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Analysis of students carbon footprint in higher education institutions amidst pandemic

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Abstract

During the onset of the COVID-19 pandemic, changes were observed in individual routines, thus affecting the amount of greenhouse gas emissions. Schools were also affected, with a sudden shift from face-to-face to online classes. To study this circumstance, it is important to account for the activities contributing to their carbon emissions. The carbon footprint is the total GHGs emissions generated by our actions, directly or indirectly. This study aimed to analyze the average carbon footprint of the Higher Education Institutions (HEIs) students during face-to-face and online learning and identify which student-related activities contribute more to one's carbon footprint. A descriptive-survey research design was employed using an online survey to gather the activity intensity of every student regarding their food, electrical consumption, ICT use, and transportation. The activity intensity was then multiplied by the emission factors based on other studies to compute their carbon footprint. It was revealed that the student's average annual carbon footprint during face-to-face learning was estimated as 2.55 t-CO2e per person and 1.35 t-CO2e during online learning. In addition, transportation use was the highest contributor and accounted for 58% of the total carbon footprint of the students during face-to-face learning. However, during the height of the pandemic, the footprint from transportation significantly dropped. Food, on the other hand, contributes the most to online learning, accounting for 48% of the total footprint. As a result, school systems may be encouraged to integrate blended learning to reduce the students' carbon footprint.

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Introduction

Greenhouse gases (GHGs) such as carbon dioxide are significant causes of air pollution and drivers of our world's biggest threat which is climate change. When more greenhouse gases are in the atmosphere, it causes the temperature to rise. In addition, human activities are responsible for a large portion of greenhouse gas emissions (IPCC, 2007). Climate change grows more catastrophic as emissions of GHGs increase. Hence, human activities that generate greenhouse gases and eventually aggravate climate change must be identified and measured to quantify emissions properly. The assessment of the impacts of individual actions have on the surroundings, and climate change is called carbon footprint (Wiedmann and Minx, 2008; Čuček *et al.*, 2015). It is calculated by taking the emissions from each activity and multiplying them by the emission factors. Analysis of individual carbon footprint covers direct or indirect emissions from activities such as food and electrical consumption, and transportation use.

There is no better place to undertake the analysis than big universities, especially higher education institutions that are large enough to support extensive, organized assessments. In addition, HEIs have academics on hand to do carbon footprint analyses (Li *et al.*, 2015). Hence, the study was then conducted in two large universities of Tacloban City namely, Eastern Visayas State University and Leyte Normal University. Before the spread of COVID-19, traditional face-to-face learning was primarily the learning modality used in schools. Students attend classes in person. In the study of Li *et al.* (2015), the daily activities relating to school for students were categorized as daily life (food and dorm plugs), academics, and transportation. When compared among these activities, daily life (food) contributed the most to their carbon footprint. However, when COVID-19 disease became a worldwide issue, many institutions around the world were affected. The educational system, including higher education institutions (HEIs) in the Philippines, faced the same challenges. With online learning, students' activities changed. Hence, the study aimed to examine the students' activities contributing to their carbon footprint during online learning and compared them to face-to-face learning.

Materials and methods

Use of Online Survey

Due to no in-person interaction, an online survey questionnaire with the use of Google forms were utilized to collect the students' activities that affect their carbon footprint. The researcher used a modified online survey questionnaire adapted from the study of Li *et al.* (2015) where related questions were added to contextualize the activities that contribute to the students' carbon footprint in the locality. The questions were grouped into five (5) categories considering that these activities are school related. The activities include food consumption, electrical consumption, ICT use, and transportation use.

Sampling method

Since the population of each HEIs is large and heterogeneous, a proportional representative sample must be achieved. Moreover, a simple random sampling was used to ensure that every student from the different programs and year levels had equal chance of being selected. The researcher secured the list of students and email addresses per HEI. Then they were randomized using Microsoft Excel. A link to the face-to-face survey form was sent to the first half of the list of students, and the online survey form was sent to the other half. In addition, the sample size that represented the population was determined using the Cochran formula, which was developed by Cochran (1963).

Carbon Footprint Analysis

After the number of responses had been reached, the data collected was subjected to Microsoft Excel calculation which includes the emission factor per activity, as shown in the table below. To compute the individual carbon footprint of the student is to calculate the GHG per activity, as shown in the equation below. The emission factors F_i used in this analysis for each student activity were mainly taken from different reliable sources, as shown in Table 1. The emission factors are similar for all respondents.

However, for each respondent, the varying point is the intensity of their activity, or the number of U_i units per year associated with the *i*-th activity, such as the amount of time spent using devices, distance traveled, etc. Thus, to compute the carbon footprint per activity i, the emission factor F_i was multiplied by the activity intensity U_i.

$$GHG_i = F_i \cdot U_i$$

Table 1. GHG emission factors to be used in computing the Carbon footprint per activity.

	Emission Factors	Sources
Electricity	0.548kg CO2e / kWh	WWF (Philippine Version)
LPG	3.02kg CO_2e /kg LPG	
Pork	12.1kg CO2e /kg	Hamerschlag (2011) on Meat Eater's Guide
Chicken	6.9kg CO2e /kg	
Vegetables	2.0kg CO2e /kg	
Fish (Tuna)	6.1kg CO2e /kg	
Use of Personal Computer	0.079kgCo_2e / hour	Li *et al* (2015)
Scanning	0.0013kgCo_2e / page	
Printing	0.0043kgCo_2e / page	
Use of smartphone	0.011kgCo_2e / hour	
Multicab/Jeep	0.022kg CO_{2e} / km	
Bus	0.015kg CO_{2e} / km	WWF (Philippine Version)
Van	0.029kg CO_{2e} / km	
Tricycle	0.022kg CO_{2e} / km	
Bicycle	0	
Walk	0	
Personal Car		
a. Diesel	2.64kg CO_{2e} / L	
b. Gasoline	2.30kg CO_{2e} / L	
c. Unleaded	2.39kg CO_{2e} / L	
Airplane	12.7kg CO_{2e} / km	

Results and discussions

The students' average carbon footprints during the face-to-face and online learning

A total of 831 students from HEIs in Tacloban City were able to answer the survey form evaluating their activities during the face-to-face learning and 847 students for the online learning. As shown in Table 2, the mean of the annual carbon footprints during the face-to-face learning was estimated as 2,554.59kg CO2e (2.55 t-CO2e) per person, which is lower than the worldwide carbon footprint per person, which is 4.79 t-CO2e but higher than that of India which is 1.91 t-CO2e (UN World Population Prospects, 2019).

Furthermore, in the study by Li, Tan, and Hackes (2015), the average annual carbon footprint of students at Tongji University was 3.84 tCO2e, with a standard deviation (SD) of 1.01 tCO2e.

Table 2. The Students' Average Carbon Footprint during Face-to-face and Online Learning

Group	N	Category	Mean (Ave. Carbon footprint) (kg CO_2e)	Median (kg CO_2e)	SD
Face-to-face	831	Total	2554.59	1222.83	11104.59
		Electricity	188.42	146.13	
		Food	685.61	473.42	
		ICT use	212.71	174.22	
		Transportation	1476.03	106.98	
Online	847	Total	1354.42	1068.97	2135.31
		Electricity	241.53	175.36	
		Food	649.85	407.98	
		ICT use	277.09	235.59	
		Transportation	185.95	0.00	

Another essential thing to note is that the total average carbon footprint of the students during face-to-face learning is numerically higher than online learning. Based on the table below, the weighted mean of carbon footprints during online learning was assessed to be 1,354.42kg CO2e (1.35 t-CO2e) per person.

However, when examined individually, the assumption is invalid since some areas, such as electric consumption and ICT use, have larger values in online learning than face-to-face learning. Thus, an increase in electric consumption and activities related to ICT use, such as using computers and smartphones during online learning, were observed.

One issue that emerged as seen from the table was that the median (1,222.83kg CO_2e for Face-to-face learning; 1,068.97kg CO_2e for Online learning) is substantially smaller than the mean (2,554.59kg CO_2e for Face-to-face learning; 1,354.42kg CO_2e for Online learning). These findings suggest that the carbon footprints is right-skewed, inferring that few students have particularly large footprints and thus produced an overwhelming impact on their footprints. This observation seems consistent with the findings of the study of Koide *et al.* (2019), in which they examined the household carbon footprint in Japan and discovered that a few consumers who had large footprints have a significant impact on the total carbon footprint.

Areas that contribute to the students' carbon footprint in face-to-face learning

Turning now to the individual areas contributing to the carbon footprint, as shown in Fig. 1, transportation accounts for 58% of the total footprint, making it the biggest contributor to the students' carbon footprint during face-to-face learning. This outcome is inconsistent with Li, Tan & Hackes (2015), who found the daily life category (dining, showering, and dorm plug load) the largest contributor and accounts for 65% of the students' carbon footprint.

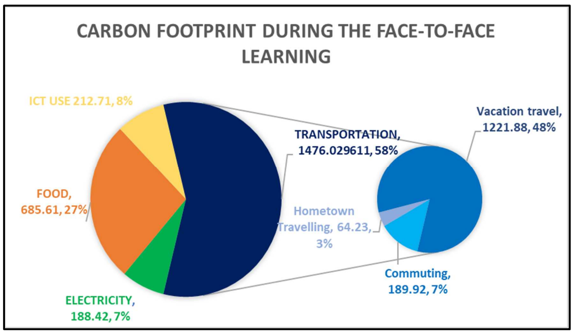

Fig. 1. Carbon Footprint during the Face-to-face learning.

Transportation includes the day-to-day commute to school, which accounts for 8% of the total transportation, hometown traveling for those living in the city during classes for 7%, and vacation travel throughout the year of 48%. Vacation travel includes going to places with land transport vehicles such as buses, personal cars, and public utility vans.

In addition, according to Kleefeld *et al.* (2013), air travel continues to have the most significant climate impact per distance traveled. In support, traveling by air pollutes the atmosphere the most, accounting for 22 percent of the global carbon budget as demand grows (Cames *et al.*, 2015).

Although only a few students seem to travel for a vacation riding an airplane, the amount of carbon emission due to flight travel has affected the total average carbon footprint. These results support the previous findings, stating that a small number of students with larger footprints have pulled the mean and made the distribution positively skewed. Thus, it can be assumed that the students who prove to contribute higher carbon emissions due to vacation travel have a higher total carbon footprint during face-to-face learning.

In this study, food comes second, covering 27% of the total average carbon footprint. This area includes eating meat, pork, fish, and vegetables per meal and using Liquified petroleum gas (LPG). However, a limitation of this area is that it only accounts for food consumption without considering its production. Such that food production is responsible for 68 percent of all food emissions, based on the results found by Boehm *et al.* (2018).

The contribution is then followed by the activities related to ICT use, such as using computers for entertainment and studying, printing, scanning, and smartphones, which account for 8% of the total average carbon footprint. Lastly, electric consumption only covers 7% of the total footprint. It was calculated by the estimated electric bill per month divided by the number of household members.

Areas that contribute to the students' carbon footprint in online learning

The Fig. 2 shows the proportion of areas contributing to students' total average carbon footprint during online learning. It can be noted that the highest contributor was the food which accounts for 48% of the total footprint of the students. However, as shown in table 2, the average carbon footprint from food in online learning (649.85kg CO2e) is lower than that of face-to-face (685.61kg CO2e). This inconsistency may be due to a substantial reduction in emissions from other areas during online learning.

A study by Janssen *et al.* (2021) in Denmark, Germany, and Slovenia revealed that during the COVID-19 pandemic, people tended to lower their consumption of fresh food due to decreased shopping frequency. However, it was also observed that the consumption of non-perishable food intensified.

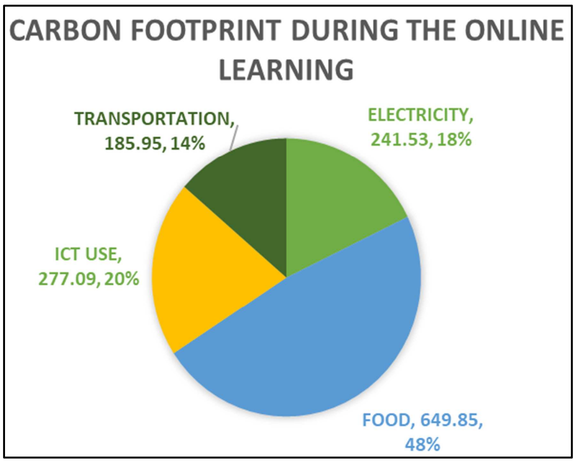

Fig. 2. Carbon Footprint during the Online learning.

ICT use and electricity account for 20% and 18% of the total footprint, respectively. An increase in these two areas during online learning may be due to the increased time spent using gadgets such as cell phones and personal computers for either studying or entertainment. On the other hand, it is apparent in Fig. 2 the huge decrease in the contribution of transportation to the total footprint during online learning. This result may be due to the preventive measures implemented by the government to decrease the chance of spreading the disease, such as staying at home and maintaining physical distancing.

It is consistent with the data obtained by Le Quere *et al.* (2020), where transport use declined by 75 percent for aviation and by 50 percent for surface transport. In support, even before the COVID-19 pandemic, a study in the Netherlands by Versteijlen *et al.* (2017) claimed that student travel, including the daily commute between residence and HEI, traveling back to hometown for study activities, would be lessened due to online education. According to this study, the average carbon footprint of students from Higher Education Institutions (HEIs) amidst the pandemic is much lower than the pre-pandemic. The result suggests the benefit of conducting online learning. Alternatively, it may be encouraged that the school systems may integrate blended learning as a way to reduce the students' carbon footprint without compromising the students' interactive in-person classes. In fact, in accordance with the Paris Climate Agreement, the Philippines pledges to reduce and avoid greenhouse gas emissions by 75% by 2030. This may be how we can help reduce the impact of climate change.

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