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Green University and the reduction of the carbon footprint in academic activities at a public university in Ecuador

Universidad verde y la reducción de la huella de carbono en las actividades académicas en una Universidad Pública del Ecuador

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Abstract

The carbon footprint is one of the main factors for measuring CO₂ emissions, this atmospheric gas represents a worldwide environmental problem. Currently, universities are making inroads into the solution through the quantification and mitigation of CO₂. Academic activities and the delivery of physical documents generate high amounts of paper consumption and consequently levels of CO₂, which establishes a problem. The objective is to estimate the carbon footprint of the Universidad Técnica Estatal de Quevedo (UTEQ) located in Ecuador. The methodology employed consisted of a quantification of the number of files registered in the academic system per year. The files were multiplied by an average number of sheets obtained through a survey applied to teachers. The carbon footprint was determined by multiplying the CO₂ emission factor by annual paper consumption. The emissions obtained are 3.21 ton CO₂ eq to 3.00 ton CO₂ eq for the year 2020-2021 and 2021-2022, respectively. The virtual education implemented at UTEQ contributed to the fulfillment of climate change objectives, due to the non-emitted CO₂ emissions determined in this study, an issue that is related to the achievement of a green university.

Keywords: carbon footprint, carbon dioxide, carbon dioxide CO₂, paper, green university

Resumen

La huella de carbono es uno de los principales factores para medir las emisiones de CO₂, este gas atmosférico representa una problemática ambiental a nivel mundial. Actualmente, las universidades están incursionando en la solución por medio de la cuantificación y mitigación del CO₂. Las actividades académicas y la entrega de documentos físicos generan altas cantidades de consumo de papel y en consecuencia niveles de CO₂, lo que establece un problema. El objetivo es estimar la huella de carbono en la Universidad Técnica Estatal de Quevedo (UTEQ) ubicada en Ecuador. La metodología empleada consistió en una cuantificación del número de archivo registrado en el sistema académico por año. Los archivos se multiplicaron por un promedio de hojas obtenidos a través de una encuesta aplicada a los docentes. La huella de carbono se determinó multiplicando el factor de emisión de CO₂ por consumo de papel anual. Las emisiones obtenidas son 3,21 ton CO₂eq a 3,00 ton CO₂eq para el año 2020–2021 y 2021-2022, respectivamente. La educación virtual que se implementó en la UTEQ, contribuyó al cumplimiento de los objetivos del cambio climático, debido a las emisiones no emitidas de CO₂ determinadas en este estudio, tema que está relacionado con la consecución de una universidad verde.

Palabras clave: huella de carbono, dióxido de carbono CO₂, papel, universidad verde

Introduction

Adaptation to climate change has become one of the main policies and projects of NGOs, donors and governments around the world. Ecuador's concern for the climate phenomenon is expressed at the international level through its commitment to the United Nations Framework Convention on Climate Change (UNFCCC) in 1994. Likewise, in 1999, it ratified its adherence to the Kyoto Protocol (KP), in 2017 to the Paris Agreement, and in 2021 it reaffirms its commitment in the Conference of the Parties - COP of 2021. At the national level, the country has a regulatory framework that addresses aspects of sustainability and climate change through the 2008 Constitution of the Republic of Ecuador.

Scientific studies point to carbon dioxide (CO₂), the gas that causes the greenhouse effect, as the main culprit in the process of climate change due to the accelerated carbon footprint since the industrial revolution. CO concentrations₂ were in the range of 130 and 320 ppm approximately 800,000 years ago and by the year 2021 levels reached 414.72 ppm.

The carbon footprint is an environmental indicator, which serves to measure the amount of greenhouse gases (GHG) emitted into the atmosphere, allowing to know the impact of human activities on the environment. These studies facilitate the development and strategy to mitigate the effects of climate change resulting from atmospheric emissions, mainly due to anthropogenic activities. (Dias & Arroja, 2012; Torres Ramos et al., 2017)..

Carbon footprint studies on the paper production and consumption process are not indifferent to the scientific community. In this sense; Wencong Yue (2017)) performs a life cycle analysis of photocopy paper produced in a factory in China, applying a comprehensive methodology to

account for the carbon footprint, as well as to evaluate the effects of reducing pollution percentages. The results show that the carbon footprint per 1000 kg of copy paper reached 647.89 kg CO₂.

Currently, there are many paper industries in different countries that are committed to the preservation of wood, the main raw material for paper, as well as to reducing the carbon footprint. To this end, paper recycling policies have been adopted, preventing paper from ending up in landfills or being incinerated with the consequent emission of greenhouse gases. (Fernandez et al., 2021).

This article focuses on climate change due to CO₂ emissions associated with academic management within universities. The main objective is to estimate the carbon footprint of the Universidad Técnica Estatal de Quevedo (UTEQ) located in Ecuador. The study focuses on the years 2020 to 2022, from which due to the effects of the COVID 19 pandemic there was a transition to online education. These digital transformation processes allowed reducing paper consumption and accounting for the amount of paper generated in the university's teaching activities. Therefore, the aim is to determine what would be the carbon footprint that would have been generated in face-to-face education, where students and teachers printed documents. The study will provide a quantification of the carbon footprint not emitted as a result of UTEQ's online education and its contribution as a Green University.

If in the last 50 years the preservation of the environment has become one of the most important issues in regional and global agendas, environmental education is key to achieve this goal, being one of the pillars that has the ability to redirect and modify the behavior of citizens in order to achieve a balance between man and nature (Fiallos, Mendoza, Escobar & Intriago, 2022). However, with the appearance of the COVID-19 pandemic and in view of the requirement and obligatory nature of social isolation in all regions, the goals set in this sense have had to be rethought and the strategies drawn up by governments and institutions, mainly educational ones, must include new guidelines to address this new affectation. (López M. , 2020).

Higher education is no stranger to this reality; and in the eagerness to build sustainable societies, since the beginning of the century it has been working to mitigate the problem, becoming a key element to ensure that the training processes of the citizens of the future, incorporate among its lines of action, environmental sensitivity and sustainability in their administrative and academic processes. (Muñoz et al., 2017; Nieto & Medellín, 2007)..

If universities are institutions that prepare and train generations to constitute the workforce of a country, countries need "green" universities, oriented to sustainability, for their social and economic development, which at the same time are linked to the processes of innovation, research and problem solving, based on the knowledge of reality, the current circumstances of society. For this reason, the academy plays a very important role in the preparation of

responsible citizens and leaders with full social conscience, in charge of projecting and sustaining in some way sustainable societies. (Salas, 2021).

According to Lopera and Duque (2019) the educational institutions themselves should have an academic unit that is at the forefront of projects and programs of clean energy, environmental responsibility, reuse and recycling, preservation of resources, which raises the proposal for changes in the management, participation and management of green universities.

In accordance with the above, the Universidad Politécnica Salesiana, Quito headquarters, south campus, in 2012 conducted a carbon footprint study. Since in that year there were 3870 individuals performing activities within the facilities of the UPS-South, it was possible to establish an annual per capita H-C value of 225.81 kg CO₂ eq, emitted into the atmosphere. To verify these results, the SimaPro 7.3 software was used to obtain a total of 861.03 ton CO₂ eq. (Vilches et al., 2015).

In this same line, the Universidad San Francisco de Quito (USFQ), an HEI seriously committed to the environment, in 2015 conducted a new study to update the carbon footprint CO₂, generated by different items of activities of the university community: students, teachers and administrative staff. The final results indicate that, in 2015, USFQ emitted 6225.4 tons of CO₂ per year into the atmosphere. (Salazar et al., 2019).

With this perspective, the Technical University of Machala, an IES noted for its sustainable performance, through the determination of its carbon footprint as an indicator of environmental impact and climate change, has been conducting studies using the guidelines of the ISO 14064-1:2006 standard and the GHG Protocol (Guide to Designing GHG Accounting Reporting Programs). According to the latest results obtained, the total estimated carbon footprint in 2018, 2019 and 2020 was 16803 ton CO₂/year, 15400 ton CO₂/year and 15203 ton CO₂/year respectively, with Scope 3 being the largest contributor with 94% of the total. It was found 1.66 ton CO₂/student for the year 2018; 1.57 ton CO₂/student for the year 2019 and 1.29 ton CO₂ /student in the year 2020, data that evidences that emissions are below the national average for both universities and inhabitants of the country. (Ferre-Gutiérrez et al., 2021 p. 56).

For its part, the National University (UNA), an institution concerned with improving conditions that promote a positive impact on the environment for its staff and students, conducted a study between 2012 and 2014 to quantify and update the carbon footprint generated by its administrative and academic activities.

For the greenhouse gas (GHG) emissions inventory, it applied the methodology endorsed by the National Meteorological Institute (IMN), using the officialized factors indicated in the Greenhouse Gas Emission Factors Manual, fourth edition of 2014. The results of this study evidenced a 22% increase in the carbon footprint, from 2.91 to 3.57 tons CO₂ equivalent. These results are intended to establish specific environmental strategies or measures for their reduction. (Chavarría-Solera et al., 2016 p. 45).

From another angle, the Quevedo State Technical University has also carried out actions that lead to the optimization of large material, human, economic and environmental resources that contribute to environmental sustainability and therefore to the reduction of the carbon footprint. During the period between 2019 and the first months of 2022, it carried out all academic processes in virtual mode, reducing to 0% the printing of academic documents (Fiallos, et al., 2022).

At present, although UTEQ returned to face-to-face mode, it was decided that 75% of the curriculum will be developed in the face-to-face mode, the policy of 0% of printed documents is maintained, being inserted in the initiative of "Green University" which arises with the vision of generating greater responsibility regarding the correct and efficient use of resources, as well as promoting the implementation of good environmental practices by the teaching staff, administrative staff and students of universities and other educational centers in each country. (Ordorika, 2020). This is how this health center contributes to minimize the generation of carbon footprint.

Secondary level educational institutions also conduct research to determine the relationship between carbon footprint levels and students' knowledge, attitudes, and practices. According to Torres Ramos et al. (2017) for the measurement of the carbon footprint in the study population, the Greenhouse Gas Protocol was used, through the emissions calculator of Libélula Gestión en Cambio Climático y Comunicación; as well as, the application of a test of knowledge, attitudes and practices. The results obtained showed that the emissions per year in the educational institution were: 25.36 ton CO₂ eq and the average emission of the population under study was 2.18 ton CO₂ eq with a negative correlation of -0.228 between the carbon footprint and the knowledge, attitudes and practices of the population.

Other HEIs are also aware of the benefits of being environmentally friendly through the reduction of paper consumption, for which they point out the importance of document management as good practices that contribute to saving paper and therefore to sustainable development. The methodology used is synthesis and cause-effect analysis. Good practices of several organizations are analyzed, as well as the problems that paper waste causes to the environment. The result of this work has led to the definition of processes for the implementation of Document Management. (López, 2019; Ramírez, 2020)..

Between the years 2019 and 2021, the world population had to confine itself and maintain physical distance in public spaces, as a result of the global health crisis of COVID-19. As a result, states modified their policies to implement telework and online education at all levels, measures that were possible thanks to technological innovation, precisely the Information and Communication Technology (ICT). (Kem-Mekah, 2020 p. 23).

Articles published on university teaching during the COVID-19 crisis in Spain, analyze the main teaching resources used by professors, 73.2% of the students who participated in the research indicate that their professors have uploaded files with contents of the subject syllabus,

this means being greater with respect to videoconferences and online assignments (Pazos et al., 2020).

At the beginning of the year 2022, after two years of confinement, humanity partially returns to normality, but it left wise lessons at all levels of academia. In the environmental aspect, it contributed to the reduction of the carbon footprint because many IES resorted to digital documents, avoiding the printing on paper of student assignments and administrative reports.

In summary, the change seems appropriate, as technology should be able to be integrated into the day-to-day life of an organization to improve it and contribute to the conservation of the environment (Leiva-Aguilera, 2016 p.54).

In context, nowadays governments, companies, educational system and people converge in the idea of reducing to a great extent the use of vegetable matter in the manufacture of paper, cardboard, as well as to reduce the use of chemical products in the elaboration of inks necessary elements in the printing of documents; in contrast to this, they bet for using digital documents, helping to reduce deforestation, saving time, money and reducing the carbon footprint.

Materials and methods

The study area is the State Technical University of Quevedo, located in the Province of Los Ríos, Ecuador. The study analysis comprises four academic periods from 2020 to 2022, classified into First Academic Period (PPA) and Second Academic Period (SPA). These periods were selected due to the COVID 19 pandemic that caused a radical change from face-to-face to virtual education. In this process there was a change from physical to digital documents. These data on the number of documents generated by UTEQ were obtained from the reports of the institution's Academic Management System (SGA).

The data processing consisted of four phases: 1) the number of text files was counted; 2) a survey was applied to teachers to estimate the average number of sheets for each academic activity (analytical plan, syllabus, didactic guide, subject reports, expositions, lessons, homework and practice reports) (Kapuka et al., 2017) 3) the total number of sheets for each file was calculated; and, 4) the carbon footprint was determined based on the paper emission factor, given by the methodology of (Dias & Arroja, 2012; Yue et al., 2017).. No other CO emission factors were considered in the calculations of this research₂ .

Carbon footprint calculation

The determination of the carbon footprint proposed is based on the ISO 14040/14044 standard, which according to the documentary review of similar works, has been used to quantify the environmental impact in the life cycle of photocopying paper, a practice widely used in

document printing in Ecuador (Dias & Arroja, 2012; Ferre-Gutiérrez et al., 2021; Yue et al., 2017). The method for calculating CO₂ of the life cycle of photocopying paper is 4.64 g CO₂ equivalent (eq) per A4 sheet, according to ISO 14040/14044 standards. (Dias & Arroja, 2012).

The procedure to obtain the CO₂ emission due to paper consumption at UTEQ consisted of multiplying the emission factor by the number of sheets and transforming grams to tons (Cabezas & Chavarro, 2020; Dias & Arroja, 2012; Rojas Ruíz, 2017). The application of this standard allows the quantification of 98% of total GHG emissions with the least effort in data processing. (Dias & Arroja, 2012).

Data analysis

The data were analyzed using descriptive statistics, such as averages, mode, percentages and bar graphs.

Result

Leaf consumption

The number of sheets that are usually generated as a result of academic management are described in Table 1, categorized by seven groups, such as: classroom management, autonomous work, evaluations, reports, weekly planning, didactic resources and the teaching portfolio. The total number of sheets that would have been issued without having ventured into online education at UTEQ is 692,511 in the 2020-2021 academic year and 646,706 for the 2021-2022 cycle. Within the results, project activities and didactic guides stand out as consuming high amounts of sheets, ranging from a minimum of 162,435 to a maximum of 180,807 sheets.

Table 1. *Estimated number of leaves*

Groups	Activities	2020-2021			2021 - 2022		
		Archives	\bar{x} hojas	Total sheets	Archives	\bar{x} hojas	Total sheets
Classroom management	Exhibitions	5211		20844	5377		21508
	Workshops	8685	5	43425	8963	5	44815
	Classroom practice	3474		10422	3585		10755
Self-employment	Tasks	11885		47539	10 976		43903
	Projects	5942		178272	5488		164637
	Out-of-class practice	1981		5942	1829		5488
Evaluations	Frequent and partial lessons	13741		27482	14119		28238

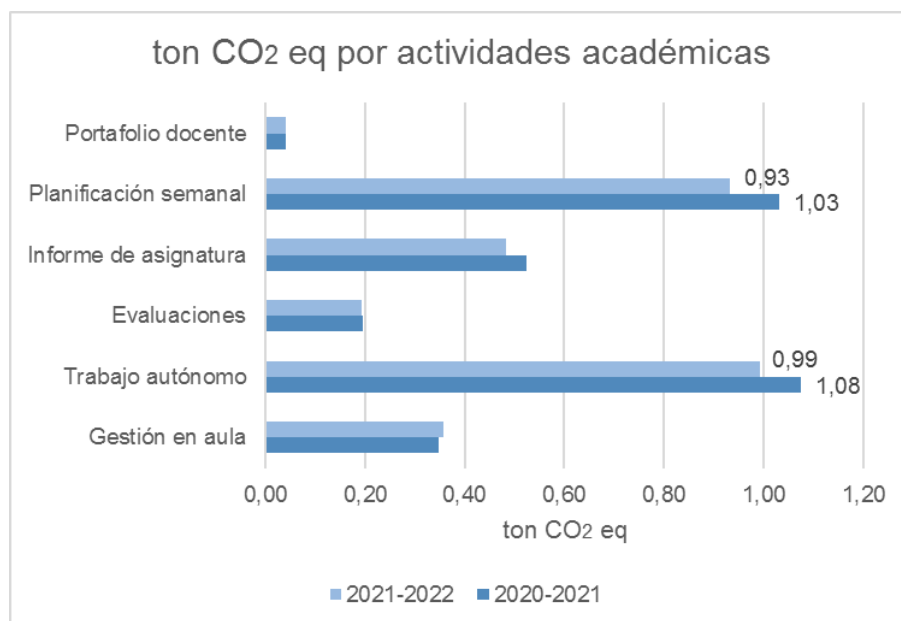
Subject report	Examinations	7263	14526	6692	13384		
	Monthly reports	16418	98508	15069	90414		
	End-of-subject reports	3665	14660	3393	13572		
Weekly planning	Analytical plan	2415	5	12075	2309	5	11545
	Syllabus	3665		29320	3393		27144
	Didactic guides	60269		180807	54145		162435
Teaching portfolio	Resume	724		8688	739		8868
Total sheets per year				692511			646706

Source: UTEQ Academic Management System

Carbon Footprint Projection

CO Emissions₂ by Academic Management

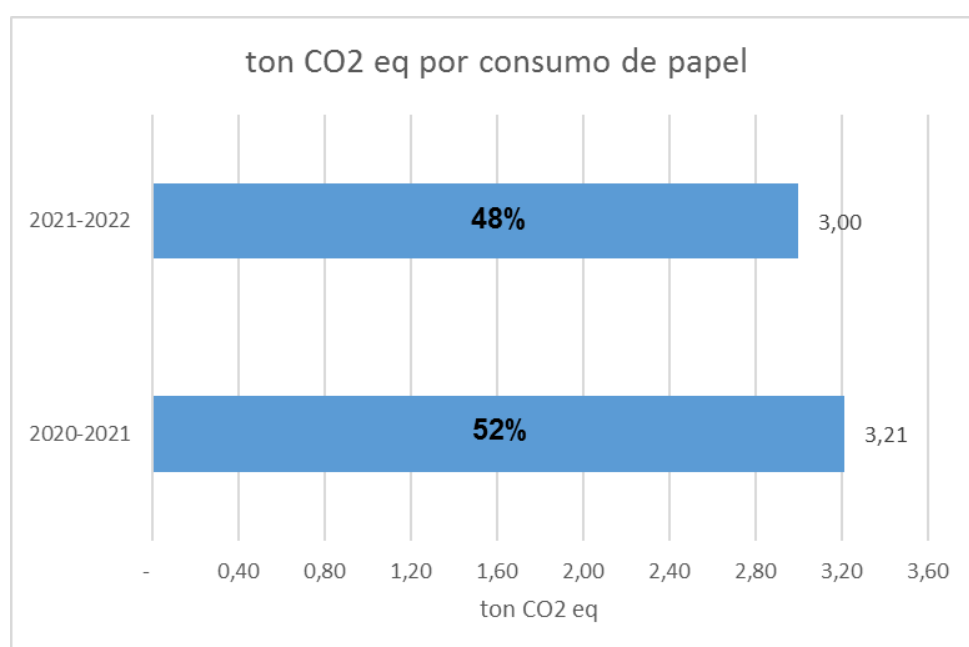
Within academic management, it should be noted that the activities within the weekly planning and autonomous work groups are those that generate the greatest amount of CO₂ emissions due to the number of files developed at the University. Through virtual education, annual emissions have been reduced for the period 2020-2021 in a range of 1.03 to 1.08 ton CO₂ eq and for 2021-2022, the levels have decreased between 0.93 to 0.99 ton CO₂ eq, respectively (Graph 1). On the other hand, the teaching portfolio and evaluations would have been located in lower amounts of CO₂ released to the environment, below 0.20 ton CO₂ eq per year.



Graph 1. Carbon footprint by academic activities. Source: Prepared by the authors

CO emissions₂ annual - online education

The carbon footprint mitigated through UTEQ's online education is 3.21 ton CO₂ eq for the period 2020-2021 and for the following academic period 2021-2022 it is 3.00 ton CO₂ eq (Graph 2). Within these two years there has been a 4% reduction in CO₂ emissions from paper consumption.



Graph 2. Annual carbon footprint. Source: Prepared by the authors

Paper consumption as a result of face-to-face education is high; however, online education in the context of the COVID -19 pandemic made it possible to reduce paper consumption. The amount of paper that UTEQ would have consumed in all its academic faculties would be very high, exceeding 600,000 sheets per year in the academic part alone. Similarly, in Mexico within one faculty the consumption of virgin paper was 150,000 for the year 2016. (Rojas Ruíz, 2017). Another influencing factor is the pattern of paper consumption and of the academic units enrolled for the case of evaluating at the student level. Forty percent of students at Copperbelt University in Zambia, consume less than 100 sheets, while 60% greater than 100 sheets per course. (Kapuka et al., 2017). Helmers et al., (2021) highlights that paper consumption is an important factor and varies substantially between universities. For example, differences between Duquesne University (Pittsburgh - USA) of 0.04% and KU Leuven (Belgium) of 14.8%.

The methodology applied to calculate the carbon footprint due to paper consumption based on emission factors is supported by several researches. (Dias & Arroja, 2012; Muthu, 2016; Rojas Ruíz, 2017; Yue et al., 2017). The carbon footprint mitigated by UTEQ 3.00 ton CO₂ to 3.21 ton CO₂ differs with respect to other universities, 2.83 ton CO₂ eq for the Universidad Autónoma de Baja California (Rojas Ruíz, 2017) 2.03 ton CO₂ eq for Universidad de La Salle, 2.03 ton CO eq for Universidad de La Salle. (Cabezas & Chavarro, 2020). Likewise, large differences are observed when the Universities have a student population, with a high carbon footprint of approximately 33.58 ton CO₂ eq (Fueyo-Cubes, 2020).

Conclusions

This study has shown that virtual education contributes to climate change mitigation through CO₂ emission reductions. UTEQ's online education has allowed minimizing carbon emissions in a range of 3.21 ton CO₂eq to 3.00 ton CO₂eq for the year 2020-2021 and 2021-2022, respectively. These values correspond to a 4% difference in emissions between the two years. The activities that cause the greatest impact on the environment are weekly planning and autonomous work due to the amount of files generated in these activities. Therefore, UTEQ has contributed to the objectives of climate change in reducing the carbon footprint through online education as a result of the COVID-19 global health crisis. The aforementioned actions set the institution on a path towards sustainability and a green university.

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