Turning Climate Mitigation Concerns into Institutional Sustainability: Using Carbon Accounting as a Tool for Resource Management in a Desert Environment

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1 Introduction

The term "Carbon Footprint" (CF) has been the subject of interest and debate among environmentalists and scientists worldwide for the past few decades. Greenhouse gases are defined as gases that trap heat within the atmosphere and include carbon dioxide (CO_2), methane (CH_4), and hydrofluorocarbons (HCFCs), among others. The scientific community focuses research on CO_2 concentrations more than on other greenhouse gases due to the gas's abundance in the atmosphere and Global Warming Potential (GWP). The greenhouse effect is defined as the process by

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which radiation from the sun is trapped in the earth's atmosphere and warms the surface. CO_2 is the main component of the greenhouse effect; without it, there would be no sustained life on earth. While the planet is defined as a closed system, meaning the total carbon stock has remained unchanged—be it in solid, liquid, or gaseous form—the growth of industry and subsequent globalization has led to fossil fuels being extracted from the earth at a rapid rate. Burning fossil fuels, such as coal, crude oil, and natural gas for power generation releases excess CO_2 into the atmosphere and amplifies the greenhouse effect. The amplification of the greenhouse effect creates global warming or a long-term increase in the average temperature of the earth's climate system. The repercussions of delaying action to reduce greenhouse gas emissions include the risk of cost escalation of goods and services, locked-in carbon-emitting infrastructure, stranded assets, and reduced flexibility in future response options to climate change (IPCC, 2018).

The United Nations' Intergovernmental Panel on Climate Change (IPCC), the leading body for assessing climate change globally, concludes that higher concentrations of greenhouse gases in the atmosphere due to human activity, most notably CO_2, are the predominant cause of recently observed global warming, glacial melt, and rising sea levels. Following the adoption of the Paris Agreement in December 2015, a landmark decision to combat climate change and accelerate the actions and investments needed for a low carbon future, the United Nations called upon the IPCC to produce a special report on global warming. Released in October 2018, the IPCC deduced that limiting global warming to 1.5°C above preindustrial levels[1] would "require rapid, far-reaching and unprecedented changes in all aspects of society" (IPCC Summary, 2018, p. 5). The special report also argues that climate change's various impacts, such as rising global sea levels or melting of Arctic Sea ice, could be lessened or avoided altogether if global warming were limited to 1.5°C in comparison to 2°C.

Currently, global warming has already surpassed preindustrial levels by 1°C. The consequences of this warming are evident in the increased

[1] The IPCC uses 1850–1900 as the reference period to represent pre-industrial temperature (IPCC, 2018).

frequency and intensity of extreme weather events, localized sea level changes, less sea ice coverage. If the world continues to hold a "business-as-usual" mindset and does not implement sustainable development strategies, global warming will continue to increase past 1.5°C. Unchecked global warming above 2°C or beyond would increase the risk of long-lasting or irreversible changes, such as the loss of some ecosystems (IPCC Summary, 2018). If global CO_2 emissions reach net zero in 2055, meaning that the reduction efforts for CO_2 would equal the amount of CO_2 being emitted, the likelihood of limiting warming to 1.5°C is more favorable. However, the emissions of certain countries, such as China and the United States, continue to grow, leading the world into uncertain climate change.

With the dangers of global warming heightening, plans to slow down climate change have been on the political and corporate agenda globally. Egypt is one of the most susceptible countries to global warming, mainly due to uncertainties related to water availability (Wes, 2022). Within the broader agenda of climate change mitigation, carbon accounting, which entails quantifying carbon emissions, is one of the valuable first steps toward making reductions in footprint. Of course, to quantify carbon emissions on the national level, for Egypt, for example, would require calculating emissions for different organizations and institutions. This quantification can help clarify which activities contribute most to the organization's footprint, enabling organizations to benchmark their environmental performance within their sector of activity, track progress and improvement, and above all, can help guide executive decisions that can yield financial, environmental, and reputational benefits (Awanthi, 2018). Additionally, with the rise of environmental policies, organizations (especially large ones) must be prepared to meet the expected regulatory requirements for carbon reduction and to follow more stringent and transparent reporting requirements.

For higher education institutions (HEIs), sustainability has become a major area of interest. Recent ranking agencies have started considering universities' actions in sustainable development and green economy. A recent example is the Impact ranking[2] which ranks university activities

[2] https://www.timeshighereducation.com/rankings/united-states/2022.

based on their alignment with the United Nations' Sustainable Development Goals (2015). While much of the ranking is focused on the universities' academic output, a large portion of the score is still based on the HEIs internal policies and processes. Additionally, recent research has shown that more sustainable and green universities are more competitive and attractive to students. For example, studies have shown that students are more satisfied in HEIs, which boast a green image (Chairy et al., 2019) and are usually more engaged in sustainability skill-building activities, which they perceive as an added value (Dagiliūtė et al., 2018).

One of the first steps to becoming a green or sustainable campus is tracking and managing carbon footprints (CF). For HEIs, quantifying, tracking, monitoring, and controlling environmental footprints are key strategies to institutionalize sustainability in the operation and management of campuses. In addition, the practice contextualizes the environmental footprint of these institutions within the global university network, promotes their sustainability interventions, and internationalizes their practices. Carbon accounting in HEIs is especially important for institutions in developing countries, such as Egypt, where quantifying carbon emissions is not readily practiced nationally. The American University in Cairo (AUC) is one of the first HEIs in the Middle East to take on this challenge. The Carbon Footprint Reports for AUC have provided insights on higher education's carbon and environmental footprint in the hot arid climate region of the Middle East and North Africa (MENA). Most importantly, AUC's Carbon Footprint Reports presented themselves as strategic planning documents, which highlighted key gaps in the operational standards of the campus, and key areas where energy, water, and material resource are not effectively used. Thus, the reports quickly became used to guide decision-making in the operation, management, and optimization of the campus and its facilities and services.

This chapter examines CF in detail, presenting their relevance to HEIs, especially in locations where carbon data is scarce, such as Egypt. The chapter first provides a short overview of the climate challenges in Egypt and the MENA region before presenting an in-depth analysis of CF practices in HEIs and beyond. Then, an overview of AUC's Carbon Footprint report highlights its major findings since the beginning of the initiative in 2012. The review and data we present highlight how the carbon footprint estimate at AUC's campus helped develop key recommendations that were beneficial for reducing the environmental damages on campus, potentially resulting in significant savings in operational costs (Bull et al., 2011).

2 Regional Challenges in Egypt and the MENA Region

According to the AUC's annual Carbon Footprint Report for the year 2015, "The rising sea levels predicted by climate change models threaten to flood large swaths of the Delta, Egypt's breadbasket, undermining Egypt's food security and threatening the livelihoods of millions of agricultural workers" (AUC, 2015, p. 10). Despite imminent threats from climate change, such as rising sea levels, water scarcity, and food insecurity, Egypt is among the top ten countries with the greatest greenhouse gas (GHG) emission increases.

Egypt's rapid population growth coupled with previous subsidies from the national government may have led to overconsumption and overreliance on fossil fuels. As the largest non-OPEC (Organization of the Petroleum Exporting Countries) oil producer and the second-largest dry natural gas producer in Africa, Egypt has a robust fossil fuel energy sector (African Vault, 2017). Egypt's total GHG emissions were approximately 272 million MT CO_2e per the latest Climate Data Explorer data in 2014. Egypt's GHG emissions are considered the third highest out of all countries in the MENA region, behind Saudi Arabia and Iraq. This is illustrated in Fig. 1. More than 40% of Egypt's GHG emissions come from just two sectors: power generation and road transport. By 2030, it is predicted that national emissions will have more than doubled current levels and will increase faster than population growth.

Simultaneously, Egypt is widely considered a country with the right physical environment to meet a significant portion of its energy needs by utilizing wind and solar power. The power dynamic between Egypt's renewable and nonrenewable energy sectors will shift with the global push for renewable energy resources. Over the past few years, policy changes and the gradual removal of fossil fuel and electricity subsidies have created

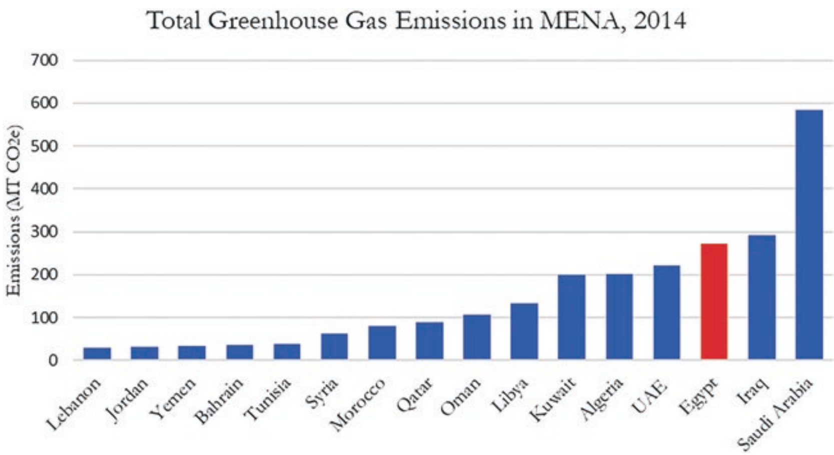

Fig. 1 Egypt's greenhouse gas emissions in comparison to other countries in the Middle East and North Africa region (Climate Watch, 2015)

public awareness and shift in consumption behaviors. Recognizing the potential of the renewable energy sector, the Egyptian government recently announced its ambitious goal of growing the domestic renewable energy sector to 20% of the national electricity grid by 2022. In pursuit of this goal, governmental agencies have partnered with internationally based renewable energy companies, established a net-metering energy tariff, and drafted a standard power purchase agreement for Egyptian organizations to use when purchasing renewable energy. According to the New and Renewable Energy Authority (NREA), Egypt is the only nation in the Middle East that has allocated land specifically for developing renewable energy sources. Egypt is primed to assume a regional leadership position in using renewable energy over the coming decade.

Aside from challenges in the energy sector, climate change poses an immediate threat to agriculture. Warmer temperatures and decreased precipitation in already arid climates, such as Egypt, will hinder the country's agriculture output, potentially impede development, and reduce national crop exports. Projected population growth from 80 million to 98.7 million by 2025 will only put further stress on crop yields and the fixed water output of the Nile River. According to the Ministry of Water Resources and Irrigation, the country will need 20% more water by 2020 to sustain its population and agriculture, a goal that the country is mobilizing its resources to meet.

In response to the Sustainable Development Goals, Egypt launched its Sustainable Development Strategy (SDS) titled “Egypt Vision 2030.” This strategy addresses vital targets and goals in terms of social, economic, and environmental development to be achieved by 2030, and serves as a guiding framework for all national development. Egypt Vision 2030 can be broken into four main pillars: (a) Social Justice; (b) Knowledge, Innovation & Scientific Research; (c) Economic Development; and (d) Environment. The Vision hopes to usher in a new Egypt where the population has access to adequate living standards, healthcare, employment opportunities, and climate change mitigation. To address these concerns, there are concrete goals centered on energy, health, education, and training.

These challenges necessitate organizations, including HEIs, to begin tracking their greenhouse gas emissions to identify possible improvements and carbon reduction areas. The literature analysis presented in the upcoming section offers a synthesis and critique of some studies on the importance of tracking carbon emissions and the various methods of calculating greenhouse gas emissions. It also reflects on some of the recommendations for reducing CO_2 emissions on university campuses.

3 Carbon Footprint Accounting in HEIs and Beyond

In the many studies published on reducing CO_2 emissions and increasing sustainability, one can find a broad range of perspectives as well as in-depth case studies. These works must be studied together to provide a more holistic and comprehensive understanding of which reduction strategies can be best applied.

For HEIs, all campus activities and maintenance contribute to an institution’s carbon footprint and reducing these emissions depends on the active participation of its occupants and stakeholders (Hignite, 2009). To better understand each stakeholder’s needs, it is important to divide them correctly, as carbon footprint structures vary from one department to another. This highlights the importance of conducting individual departmental analyses to determine which strategy will best help reduce greenhouse gas emissions (Larsen et al., 2013). For example, in departments more heavily reliant on Information Communication Technology (ICT), Song et al. (2016) suggest that changes in ICT use could help sustainability efforts by reducing the digital presence of the campus.

Studies show that on-campus education and awareness about sustainable development is an integral part of implementing plans to reduce the institution's carbon footprint (Lozano et al., 2013; Lambrechts & Van Liedekerke, 2014). To do so, the HEI must integrate carbon footprint analysis, whether as an education tool for students or as a part of policy development, a process that is outlined by Lambrechts and Van Liedekerke. A case study analyzing a university in Shanghai suggests mapping the consumption patterns and behavioral tendencies of students, then using that data as a reference for how to better engage the campus population with sustainable development projects (Li et al., 2015).

Combining broader perspectives with individual case studies such as this one is an important part of developing successful approaches to carbon footprint reduction. Important case studies we examined include resource consumption-based research from universities in the United Kingdom (Meida et al., 2011), Thailand (Aroonsrimorakot et al., 2013), and Chile (Vasquez at al., 2015). Individual case studies may prove useful to universities in similar environments, and looking at them from developed and underdeveloped regions may assist comparisons across socio-economic and regional contexts. Studies employing a multiregional approach may pave the way for a regional analysis for the ways carbon footprint may vary between different environments within a single country or set of institutions in the same region (Gómez et al., 2016).

Specific case studies also allow for collaboration and attempts at standardization. Geng et al.'s study at Shenyang University (2013) proposes an integrated model for green universities, emphasizing the importance of HEI collaboration with local governments to formulate a detailed plan for the stakeholders involved. Additionally, Klein-Banai and Theis (2013) argue that large-scale interinstitutional collaboration is required to help reduce carbon emissions on a much larger and thus, much more significant change. Moreover, the benefit of formulating a standardized methodology to assess HEIs carbon footprint would be the elimination of discrepancies and the assurance that all data is collected analogously, which would allow for comparison with similar institutions (Robinson et al., 2018).

Such comparisons could improve ranking systems, such as the GreenMetric Ranking, developed by Universitas Indonesia in 2010, which Ragazzi and Ghidini (2017) argue could benefit from adding thresholds and scoring bands. These systems facilitate case studies and contribute to global awareness of sustainability. On a larger scale, the United Nations' Sustainable Development Goals (SDGs) can help individuals, institutions, and governments naturally gravitate toward policies that encourage environmental sustainability (Mori Junior et al., 2019). Moreover, because the SDGs are applied to numerous countries and regions across the globe, their universality makes it easier to compare different application methods.

Though trend charts may be inadequate as institutions attempt to compare with one another, a composite indicator could overcome this issue (Olszak, 2012). Any methodology or charts developed to address sustainability, however, must be user-friendly, accessible, and easily adoptable in order for them to be widely implemented (Schwartz et al., 2016; Tjandra et al., 2016).

Following awareness campaigns and collaborative studies, HEIs must then actively work toward attaining their goals. When implementing sustainable development plans, within the scope of interinstitutional collaboration, individual HEIs must remember to consider their specific needs when creating carbon emission reduction goals that align with the institution's mission, culturally and financially (Hignite, 2009). Faghihi et al. (2015) argue that there is potential to design sustainable campus improvement program by creating dynamic models that use energy efficiency and conservation (Faghihi et al., 2015). Moreover, by turning again to individual case studies, HEIs can learn how to implement specific, measurable goals according to specific resource conservation.

For example, changes to campus building design can have an impact on energy consumption by using more energy-efficient methods to cut down on lighting and air conditioning (Luo et al., 2017). Energy simulation software is an important tool as it enables the testing of the impact of design interventions on energy consumption. Moreover, Schwartz et al. (2016) highlight the impact and potential of building refurbishment and redesign to minimize carbon emissions in a cost-efficient manner. This would not only result in the reduction of on-campus carbon emissions, but would help to reduce new raw material production, as well as other associated carbon footprint reductions across the supply chain (Cobut et al., 2015).

In these designs, renewable energy and energy optimization are integral factors in reducing their carbon footprint. Onat et al. (2014) show that on-site renewable energy and optimizing energy performance are essential to ensure buildings meet sustainability goals. When analyzing the carbon footprint of electric processes, it is important to contextualize them and consider the hindrances to simulation, such as electricity usage being dependent on immediate need (Marnay et al., 2002). With these considerations in mind, renewable energy in its different forms—solar, wind, hydro, geothermal, and biomass—are potential solutions to help reduce carbon emissions from electricity However, when examining hydroelectric energy, it is important to consider other uses for water sources and how this process impacts resources (Liu et al., 2015). This can be carried out using an environmental framework, where indirect emissions from the water supply, wastewater treatment, and disposal are assessed (Gu et al., 2018).

New tools, models, and methods for tracking, monitoring, and reducing carbon footprint are developed and introduced as a result of specific case studies. These include a compound method based on financial accounts (Alvarez et al., 2014), and a calculator that allows users to examine the different amounts of materials and waste produced on campus (Conway et al., 2008). One important tool relied on by many is the life cycle assessment (LCA), used to examine the entire cycle of a product which "is a unique method to assess the environmental performance of buildings and in decision making in building projects" (Munarim & Ghisi, 2016, p. 235). Evaluating different examples of LCA can also be helpful as expanding research to "include full life cycle contributions and impacts," studies can highlight the benefit of reusing and recycling, especially evident in the construction of new buildings instead of refurbishing older ones (Bin & Parker, 2012).

In this study, we use the following tools and frameworks to analyze AUC's CF. The examination of carbon footprint measurement methodologies and exploration of the ecological footprint by Mancini et al. (2016) helps inform this study. Additionally, a brochure issued by the US DOE/EIA provides metrics for measuring and analyzing carbon footprint. Important models include the Green Building Eco-environment (GBE) model, which is used to track and record the existing state and future trend of variation in green building development's eco-environmental impact (Teng et al., 2016). To create a Green Building Eco-Environment System Dynamic (GBE-SD) model, Venism Software was used (Teng et al., 2016). Numerous other tools, such as Umberto NXT and the GHG protocol of ISO 14064, were also implemented to estimate total CO_2 emissions (Singh et al., 2018).

These sources, when studied together, help to inform the process of monitoring carbon emissions and creating effective plans for their reduction. For Egypt, this perspective is especially important given that the country's national greenhouse gas (GHG), or carbon emissions, are the second highest in the MENA region and are expected to increase at a faster pace by 2011 based on a study done by Carbon Group, 2011; Egyptian Environmental Affairs Agency, 2012.

4 The AUC Carbon Footprint Report

The 2021 AUC Carbon Footprint report sheds light on the significance of monitoring carbon footprint in the transition toward a more sustainable, energy-efficient environment. The AUC's series of published reports from 2012 to 2021 discuss how carbon footprint is a good indicator of how human activity influences global warming. Their Carbon Footprint Reports list the annual total of carbon dioxide (CO_2) and other significant greenhouse gases produced because of daily on-campus operations and activities measured in metric tons (MT CO_2). The report exemplifies that investing in investigating the carbon footprint of HEIs is both important and rewarding.

The authors position this report, and the investment in carbon accounting at AUC, as one of the first steps in the mitigation of the potentially disastrous consequences that global warming could have on Egypt and the university's duty. They also highlight the commitment of their institution to the goal of contributing innovative research to the field of sustainability. Finally, this study acts as a base for AUC's desire to make its operations more efficient and sustainable.

In the first report, published 2012, the carbon footprint of AUC's New Campus was closely tracked and recorded for the academic year 2010–2011 (AUC, 2012). The study showed that 90% of the carbon produced by the university operations is mainly attributable to HVAC systems and domestic hot water (about 40% of emissions), transportation (about 31% of emissions, with very high emissions due to the use of private cars), lighting, and the electricity of other nonlighting and electrical equipment (22% of emissions). The average total emissions per full-time-equivalent-students[3] for that year was 9.3 MT CO_2e. The main recommendations in the report included:

- Adjusting the cooling and heating temperature for HVAC
- Pausing HVAC equipment when spaces are not being used
- Diversifying energy sources (to include solar photovoltaic and thermal systems)
- Encouraging the use of AUC transport buses or public transport, to reduce private car ridership
- Improve operational efficiency of bus fleet
- Equipping spaces with automatic motion sensors to ensure lights are turned off when not in use
- Mandating double-sided printing
- Using recycled water for irrigation

The report published in 2015, summarizes the historical data when it comes to greenhouse gas emissions for the academic years 2011–2013 and 2013–2014. The report summarizes the carbon footprint results in graphs and tables, making it easier for readers to comprehend. The report showed that the implementation of the recommendations from the previous reports resulted in reduction of 1611 MT CO_2e (or approximately 4.25%)

[3] Calculating by dividing the average total emissions of the campus for a given year by the number of students. While the full-time-equivalent-student (FTE) calculation standardizes students' actual course load against the full course load (15 credits per semester).

from the 2012 levels. Some components saw significant reductions such as HVAC (-22%), water (-25%), and paper (-21%). However, transportation and emissions due to the use of refrigerants increased by 25% and 13% respectively. The average total emissions per full-time-equivalent-students for that year was 6.1 MT CO_2e, a reduction of more than 30% from the 2012 years. While the overall reduction was small, the increasing number of enrolled students highlight the importance of the recommendations and sustainability initiatives that the university applied. The study still showed that 95% of the carbon produced by the university operations is mainly attributable to HVAC systems, domestic hot water, transportation (especially private cars), lighting, and the electricity of other nonlighting and electrical equipment. Based on these findings, the report suggested a series of recommendations including:

- Improving HVAC Schedule to actual match class and space usage
- Diversifying energy sources (to include solar photovoltaic and thermal systems)
- Improving incentives for using AUC transport buses or public transport, to reduce private car ridership
- Reducing HVAC water usage through recirculation
- Use of native plants, which commonly use less water, to reduce irrigation water consumption

In the most recent report, published in 2021, the university reported a total reduction from 2012 levels of about 19% (8145 MT CO_2e), with all categories seeing reductions ranging from 22% to 51%. The average Total Emissions /full-time-equivalent-Student for that year was 3.9 MT CO_2e, a reduction of almost 58%. The categories of emissions were further broken down to include solid waste management and use of fertilizers. A comprehensive study on the effect of transportation on CO_2 emissions was also established; the rise in the emissions was mainly attributed to commuting by buses and cars. Figure 2 shows an illustrative summary of the report, and Fig. 3 shows the Total Emissions /full-time-equivalent-Student in MT CO_2e for Academic Years (AY) 11 to AY20.

The findings indicate that there was a significant drop in emission in 2020, which was mainly attributed to slowed down or partial operations during COVID. Thus, the data reported for that year was contingent on the remote learning conditions that were enacted for almost half of the report period (i.e., from March 2020). Based on this, the authors

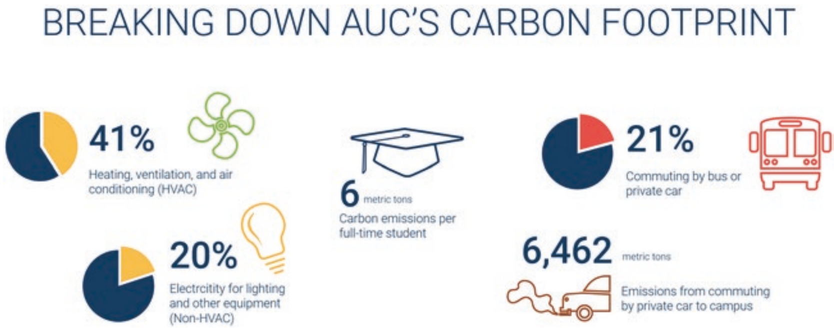

Fig. 2 Illustrative summary of the 2021 AUC Carbon Footprint Report (AUC, 2021)

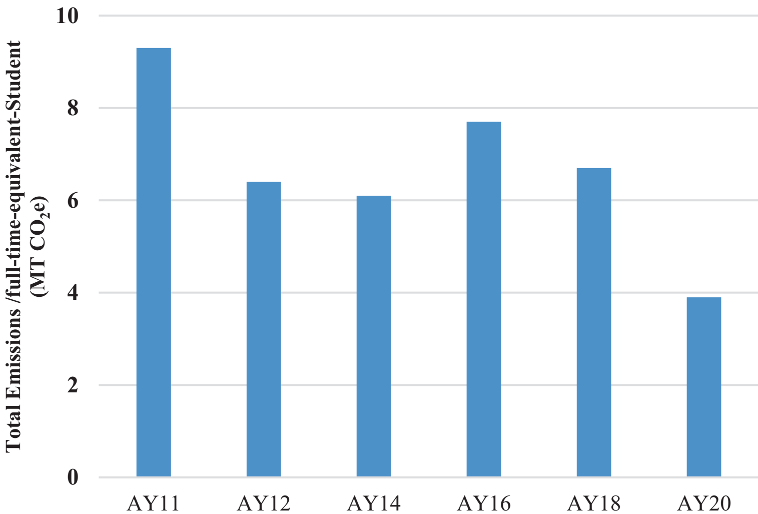

Fig. 3 Total emissions per full-time-equivalent student, AY11 to AY20

modeled the forecast for future emissions on the institutions, considering possible future teaching modality scenarios: continuing the hybrid model with 50% campus utilization or returning to full face-to-face instruction. A third alternative expects a return to full face-to-face modality, but with increased health considerations, such as adding more filtration. Each

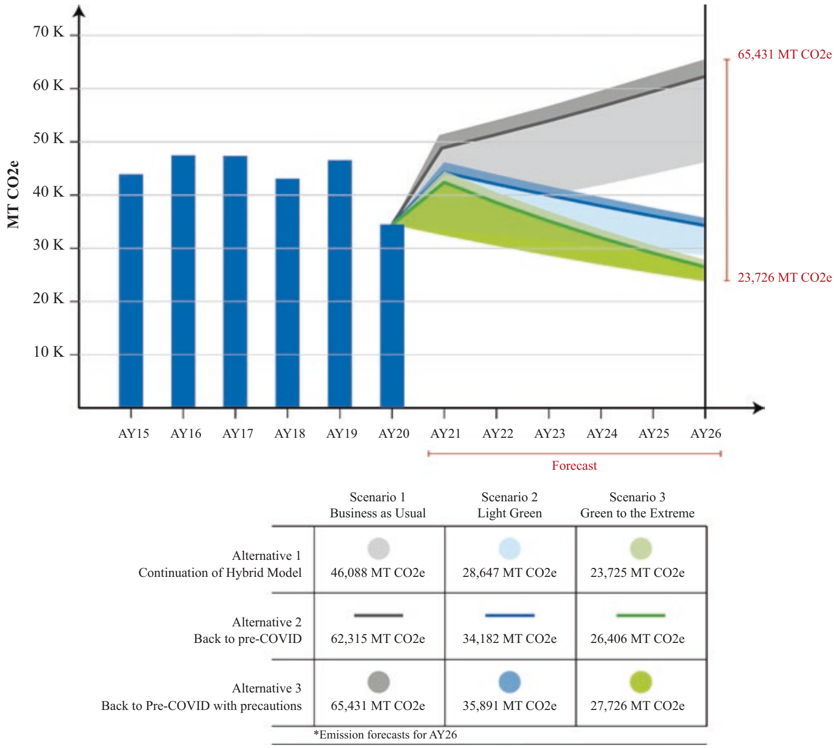

Fig. 4 AUC emissions forecast (AUC, 2021)

alternative is accompanied by three scenarios of carbon emission reduction (light to dark green). These forecasts are presented in Fig. 4. Maintaining AY20 carbon emission levels with an on-campus teaching modality (Alternative 2) by adopting the Light Green Scenario is required. In fact, even with a hybrid teaching modality (Alternative 1), the business-as-usual scenario would return AUC's emissions to its AY19 emission levels (at around 46,000 MT CO_2e). Investing in green solutions could help significantly reduce the emission of the institutions below 30,000 MT CO_2e in all modalities within 6 years.

The American University in Cairo aims to address goals set forth by the Egypt Vision 2030 (Ministry of Planning and Economic Development, 2020) in subsequent Carbon Footprint Reports. The Sustainable

Development Strategy (SDS) has followed the principles laid out by the SDGs as a general framework for improving the quality of life and welfare, considering the rights of new generations for a prosperous life. In addition, the SDS is based upon the principles of "inclusive, sustainable development" and "balanced regional development," emphasizing full participation in development and ensuring its yields to all parties (Ministry of Planning and Economic Development, 2020). Overall, the strategy considers equal opportunities for all, closing development gaps, and efficient resource use to ensure the rights of future generations. Within this report, each chapter corresponds to various SDGs to solidify AUC's commitment to global sustainability efforts. This correspondence will examine the critical role of higher education in achieving and implementing the SDGs. The SDGs also elevate the information communicated through the Carbon Footprint Reports to a national and international scale and provide access to a broader audience outside the scientific community.

Thus, AUC's attempt to reduce its carbon footprint aligns with many of the 17 SDGs adopted by the United Nations in 2015. The goals illustrated provide a holistic approach to looking at the full spectrum of global challenges, including poverty alleviation, water sanitation, global education, and economic growth. Now, three years after their adoption, the SDGs serve as a benchmark toward which participating nations worldwide can strive for. Likewise, the private sector has stepped up its efforts to aid nations in achieving the SDGs by researching environmental issues and funding sustainability initiatives. Through collaboration between all sectors of society, we can end extreme poverty and hunger, fight socio-economic inequalities, address climate change, and ensure that no one is left behind.

5 Conclusion: Utilizing Carbon Footprint Reports as Strategic Planning Tools

Higher education institutions are perfectly situated to be the leaders of decarbonization in the future. Their educational role, research, and potential for community outreach allow for experimentation and showcasing of technologies and methods that would have a great impact if other institutions are to follow. A critical factor is an institutional capacity of faculty, students, and staff to act as leaders in the community. The sustainable campus is no longer regarded as an educational objective but as a key strategic objective that not only carries operational efficiency and cost savings benefits but provides marketing and positioning power against other institutions in the future. With looming climate change challenges in water, energy, and resources, higher education institutions can use carbon footprint reporting to align their future growth and educational mission with the SDGs and national/regional objectives. As a result, the need for smart projections of carbon emissions will be a must to achieve higher levels of climate neutrality.

Some key recommendations could be extracted based on the experience of carbon accounting experience at AUC. The recommendations, summarized in the list below, could be beneficial for HEIs' administrators and operators who are launching new CF programs on their campuses or trying to improve their CF processes.

1. "You cannot manage what you cannot measure"; the quantity, quality, and data integrity are a must.
2. Institutionalizing the data collection and unit-to-unit commitment for data compilation is critical
3. Creating partnerships across the academic departments is critical for success.
4. The linkage to sustainable development goals allows for disseminating knowledge in line with global benchmarks and key performance indicators.
5. Institutional commitment and integration of sustainability in the curriculum are vital to the success of a sustainability agenda in the short and long term.

Appendix: Summary of Literature Review

Source/ Topic Covered			*Importance of Monitoring Carbon Footprint*	*Green House Gases Emissions in Egypt*	*GHGE International Case studies*	*Methods for Measuring Carbon Footprint*	*Comparative analysis of Energy Use Intensity (EUI) or Emissions Factors*	*Comparative analysis of Carbon Emissions*	*Calculations / Unit Conversions*	*Analyzing Activities contributing to Carbon Emissions*
Title	*Author*	*Year*								*HVAC and Domestic Hot Water*
AUC's Carbon Footprint Report	Mansour, Y., Tarabieh, K., Goubran, S., Krisanda, S., & El-Ghandour, S.	2021	•	•	•	•	•	•	•	•
Decision-making tools for evaluation the impact on the eco-footprint and eco-environmental quality of green building development policy	Teng, J., Wang, P., Wu, X., & Xu, C.	2016	•		•	•			•	
Implementing multi objective genetic algorithm for life cycle carbon footprint and life cycle cost minimization: A building refurbishment case study	Schwartz, Y., Raslan, R., & Mumovic, D.	2016	•		•	•			•	•
Ecological Footprint: Refining the carbon Footprint calculation	Mancini, M. S., Galli, A., Niccolucci, V., Lin, D., Bastianoni, S., Wackernagel, M., & Marchettini, N.	2016	•			•		•	•	
Framework and methods to quantify carbon footprint based on an office environment in Singapore	Tjandra, T. B., Ng, R., Yeo, Z., & Song, B.	2016	•		•	•	•			•
Environmental feasibility of heritage buildings rehabilitation	Munarim, U., & Ghisi, E.	2016	•		•	•		•	•	

Transportation	*Water Supply*	*Refrigerant*	*Paper Use*	*Electricity/ Fossil Fuels*	*Solid waste, Fertilizers, and Biomass*	*Natural gas for domestic & lab use*	*On site Construction activities*	*Obstacles in monitoring Carbon emissions*	*Recommendations/ Methods to reduce carbon footprint*	*Characteristics of Greenhouse Gas Inventories*	*Sustainable Development and reducing environmental footprint*	*Life Cycle Assessment (LCA)*
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Source/ Topic Covered			*Impor tance of Monito ring Carbon Footprint*	*Green House Gases Emissions in Egypt*	*GHGE Interna tional Case studies*	*Methods for Measu ring Carbon Footprint*	*Compa rative analysis of Energy Use Intensity (EUI) or Emissions Factors*	*Compa rative analysis of Carbon Emissions*	*Calcula tions / Unit Conver sions*	*Analyzing Activities contributing to Carbon Emissions*
Title	*Author*	*Year*								*HVAC and Domestic Hot Water*
Carbon footprint of a scientific publication: A case study at Dalian University of Technology, China	Song, G., Che, L., & Zhang, S.	2016	•		•	•	•			
Carbon footprint of a university in a multiregional model: the case of the university of Castilla-La Mancha	Gómez, N., Cadarso, M. A., & Monsalve, F.	2016	•		•	•	•			
Calculation of carbon footprints for water diversion and desalination projects	Liu, J., Chen, S., Wang, H., & Chen, X.	2015	•		•	•			•	
Reducing the environmental footprint of interior wood doors in nonresidential buildings e part 2: eco-design	Cobut, A., Beauregard, R., & Blanchet, P.	2015	•			•	•			
Sustainable campus improvement program design using energy efficiency and conservation	Faghihi, V., Hessami, A. R., & Ford, D. N.	2015	•		•	•		•		
Carbon footprint analysis of student behavior for a sustainable university campus in China	Li, X., Tan, H., & Rackes, A.	2015	•		•	•	•	•	•	•
Evaluation of greenhouse gas emissions and proposals for them reduction at a university campus in Chile	Vásquez, L., Iriarte, A., Almeida, M., & Villalobos, P.	2015	•		•	•	•			•

								Obstacles in monitoring Carbon emissions	*Recommendations/ Methods to reduce carbon footprint*	*Characteristics of Greenhouse Gas Inventories*	*Sustainable Development and reducing environmental footprint*	*Life Cycle Assessment (LCA)*
Transportation	*Water Supply*	*Refrigerant*	*Paper Use*	*Electricity/ Fossil Fuels*	*Solid waste, Fertilizers, and Biomass*	*Natural gas for domestic & lab use*	*On site Construction activities*					
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Source/ Topic Covered			*Importance of Monitoring Carbon Footprint*	*Green House Gases Emissions in Egypt*	*GHGE International Case studies*	*Methods for Measuring Carbon Footprint*	*Comparative analysis of Energy Use Intensity (EUI) or Emissions Factors*	*Comparative analysis of Carbon Emissions*	*Calculations / Unit Conversions*	*Analyzing Activities contributing to Carbon Emissions*
Title	*Author*	*Year*								*HVAC and Domestic Hot Water*
Scope-based carbon footprint analysis of US residential and commercial buildings: An input–output hybrid life cycle assessment approach	Onat, N. C., Kucukvar, M., & Tatari, O.	2014			•	•	•		•	•
Using ecological footprint analysis in higher education: Campus operations, policy development and educational purposes	Lambrechts, W., & Van Liedekerke, L.	2014	•		•	•			•	
Renewable energy: Comparison of CDM and Annex I projects	Kirkman, G. A., Seres, S., & Haites, E.	2013				•	•		•	
Carbon Footprint of Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Thailand	Aroonsrimorakot, S., Yuwaree, C., Arunlertaree, C., Hutajareorn, R., & Buadit, T.	2013	•		•		•	•		•
Creating a "green university" in China: a case of Shenyang University	Geng, Y., Liu, K., Xue, B., & Fujita, T.	2013	•		•		•			•
Carbon footprint as a basis for a cleaner Research institute in Mexico	Güereca, L. P., Torres, N., & Noyola, A.	2013	•		•	•	•	•	•	•
Quantitative analysis of factors affecting greenhouse gas emissions at institutions of higher education.	Klein-Banai, C., & Theis, T. L.	2013	•		•	•	•	•		

								Obstacles in monitoring Carbon emissions	*Recommendations/ Methods to reduce carbon footprint*	*Characteristics of Greenhouse Gas Inventories*	*Sustainable Development and reducing environmental footprint*	*Life Cycle Assessment (LCA)*
Transportation	*Water Supply*	*Refrigerant*	*Paper Use*	*Electricity/ Fossil Fuels*	*Solid waste, Fertilizers, and Biomass*	*Natural gas for domestic & lab use*	*On site Construction activities*					
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Source/ Topic Covered			*Importance of Monitoring Carbon Footprint*	*Green House Gases Emissions in Egypt*	*GHGE International Case studies*	*Methods for Measuring Carbon Footprint*	*Comparative analysis of Energy Use Intensity (EUI) or Emissions Factors*	*Comparative analysis of Carbon Emissions*	*Calculations / Unit Conversions*	*Analyzing Activities contributing to Carbon Emissions*
Title	*Author*	*Year*								*HVAC and Domestic Hot Water*
Declarations for sustainability in higher education: becoming better leaders, through addressing the university system.	Lozano, R., Lukman, R., Lozano, F. J., Huisingh, D., & Lambrechts, W.	2013	•		•	•	•			
Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study.	Ozawa-Meida, L., Brockway, P., Letten, K., Davies, J., & Fleming, P.	2013	•		•	•	•			
Understanding and advancing campus sustainability using a systems framework.	Posner, S. M., & Stuart, R.	2013	•		•	•	•			
Measuring buildings for sustainability: Comparing the initial and retrofit ecological footprint of a century home—The REEP House	Bin, G., & Parker, P.	2012	•		•	•	•			•
The Educational Facilities Professional's Practical Guide to Reducing the Campus Carbon Footprint	Hignite, K.	2009	•		•	•	•			
Developing ecological footprint scenarios on university campuses: a case study of the University of Toronto at Mississauga.	Conway, T. M., Dalton, C., Loo, J., & Benakoun, L.	2008	•		•		•	•		•

								Obstacles in monito ring Carbon emissions	*Recommen dations/ Methods to reduce carbon footprint*	*Charac teristics of Greenhouse Gas Inventories*	*Sustainable Develop ment and reducing environ mental footprint*	*Life Cycle Assessment (LCA)*
Trans por tation	*Water Supply*	*Refri gerant*	*Paper Use*	*Electri city/ Fossil Fuels*	*Solid waste, Fertili zers, and Biomass*	*Natural gas for domestic & lab use*	*On site Const ruction activities*					
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Source/ Topic Covered			*Importance of Monitoring Carbon Footprint*	*Green House Gases Emissions in Egypt*	*GHGE International Case studies*	*Methods for Measuring Carbon Footprint*	*Comparative analysis of Energy Use Intensity (EUI) or Emissions Factors*	*Comparative analysis of Carbon Emissions*	*Calculations / Unit Conversions*	*Analyzing Activities contributing to Carbon Emissions*
Title	*Author*	*Year*								*HVAC and Domestic Hot Water*
Unit Conversions, Emissions Factors, and other Reference Data	Environmental Protection Agency	2004					•		•	
Estimating Carbon Dioxide Emissions: Factors for the California Electric Power Sector	Marnay, C., Fisher, D., Murtishaw, S., Phadke, A., Price, L., & Sathaye, J.	2002	•		•	•	•	•	•	

	Transportation	*Water Supply*	*Refrigerant*	*Paper Use*	*Electricity/ Fossil Fuels*	*Solid waste, Fertilizers, and Biomass*	*Natural gas for domestic & lab use*	*On site Construction activities*	*Obstacles in monitoring Carbon emissions*	*Recommendations/ Methods to reduce carbon footprint*	*Characteristics of Greenhouse Gas Inventories*	*Sustainable Development and reducing environmental footprint*	*Life Cycle Assessment (LCA)*
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