Journal of Sustainability Perspectives

journal homepage: https://ejournal2.undip.ac.id/index.php/jsp/

Towards the Neutralization of the Carbon Footprint at the Autonomous University of the State of Mexico

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Article Info

Received:
06 June 2024
Accepted:
20 June 2024
Published:
28 June 2024

DOI:
10.14710/jsp.2024.24795

Presented in the 10th International Workshop on UI GreenMetric World University Rankings (IWGM 2024)

Abstract. The primary objective of the research was to calculate the carbon footprint resulting from the substantive activities of the Autonomous University of the State of Mexico between the years 2021 and 2022, to propose strategies for carbon footprint neutralization. The scientific and methodological contribution of this research can serve as a model for Mexican universities that wish to measure their carbon footprint. The research encompasses several sections. The first section delineates the issues pertinent to this study, along with the primary objective and specific goals. The subsequent section defines the conceptual framework employed. Regarding the state of the art of this research, it was necessary to identify that it is doing in this regard in other latitudes, which is why an analysis is presented of some of the universities in Europe and Latin America that have added work and effort to carry out studies on their greenhouse gases emissions generated and, in some cases, have achieved quantify their ecological or carbon footprint. The proposed methodology takes up the guidelines of the ISO 14064-1:2019 standard and presents eleven steps. The results of the carbon footprint of the UAEMéx in 2021 were 14,077,136.90 kg of CO_2e, and considering that the total of the university community at that time was 105,249 members, the amount per capita was 133.75 kg of CO_2e/person/year. On the other hand, for the year 2022, the carbon footprint was 28,019,621.33 kg of CO_2e, and the per capita of 261.30 kg of CO_2e/person/year, considering that the university community was cemented to 107,231 members. Based on the results obtained, neutralization strategies were developed, consisting of a list of activities aimed at reducing greenhouse gas emissions. Finally, the conclusions of this research are presented.

Keyword:

Carbon footprint, Climate change, Greenhouse gases, Neutralization, University.

1. Introduction

The Autonomous University of the State of Mexico (UAEMéx) is a Higher Education Institution (HEI) comprising a high-impact community, wherein diverse daily activities

generate significant quantities of Greenhouse Gases (GG). Consequently, the primary objective of this research was to calculate the carbon footprint stemming from its substantive activities for the years 2021 and 2022, as well as to propose the design of a neutralization plan. The research elucidates the issues related to climate change, particularly the temperature variations caused by the generation of greenhouse gases, which result in multiple consequences such as the manifestation of extreme weather events, species extinction, and adverse effects on human health. The terminology used throughout the research is defined to facilitate a comprehensive understanding of the topic of carbon footprint. As a reference for the present research, several case studies of universities at the international level, including those in Europe and America, are presented. Subsequently, the Mexican context is examined by analyzing different HEI that have worked on calculating their carbon footprints. Some of these institutions have engaged in reducing their emissions, thus serving as benchmarks for the methodologies applied and the results obtained. Following this, the methodological section outlines the principal methodologies utilized internationally. From these analyzes, the primary elements applicable to HEI were identified. This process facilitated the design and proposal of a hybrid methodology specifically tailored for HEI, which was applied to UAEMéx as a case study.

Utilizing the devised methodology, the carbon footprint calculation was conducted at UAEMéx for the years 2021 and 2022. Initially, the primary activities generating greenhouse gas emissions were identified: electricity consumption, mobility, fossil fuel consumption, waste generation, paper consumption, and construction activities. This categorization enabled the classification of emission sources into three scopes, as defined by methodologies. Firstly, Scope One, encompassing direct emissions, considered the consumption of fossil fuels by UAEMéx for its vehicles, including gasoline, diesel, natural gas, and compressed natural gas. Conversely, Scope Two, addressing semi-direct emissions originating externally, calculated energy consumption, an essential resource vital for the University's operations. Regarding Scope Three, which denotes indirect emissions, factors such as waste, paper consumption, and construction activities were taken into account. Based on the obtained results, a neutralization proposal was formulated, comprised of a list of activities aimed at reducing greenhouse gas emissions. This is detailed in Section Seven. Additionally, the implementation of tree and plant species is revisited, highlighting their role in absorbing CO_2e from the environment.

Finally, the conclusions of this research are presented, underscoring the importance of calculating the carbon footprint in the HEI. Additionally, the proposed hybrid methodology is discussed, which aims to be replicated in more institutions, enabling them to conduct self-assessments and formulate neutralization plans through various actions, thereby steering towards greener institutional practices. By suggesting a novel methodology tailored for HEI to calculate the carbon footprint of the UAEMéx, and concurrently proposing a neutralization plan, this research establishes itself as a paramount reference at the forefront of carbon footprint discourse within higher education.

2. Theoretical Approach and Methodology

To enhance the comprehension of the current investigation, this section delineates the fundamental terms related to the topic of carbon footprint, including climate change, the greenhouse effect and its primary gases, global warming, among others. These terms are organized in a progression from a broad perspective to a more specific one, prioritizing concepts that contribute to the understanding of carbon footprint and its neutralization.

The aim is to provide a comprehensive understanding of the issue at hand by elucidating key concepts in a structured manner.

2.1 Cases of Carbon Footprint measurement (state of the art)

Regarding the state of the art of this research, it was necessary to identify that it is doing in this regard in other latitudes, which is why an analysis is presented of some of the universities in Europe and Latin America that have added work and effort to carry out studies on their greenhouse gases emissions generated and, in some cases, have achieved quantify their ecological or carbon footprint.

Case of the University of Alcala de Henares, Spain: According to GreenMetric (2022), this university is ranked 32nd internationally (RGM, 2023), which represents a significant achievement in terms of the score attained and reflects its commitment to environmental sustainability on campus. The University of Alcalá de Henares conducted its study for the years 2008 to 2011, utilizing aspects of the ISO 14064-1:2006 methodology and the Greenhouse Gas Protocol (GGP). Consequently, for the year 2011, the carbon footprint was determined to be 8,088,080 kg of CO_2e, with per capita emissions amounting to 260 kg of CO_2e per member of the university community (GNF, 2013).

Case of the University of Valencia, Spain: Calculated its carbon footprint in global hectares (gha) based on the amount of CO_2 generated from identified emission sources. It is important to note that "gha" refers to the area of bioproductive forest required to offset the produced impact. Initially, the university estimated the CO_2e emissions, which were then converted into global hectares, representing the forested area needed to compensate for its carbon footprint. The carbon footprint was determined using the methodology of Simmons and Chambers (1998), thus defining the emission activities at the university. In addition to the carbon footprint study, it is important to mention that the UV has also carried out various activities contributing to a green and sustainable campus, which allowed it to rank 147th internationally in the GreenMetric Ranking in 2022 (RGM, 2023).

Case of the University of Santiago de Compostela, Spain: They determined that the per capita ecological footprint was 0.16 gha/person/year. Additionally, they calculated the amount of land required to assimilate the generated CO_2, which was 5,217 hectares of Galician Forest (MRS, 2007). It's important to mention that this university is included in the global GreenMetric Ranking, where in 2022, it was ranked number 375 internationally (RGM, 2023), allowing for a greater reach in environmental matters.

Case of Polytechnic University of Cartagena, Colombia: Conducted a study on carbon footprint, developing a proprietary methodology while integrating certain elements from methodologies such as ISO 14064-1 and Greenhouse Gases Protocol (GGP) for calculation purposes. The procedural steps included defining boundaries, identifying emission sources, calculating emissions, verifying the results, and disseminating them (Hermosilla, 2014). Therefore, the carbon footprint in the year 2013 amounted to 9,088,395 kg of CO_2e, and in terms of per capita emissions, considering the total number of members of the University as 8,487, 1,070.86 kg of CO_2e per person were generated (Hermosilla, 2014). Finally, it is important to note that according to the UI Green Metric global ranking, the Polytechnic University of Cartagena is positioned internationally at 926th place (in the year 2020), which signifies the effort and achievement it has attained through its various initiatives in environmental matters and sustainability (RGM, 2023).

Case of the Autonomous University of Nuevo Leon: According to the GreenMetric 2022 ranking, the University ranks first in Mexico as the most sustainable Higher Education Institution (HEI) and 15th globally, a distinction earned through its remarkable efforts and

achieving high scores in the evaluated variables (RGM, 2023). The UANL calculated its carbon footprint for the years 2014-2018 using the "Carbon Footprint TM" methodology (UANL, 2023), developed by a consultancy comprising environmentalists, engineers, and scientists committed to reducing and offsetting greenhouse gas emissions. However, the information they publish is quite concise, as they do not provide details of the calculation, merely mentioning the CO_2e generation from four sources, with an approximate figure of 57.6 million kilograms of CO_2e (UANL, 2023).

Case of the Benemerita Universidad Autonoma de Puebla: This University holds the 58th position globally and the second position nationally. This commendable achievement is attributed to the institution's comprehensive initiatives and programs aimed at judicious resource management and environmental stewardship. Moreover, BUAP has proactively formulated environmental management policies with a steadfast commitment to sustainability, thereby garnering commendable scores across critical domains such as energy conservation, climate resilience, waste reduction, scholarly research, and educational outreach (BUAP, 2022). BUAP has also published a "Sustainability Manual 2025," outlining its strategic framework for Environmental Management University System. This manual delineates several key pillars, including the development of sustainable and resilient infrastructure, initiatives to address energy consumption and mitigate climate impacts, the promotion of environmentally responsible procurement and consumption practices, comprehensive waste management strategies, initiatives to foster sustainable transportation systems, and robust mechanisms for monitoring and evaluation (MS, 2023).

2.2 Research Methodology

To determine the carbon footprint, various methodologies exist with the objective of quantifying greenhouse gas emissions. Among the most prominent are PAS 2050 and PAS 2060, the Greenhouse Gas Protocol (GGP), and ISO 14064-1:2019, which are the most widely used and internationally recognized. The PAS 2050 methodology was developed by the British Standards Institute (BSI) in collaboration with Carbon Trust and the Department for Environment, Food & Rural Affairs (DEFRA) in 2007. It consists of calculating the emissions generated by a product or service and is aligned with ISO standards and the GGP. This methodology considers the calculation of CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. It also includes a guide for accounting emissions, which describes the formulas to be used (CEPAL, 2010). This method incorporates the evaluation of the life cycle analysis of products, and its guidelines and content include: principles and implementation, emission sources, offsetting, system boundaries, data and information, emissions calculation, and claims of conformity (Miguel, 2011). On the other hand, the PAS 2060 methodology was developed by the same entities as PAS 2050, but in 2009-2010. Unlike the former, it is aimed at calculating the emissions of an organization, such as a company, production site, or administration. Similarly, it adheres to the ISO standards and the GGP. Its guide includes the accounting of gas emissions and proposes measures for their offsetting and reduction (CEPAL, 2010).

2.3 Methodology for Application in the Higher Education Institutions (HEI)

The methodologies outlined in the previous section entail costs associated with their implementation, which may pose economic challenges for HEI. In this regard, a hybrid methodology is proposed, tailored to the specific conditions and characteristics of the university. This approach draws upon guidelines and criteria from the methodologies described earlier while integrating aspects not considered by them. Consequently, the

development and application of a proprietary methodology are suggested, aiming to establish a reliable and precise procedure for calculating carbon footprint. By adopting this approach, the research can be extended for replication in additional HEI. The intention is not to foster comparison or competition but rather to enable HEI to conduct self-assessments regarding their environmental impact. Subsequently, based on their individual contexts, appropriate adjustments can be made if necessary. Thus, the proposed methodology incorporates guidelines from ISO 14064-1:2019, such as determining the timeframe, defining scopes, identifying emission sources, and calculating emissions. Additionally, elements from the Greenhouse Gas Protocol, such as defining emission factors and data collection, are included. Finally, drawing from the guidance proposed by the Ministry of Ecological Transition, the determination of organizational and operational boundaries was considered. The methodology proposed in this research comprises eleven steps, which were applied to the Autonomous University of the State of Mexico. These steps are described below and, due to their general applicability, can be implemented in any Higher Education Institution (HEI). It's important to note that, for conducting the carbon footprint assessment, it is advisable to follow the following sequence:

1. Determine the year or period for evaluation: Define the timeframe for which the calculation will be performed, which can be annually or within a specified interval, spanning from one year to another.
2. Define organizational and operational boundaries: Organizational boundaries entail establishing the areas that will participate in the calculation, which may apply to the entire institution or specific areas thereof. Meanwhile, operational boundaries involve classifying emission sources into the three scopes, considering any limitations that may arise throughout the process.
3. Identify greenhouse gases emission sources: Consider all activities undertaken by the institution that directly or indirectly generate greenhouse gases, thereby causing a negative impact on the environment, thus defining them as emission sources.
4. Determine scopes 1, 2, and 3: Scope 1 involves identifying all direct emissions generated by the institution, while Scope 2 corresponds to establishing semi-direct emissions (energy consumption), and finally, Scope 3 encompasses including indirect emissions that are not directly controlled by the institution but are produced through its activities, resulting in a negative impact.
5. Establish corresponding emission factors: Define factors based on the emission source. It is worth mentioning that these factors vary depending on the location and time of calculation.
6. Collect data and information: Gather information by consulting inventories, compendiums, and other official documents from HEI containing sufficient information. Additionally, field visits may be necessary, for example, to academic spaces or departmental offices, from which the necessary data for calculation can be obtained. It is important to emphasize that this step requires collaboration and participation from all involved areas.
7. Perform the calculation: Once all necessary information has been collected, the carbon footprint calculation should be conducted, involving multiplying the quantity generated by the identified activity by the corresponding emission factor.
8. Analyze the results: Evaluate the results obtained from the carbon footprint calculation to identify potential strengths or activities with significant greenhouse gases generation. Additionally, strategies should be sought to mitigate the emissions produced.

9. Develop a carbon footprint neutralization plan: Devise a strategic plan aimed at neutralizing the generated carbon footprint, comprising tools, alternatives, and proposals that contribute to reducing greenhouse gases emissions and their impact through actions.
10. Implement the carbon footprint neutralization plan: Once the strategic plan has been designed and reviewed, it should be executed with the necessary measures and the participation of the university community.
11. Provide feedback: Analyze the successes and weaknesses of the process, including observations to initiate improvements and restart the process accordingly.

3. Results and Discussions

The Autonomous University of the State of Mexico (UAEMéx) has been involved in environmental issues through programs, projects, and research efforts. This commitment has led to its international recognition, ranking 414th according to the Green Metric 2022, and nationally positioned at number 15 (RGM, 2023). In this context, it is pertinent to highlight that the university comprises a considerable student body, whose educational journey involves daily activities as part of the learning process, each contributing to a certain amount of CO_2e emissions. Thus, one approach to understanding greenhouse gases emissions is through the utilization of carbon footprint as an environmental assessment indicator. Consequently, there arises a necessity within the University to measure its carbon footprint, not only to identify emission sources but also to provide alternatives for offsetting the generated CO_2e. Furthermore, the Institution's role as a community contributing to addressing the current issue of climate change is acknowledged.

In this way, the adoption of carbon footprint as a tool for environmental management within HEI emerges. These institutions serve as hubs for knowledge creation, innovation, and research development. This study will not only elucidate the interactions occurring within the University but also describe aspects of the student lifestyle derived from factors such as energy consumption, paper and plastic usage, waste generation, and mobility. Thus, in striving to become a more efficient and environmentally conscious University, the carbon footprint, besides serving as an environmental instrument, facilitates the presentation of appropriate solutions based on the conducted calculations, aiming to combat, reduce, and even neutralize the emitted greenhouse gases. It is noteworthy that a comprehensive search across various platforms was conducted to ascertain whether any documents exist indicating prior attempts to analyze and calculate the carbon footprint at the UAEMéx. However, no relevant works on this topic for the Institution were found. Finally, it is evident that European institutions studied produce a lesser amount of CO2e, maintaining an average of 16,079,571, while American institutions produce 19,653,599, underscoring the imperative for the UAEMéx to undertake concerted efforts towards neutralizing its carbon footprint. Among the methodologies employed by various HEI discussed, the approach utilized by the National University of Costa Rica stands out, owing to its clarity of information shared and particularly the delineated steps for carbon footprint calculation, thus serving as a valuable reference in the present research.

According to the World University Rankings UI GreenMetric, the Autonomous University of the State of Mexico holds the 65th position in Latin America. Additionally, at the state level, the University is recognized as the top Public State University according to the Latin America University Ranking 2022 (SIAA, 2023). The University has an international presence in countries such as Germany, Argentina, Spain, and Italy. Furthermore, it stands

as one of Mexico's largest and oldest institutions, boasting over 190 years of history. Comprising 10 Preparatory School Campuses, 22 Academic Bodies (Faculties), 11 University Centers, 7 Academic Units, and 9 Research Institutes and Centers, among other academic spaces (AE, 2022). In 2021, the University community comprised 105,249 individuals, including students, faculty, and administrative staff, and by 2022, this figure had risen to 107,231 individuals.

The University is home to over 100,000 students who engage in various activities daily as part of their education and stay within its premises. Each of these activities contributes to greenhouse gas emissions, thereby becoming emission sources. Hence, the carbon footprint of UAEMéx will be calculated through the application of the hybrid methodology proposed in the methodology section.

Regarding the definition of the period, the carbon footprint calculation will encompass the years 2021 and 2022. This approach enables a comparative analysis between both sets of results, facilitating the examination of emission increases or decreases as applicable. Such analysis will aid in establishing potential measures to mitigate the generated impact, in addition to designing objectives to be achieved in subsequent years. In this study, concerning the definition of organizational and operational boundaries, the carbon footprint of the entire Institution was calculated, encompassing all university spaces. Thus, the total quantity of greenhouse gas emissions generated by the Autonomous University of the State of Mexico over the established two-year period was determined. Additionally, the identified emission sources are as follows: a) Electricity b) Mobility c) Waste (solid and hazardous) d) Constructions e) Consumption of paper and supplies f) Consumption of fossil fuels.

3.1. Measurement of the carbon footprint at the Autonomous University of the State of Mexico (UAEMéx)

Following the data collection phase, the calculation of the carbon footprint of the University continued. In accordance with the methodology proposed in this research, it was carried out using the general formula, which integrates the activity data and emission factor. The Autonomous University of the State of Mexico (UAEMéx) was the subject of study, and the amount of CO_2e generated by each identified variable was measured.

The carbon footprint of the UAEMéx from its main substantive activities for the years 2021 and 2022 was calculated using a hybrid methodology designed for Higher Education Institutions, with the intention of being replicable for self-assessment. In 2021, the carbon footprint of UAEMéx amounted to 14,077,136.90 kg (fourteen million seventy-seven thousand one hundred and thirty-six and ninety kilograms) of CO_2e. Considering the total university community at that time, which consisted of 105,249 members, the per capita amount was determined to be 133.75 kg of CO_2e per person per year. On the other hand, in 2022, the carbon footprint increased to 28,019,621.33 kg of CO_2e, with a per capita amount of 261.30 kg of CO_2e per person per year, considering a total of 107,231 university members for that year. The significant increase in the carbon footprint in 2022 compared to 2021 is primarily attributed to the events that occurred in Mexico in 2020 due to the COVID-19 pandemic. This led to the suspension of in-person activities, including classes, which transitioned to online formats until 2021. This situation resulted in a considerable reduction in the consumption of some resources, such as fossil fuels, paper, and energy. However, in 2022, some administrative and academic activities gradually resumed, leading to a return to classrooms. This increase in activity was reflected in the higher consumption of resources mentioned earlier. For instance, in 2021, 47,732.22 kg of bond paper were

consumed, resulting in 85,202.02 kg of CO_2e emissions. In 2022, 68,680.98 kg of bond paper were consumed, emitting 122,595.55 kg of CO_2e.

Similarly, for toilet paper, 97,973.17 kg were consumed in 2021, producing 174,882.11 kg of CO_2e. In 2022, the amount acquired increased to 154,651.03 kg, resulting in emissions of 276,052.09 kg of CO_2e. These data reflect a significant increase from one year to the next, considering that in 2021, students attended classes online and administrative and academic staff were not fully present on campus, partially reducing the consumption of this resource.

Regarding fossil fuels, in 2021, the consumption was 391,828 liters, including gasoline and diesel, which emitted 923,311.25 kg of CO_2e. In 2022, the consumption increased to 1,095,845 liters, and this included the amount of gas used in laboratories and natural gas for vehicles, collectively generating 2,728,058.21 kg of CO_2e. Additionally, there was an increase in fuel consumption for out-of-town travel. With the resumption of in-person activities at UAEMéx, there was a higher demand for fuel, exemplified by the increased use of the university bus service, Potrobus, by more students.

Regarding energy consumption, in the year 2021, it was 6,898,576.91 kWh, which emitted 2,918,098.03 kg of CO2e. In 2022, the consumption increased to 8,372,604 kWh, generating 3,642,082.74 kg of CO2e. This increase, similar to that seen with paper and fossil fuel consumption, was due to the return of students, faculty, and administrative staff to in-person activities at the University (after the pandemic by COVID19), as well as an overall increase in the university community in the latter year. For waste, data was collected on the amount of cardboard generated by the University, as well as waste from university spaces in the Valley of Toluca. In 2021, 265,965 kg of waste was generated, emitting 187,192.30 kg of CO2e. In 2022, this increased to 682,405 kg, generating 477,857.10 kg of CO_2e.

Finally, in terms of the construction of new buildings in 2021, they totalled 22,138 m², generating 9,762,858 kg of CO2e. In 2022, 47,009 m² were built, emitting 20,730,969 kg of CO_2e. It is important to note that, among the variables identified, this category is the one that generated the most CO_2e, which makes it a significant factor that contributes to the increase of the total carbon footprint in our university.

3.2. Plan to Neutralize the Carbon Footprint at Autonomous University of the State of Mexico (UAEMéx)

Our university has embarked on a path towards sustainable development through various practices and actions in response to the environmental challenges facing planet Earth. Over the years, it has committed to environmental issues by promoting activities and improving areas such as waste management, water conservation, energy efficiency, environmental accreditations, among other elements related to the natural environment. Among the activities of the University, through the Directorate of Environmental Protection (DPA), various campaigns have been carried out, including: the university reforestation campaign, the campaign for collecting edible vegetable oil waste, the university campaign for collecting PET and plastic bottle caps, the annual campaign for collecting expired medications and their packaging, the ongoing campaign to reduce polystyrene waste, and the university campaign for waste collection.

As a result of the activities, in 2021 the generation of 1,514,784.38 kg of CO2e was avoided, while in 2022 the emission of 6,593,175.14 kg of CO2e was avoided, highlighting the importance of these actions in reducing CO2e emissions. Continuing with the proposal to neutralize the carbon footprint in our university, the following practices are suggested, which contribute to reducing greenhouse gas emissions and thus reduce the carbon footprint generated by UAEMéx: Reviving circular economy techniques, University-level

environmental fair, Environmental competition, Implementation of ecotechniques, Water harvesting systems, Green areas maintenance day, Promotion of digital assignments and exams, Encouraging Sustainable University Transportation and Bicycle Usage, Replacing luminaires with LEDs, Zero Electrical Energy Day, Waste Recycling, Battery Collection Campaign, Strengthening the Implementation of Urban Gardens and Implementing Pollinator Gardens.

4. Conclusions

In the case of the Autonomous University of the State of Mexico (UAEMéx), the aim of the present research is to serve as a model for Mexican Higher Education Institutions (HEI) that wish to calculate their carbon footprint using the methodology developed in this study. It is important to note that this study is based on internationally recognized methodologies, including ISO 14064-1:2019, the Greenhouse Gas Protocol (GGP), and the Guide proposed by the Ministry of Ecological Transition. These methodologies main evaluation criteria were considered and adjusted for easy application to HEI, resulting in a hybrid methodology that will be freely accessible to such institutions. Consequently, and as a case in point, this methodology was employed at the UAEMéx to calculate both the general and per capita carbon footprint, based on the substantive activities conducted during the years 2021 and 2022.

To calculate the carbon footprint at UAEMéx, several challenges were encountered in obtaining the necessary information. Nonetheless, data pertaining to the variables of the different scopes were successfully gathered. It is important to note that within Scope 3, only waste, paper consumption, and construction were analyzed. For future studies, it is recommended to delve deeper into this scope. In addition to the contribution of this research on calculating the carbon footprint, the design of a hybrid methodology and the proposal of a strategic plan were suggested. These activities aim to reduce greenhouse gases emissions and, to the extent possible, neutralize the university's carbon footprint. Furthermore, the calculation of the carbon footprint allowed us to conclude and identify the benefits of this research in various aspects. Educationally, it provides new knowledge and perspectives to the university community. Socially, it enhances community integration and strengthens decision-making processes and awareness generation. Economically, it helps reduce costs by adopting more sustainable practices. Culturally, it reinforces environmental education with a renewed vision of the environment and encourages participation in environmental activities. These benefits extend not only to higher education institutions but also to society as a whole, contributing to the reduction of greenhouse gases emissions in the atmosphere.

Finally, carbon footprint measurement is an immensely useful tool for calculating greenhouse gas emissions, allowing for the environmental assessment of activities within any higher education institution and serving as an indicator of green and sustainable practices. UAEMéx has constantly demonstrated its commitment to address and prevent environmental problems through various permanent initiatives for some time now. Carbon footprint neutralization strategies have positioned our university to keep its emissions levels on par with those of European higher education institutions, which are recognized for their advanced development in this area. The main scientific and methodological

contribution of this research can serve as a model for Mexican universities that wish to measure their carbon footprint.

References

1. Comisión Económica para América Latina y el Caribe (CEPAL), (2010). Metodologías de cálculo de la Huella de Carbono y sus potenciales implicaciones para América Latina. http://repositorio.cepal.org/bitstream/handle/11362/37288/1/Metodolog%C3%ADas _calculo_HC_AL.pdf

2. Espíndola C. y Valderrama J. O. (2011). Huella del Carbono. Parte 1: Conceptos, Métodos de Estimación y Complejidades https://scielo.conicyt.cl/pdf/infotec/v23n1/art17.pdf Metodológicas. Eurofins (2022). Principales novedades de la norma UNE EN ISO 14064 -1 2019: Mide la huella de tu organización. https://www.eurofins-environment.es/es/iso-14064/

3. Gas Natural Fenosa, Universidad de Alcalá (2013). INFORME DE HUELLA DE INFORME DE HUELLA DE CARBONO DE LA UNIVERSIDAD DE ALCALÁ. https://www1.uah.es/sustainability/docs/informe_huella_carbono.pdf Glosario (2019). Grupo Intergubernamental de Expertos sobre el Cambio Climático. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/10/SR15_Glossary_spanish.pdf

4. Greenhouse Gases Protocol (GGP), (2023). What is Greenhouse Gases Protocol? https://greenhousegasesprotocol.org/about- us Green Metric (2013). Overall Rankings 2022. https://greenmetric.ui.ac.id/rankings/overall- rankings-2022

5. Green Metric (2013). Ranking by Country 2022 – Mexico. https://greenmetric.ui.ac.id/rankings/ranking-by-country-2022/Mexico

6. Hermosilla (2014). Huella de Carbono en la Universidad Politécnica de Cartagena: En Busca de la https://repositorio.upct.es/bitstream/handle/10317/5043/tfm384.pdf

7. Ministerio para la Transición Ecológica (2015). Guía para el Cálculo de la Huella de Carbono y para la Elaboración de un Plan de Mejora de una Organización. https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/guia_huella_carbono_tcm30-479093.pdf

8. Ministerio para la Transición Ecológica (MTERD). Gobierno de España, (2022). HFC'S (Hidrofluorocarburos) hidrofluorocarburos,15591,11,2007.html https://prtr-es.es/HFCs-

9. National Geogrphic (2023). Rumbo a la neutralidad climática en 2050: ¿Qué es la huella cero de carbono?. https://www.nationalgeographic.es/medio-ambiente/rumbo-a-la- neutralidad-climatica-en-2050-que-es-la-huella-cero-de-carbono

10. Organización de las Naciones Unidas (ONU), (2023). ¿Qué es el cambio climático? https://www.un.org/es/climatechange/what-is-climate-change

11. Parlamento Europeo (2023). ¿Qué es la neutralidad de carbono y cómo alcanzarla para 2050?. https://www.europarl.europa.eu/news/es/headlines/society/20190926STO62270/qu e-es-la-neutralidad-de-carbono-y-como-alcanzarla-para-2050#:~:text=La%20neutralidad%20de%20carbono%20se,denominado%20huella %20cero%20de%20carbono.

12. Puchades, De la Guardia y Albertos (2011). La Huella de Carbono de la Universidad de Valencia: diagnóstico, análisis file:///C:/Users/Yoselin/Downloads/Dialnet- y evaluación. LaHuellaDeCarbonoDeLaUniversitatDeValencia-4061784%20(2).pdf

13. Trespalacios J., Blanquicett C. y Carrillo P. (2018). Gases y efecto invernadero. https://www.local2030.org/library/585/Gases-y-efecto-invernadero.pdf

14. UAEMéx (2022). Agenda Estadística http://planeacion.uaemex.mx/docs/AE/2021/AE2021.pdf

15. UAEMéx (2022). Primer Informe Anual de Actividades 2021. 2021. https://www.uaemex.mx/images/pdf/1erinforme2125/Primer_Informe_CEBD.pdf

16. UAEMéx (2023). Agenda https://spydi.uaemex.mx/docs/docs/AE2022.pdf UAEMéx (2023). Segundo Informe Anual Estadística de Actividades https://spydi.uaemex.mx/docs/InfBasCon/Institucionales/Informes/2021-2025/2IA_CEBD_web.pdf 2022. 2022.

17. UANL (2023). Balance de carbono de CO2. https://sds.uanl.mx/balance-de-carbono/ UANL (2023).