To the best of our knowledge, this is the first study to have measured carbon footprint in a public university in Egypt, with the GHG Protocol methodology, broadly covering the three recommended scopes. One limitation of the present study was not being able to calculate carbon footprint per capita. It would be better if the per capita footprint was considered as it makes it possible to know the individual contributions of the educational community. This warriants further investigation.

Disclosure statement
No potential conflict of interest was reported by the authors

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