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Research Article

Consumption-Based Estimates of Carbon Footprint and Its Global Warming Solution: Input to Awareness Campaign

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ABSTRACT

Understanding the consequences of everyday consumption, and learning how to reduce the size of collective carbon footprint, are vital to reducing CO2 emissions and slowing down human caused climate change. A carbon footprint is a measure of the amount of greenhouse gases (CO2, methane, nitrous oxide) measured in units of carbon dioxide, produced by human activities. This study aimed to quantify the carbon footprint and awareness in solving global warming of teachers and students in the College of Education based on consumptions' estimates categorized into food consumption, energy usage and household activities. The measurement of Carbon footprint of student-respondents was determined as a whole and by specialization. A number of 296 student-respondents specializing in Filipino, English, Science, TLEd and PEd had a comparable carbon dioxide emission and contributed almost the same percentage in the total carbon footprint considering the different activities they engaged in. While the 35 teacher-respondents had greatest carbon footprint in their type and choices of food consumed. These data were gathered using a survey questionnaire through google form containing different activities with corresponding points associated to greenhouse gases emission. The total emission was computed using this formula: Total Emission (tCO2e) = Activity Data Points in (lbs.) X Emission Factor (tCO2) X Global Warming Potential (e). The result implies that the average carbon footprint of each respondent ranges from 2.04 to 2.55 tCO2e which is below the global average of 4 tCO2e per person. The "average" level of awareness implies that the respondents need to change their lifestyles to cut down carbon footprint but increase knowledge in solving global warming using the developed information and awareness campaign recorded video clip.

Keywords*: Greenhouse gases, Emission factor, Global Warming Potential*

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Introduction

Everyone has a CO2 or carbon "footprint". A carbon footprint corresponds to the whole amount of greenhouse gases (GHG) produced to, directly and indirectly, support a person's lifestyle and activities. The size of footprint depends on lifestyle choices, such as diet and purchases. The increasing levels of CO2 in the atmosphere are a result of human activities and are intensifying climate change. Since the introduction of the term "global warming," however, has managed to increase awareness and accountability for CO2 emissions, but there is still a lot of work to do.

A carbon footprint is a measure of the amount of greenhouse gases, measured in units of carbon dioxide, produced by human activities. It is typically given in tons of CO2-equivalent (tCO2-e) ("CO2 Equivalents," 2018). Calculating the carbon footprint is fundamental to understand how the activities of a person or other entity (e.g., building, corporation, country, etc.) and the impact to global warming.

Federigan (2021) emphasized that there is a need for cooperation by all entities in a community be it local and national, businesses, the academe and the youth. The actions and initiatives must come from the individuals making sure that they are part of the solution and not part of the problem. This can promote a change in their mind set by being proactive rather than reactive. To mitigate this climate crisis, there should be an effort to change the different lifestyles and engagement towards conservation of the environment with the youth as initiators to effect positive action.

CO2 emissions of the Philippines increased from 25.7 million tonnes in 1970 to 150.6 million tonnes in 2019 growing at an average annual rate of 3.90% ("Philippines - CO2 emissions", 2019). It is not a major emitter but nevertheless it is relevant to investigate CO2 emissions from consumption before its emission level may become worse. However, according to a study published in the journal "Environmental Research Letters," the top carbon-emitting countries in Asia are China, India, Japan, and South Korea (Shan et al., 2018). The study found that China's carbon footprint was the largest, accounting for over 50% of total Asian emissions, followed by India at around 20% (Shan et al., 2018). The researchers also noted that the per capita carbon footprint varied significantly across Asian countries, with Singapore and Japan having the highest per capita emissions, while countries like India and Pakistan had relatively lower per capita emissions (Shan et al., 2018). Despite of its importance, carbon footprints are difficult to calculate exactly due to poor knowledge and short data regarding the complex interactions between contributing processes – including the influence of natural processes that store or release carbon dioxide. Understanding emissions from the household side, food consumption and energy usage have direct implications in developing the awareness to possible solution to global warming. Thus, this study was conducted.

Generally, this study aimed to quantify the carbon footprint and awareness in solving global warming of the faculty members and students in the College of Education based on consumptions' estimates. This further aimed to ascertain the following:

1. What is the actual carbon footprint of the student-respondents as a whole and when grouped according to specialization in terms of food consumption, energy used and household activities?
2. What percentage does the student-respondents share in the total carbon footprint when grouped according to specialization in terms of food consumption, energy used and household activities?
3. What is the actual carbon footprint and percentage of the teacher-respondents in terms of food consumption, energy used and household activities?
4. What is the level of awareness of the respondents towards solving global warming according to personal profile?
5. What awareness campaign can be developed for the reduction of carbon footprint?

Method of Research

A quantitative method using descriptive approach of research was used to quantify carbon footprint and describe the level of awareness of the respondents. This further provides systematic information about carbon footprint's consumption estimates and global warming solution.

Locale and Respondents of the Study

This research was conducted among the faculty members and students of the College of Education, CapSU Main Campus, Roxas City for the Academic Year 2020-2021. Out of 1,276, a sample size of 296 for student-respondents was determined using Raosoft Sample Size online Calculator (2004). A stratified proportionate random sampling was done for determining the sample size of each major from the student-respondents with an internet connection. However, there were 51 faculty members (regular and emergency teachers) but only 35 (68.63%) responded. The profile of the respondents is presented in Table 1.

Table 1. Profile of the respondents

Personal Profile	Teacher-respondents		Personal Profile	Student-respondents	
	F	%		F	%
Academic Rank			**Major**		
Professor	1	2.86	BPEd	63	21.28
Associate Professor	10	28.57	BTLEd	59	19.93
Assistant Professor	10	28.57	Science	45	15.20
Instructor	10	28.57	Filipino	61	20.61
Emergency Teacher	4	11.43	English	68	22.97
Total	**35**	**100.00**	**Total**	**296**	**100.00**

Research Instrument

A survey questionnaire through google form was used in gathering data to answer the problems stated. The questionnaire consisted of three parts: Part 1 was on the personal profile of the respondents; Part 2 was on carbon footprint determination categorized into: food consumed, energy usage and household activities with ten (10) questions for each category; while Part 3 contained eight (8) questions on the awareness toward global warming solution. The survey questionnaire for carbon footprint was adapted from different sources: "What kind of Footprint? Carbon Footprint" (2011) and "Footprint Commitment and Calculator –("egliseverte" n.d.). However, for global warming was adapted from "How Much Do You Know About Solving Global Warming?" by Schlossberg (2017). These were revised and content validated by the Science teachers in the College of Education who were not included as respondents. The choices in the questionnaire contained points based on the amount of greenhouse gases emitted. The point system was patterned from the adapted questionnaire. The respondents answered by checking only the choices that apply to them. Likewise, for part 3, the respondents were given two choices and checked only one which they believed would help solve global warming. Answers were corrected and counted.

Data Gathering Procedure

Since the research was conducted in the College of Education, with the permission of the dean, the different section teacher advisers with the coordination of the barangay captains were requested to facilitate in posting on their class' group chat the link of the google form having the survey questions. The survey questionnaire already contained instruction for the respondents on what to do. The respondents' responses were directly recorded to the researchers' file.

Data Analysis Procedure

The data gathered through the google form were analyzed following these steps. First, personal profile was tabulated, tallied and the percentage was computed. Then, the responses in Part 2 (carbon foot print quantification), each response was given a specific points (in pounds) and converted to tons (2.2lbs = 1 kg= 1000kg= ton) in each activity (food consumption, energy usage and household activities). Then, it was classified based on greenhouse gas emission (CH_4, CO_2 and N_2O). All GHG emissions were converted into CO_2 equivalents

so that the data could be compared ("CO_2 Equivalents," 2018). The emission factor was computed by dividing total emission in each category using the formula:

Total emission (tCO2e)	=	Activity Data Points (lbs.)	X	Emission Factor (tCO2)	X	Global Warming Potential (e)

Where: ***Total emission*** was the product of total carbon dioxide emission considering the total points from the respondents' activities multiplied by emission factor of each GHG emitted and expressed in tCO_2e.

Activity Data Points were the equivalent points assigned to each activity incurred by the respondents depending on food consumption, energy usage and household practices based on the adapted and revised questionnaire (lbs to tons).

Emission Factor was the total activity points of a specific GHG divided by the total number of samples ("Basic Information of Air Emissions Factors and Quantification," 2019).

The Global Warming Potential (GWP) is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases. ("Understanding global warming potentials," n.d.)

The emission of Carbon dioxide is attributed to the following reactions:

1. **Combustion reaction,** all hydrocarbons (including alkanes, alkenes and cycloalkanes) can undergo combustion reactions with oxygen to give the same two products (CO_2 and H_2O). Hydrocarbon fuels burn when they react with oxygen in the air. As all hydrocarbons only contain the elements carbon and hydrogen, the only products will be oxides of these elements; $CH_4 + O_2$ $CO_2 + H_2O$. ("Energy from fuels", 2021).
2. **Decomposition reaction,** $CH_2O + O_2$ $CO_2 + H_2O$ + Nutrients

The classification of Global Warming Potential (GWP) based on Kyoto Gases (IPCC 2007)

Greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's warming. Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime").

Methane (CH_4) is estimated to have a GWP of 28–36 over 100 years. CH_4 emitted today lasts about a decade on average, which is much less time than CO_2. But CH_4 also absorbs much more energy than CO_2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. The CH_4 GWP also accounts for some indirect effects, such as the fact that CH_4 is a precursor to ozone, and ozone is itself a GHG.

Nitrous Oxide (N_2O) has a GWP 265–298 times that of CO_2 for a 100-year timescale. N_2O emitted today remains in the atmosphere for more than 100 years, on average.

Likewise, for Part 3 (awareness about global warming solution), the correct answers were counted and the mean was computed. The mean score interval was verbally interpreted in terms of level of awareness

Mean scores	Level of Awareness
5.34-8.00	High
2.67-5.33	Average
0.00 -2.66	Low

Environmental awareness implies knowledge about environment and inculcates values and required skills to solve environmental issues and it is an initial step leading to carry responsible citizenship behavior (Sengupta, Das and Maji, 2010)

Table 2. Carbon footprints of the student- respondents

Respondent	Sample Size	Food Consumption (tCO_2e)	Energy usage (tCO_2e)	Household activities (tCO_2e)	Total (tCO2e)	Average carbon footprint per person* (tons)
Specialization						
English	68	74.71	1.26	89.91	165.88	2.44
Filipino	61	60.22	0.99	63.05	124.26	2.04
Science	45	44.57	0.75	57.60	102.92	2.29
TLEd	59	68.71	1.05	73.61	143.37	2.43
Ped	63	75.11	1.12	81.94	158.17	2.51
Total	**296**	**323.32**	**5.17**	**366.11**	**694.60**	

** Globally, the average carbon footprint for a person is closer to 4 tons (https://www.nature.org/en-us/get involved/how-to-help/carbon-footprint-calculator/)*

As shown in table 2, considering the 296 number of samples included in this study, they were able to record a carbon footprint total estimate of 694.60 tCO_2e. This value represents the greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and Nitrous Oxide (N_2O) which were converted to CO_2 equivalent. These GHGs are emitted or produced in the different activities by the respondents. A greenhouse gas (or GHG for short) is any gas in the atmosphere which absorbs and re-emits heat, and thereby keeps the planet's atmosphere warmer than it otherwise would be. The main GHGs in the Earth's atmosphere are water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone. GHGs occur naturally in the Earth's atmosphere, but human activities, such as the burning of fossil fuels, are increasing the levels of GHG's in the atmosphere, causing global warming and climate change (Brander, 2017).

This total CO_2 footprint was the product of activities of the respondents, emission factor and global warming potential for each GHG expressed in tons Carbon dioxide equivalent (tCO2e). Considering the specialization of the student-respondents, their activities under food consumption, PEd got the highest CO_2 footprint of 75.11 tCO_2e, followed by English 74.71 tCO_2e, then TLEd 68.71 tCO_2e, Filipino with 60.22 tCO_2e,while Science got a 44.57 tCO_2e. The activities involved were the type of food they ate (e.g. meat, dairy, vegetables and fruits), whether in fast food or home-cooked and the frequency, source (organic, locally grown or processed), amount wastage. All these generated Carbon dioxide due to utilization of fossil fuels, conversion of methane to carbon dioxide due to combustion and decomposition of organic matter and nitrous oxide attributed to agricultural products.

The energy usage got the lowest carbon footprint of 5.17 tCO2e among the activities studied. This simply shows that the respondents are very much aware and practice conservation of energy particularly among those who are specializing in Science which got 0.75 tCO2e of carbon footprint. Likewise, the rest of the respondents who belonged to other specialization had almost the same carbon footprint. The activities included in the questionnaire were all on the utilization of electricity derived from fossil fuels, an organic in origin and hydrocarbon compound. The combustion of hydrocarbon with the reaction of oxygen gas produced carbon dioxide, water and heat:

For the household activities, the student-respondents from different specializations emitted the greatest carbon footprint with English as the highest. The carbon footprint in this

category could be attributed to living space, number of people in a household, practices like water usage, purchasing of clothes and recycling. These showed the lifestyles of the respondents which unknowingly, increase their carbon footprint.

Furthermore, the average carbon footprint per respondent was in the range from 2.04 to 2.55 tCO2e. When compared with the average carbon footprint for a person in the United States is 16 tons, one of the highest rates in the world. Globally, the average is closer to 4 tons per person. To have the best chance of avoiding a 2°C rise in global temperatures, the average global carbon footprint per year needs to drop under 2 tons by 2050 ("Carbon footprint calculator", 2021).

The researchers would like to take note that these estimates were approximate and intended for enhancing the awareness and information purposes only. They should not be used for emission inventories, formal carbon footprints, or formal emissions analysis.

Table 3. Carbon footprints percentage of the student- respondents

Respondent	Food Consumption (tCO_2e) Mean	%	Energy used (tCO_2e) Mean	%	Household activities (tCO_2e) Mean	%
Specialization						
English	1.10	20.22	0.018	20.69	1.32	21.39
Filipino	0.99	18.17	0.016	18.39	1.03	16.73
Science	0.99	18.23	0.017	19.54	1.28	20.71
TLEd	1.16	21.44	0.018	20.69	1.25	20.19
PEd	1.19	21.94	0.018	20.69	1.30	21.05
Total	**5.43**	**100.00**	**0.087**	**100.00**	**6.18**	**100.00**

The mean of the carbon footprint was calculated to account for the contribution of every respondent in each specialization and expressed it in percentage. This further shows how much of this carbon footprint is shared in relation to the total carbon footprint of the student-respondents in the College of Education. When the means in each category was compared, regardless of specialization, they had almost the same carbon footprint because they have similar activities and lifestyles.

Table 4. Carbon footprints of the teacher- respondents

Activities	**Carbon Footprint (tCO_2e)**	**%**
Food Consumption	43.37	57.62
Energy usage	0.02	0.03
Household activities	31.88	42.35
Total (35)	**75.27**	100.00
Average carbon footprint per person* (tons)	**2.15**	

* Globally, the average carbon footprint for a person is closer to 4 tons (https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator/)

The teacher-respondents involved in this study were from the College of Education who answered the questionnaire using google form. It can be noted that the lowest carbon footprint was in the energy used. This only shows that they are really practicing energy conservation as their way of life by cross cutting their monthly electrical bills. However, their food consumption got the highest carbon footprint which can be attributed to busy schedule that sometimes they opted to eat processed food, and packed foods which have to be delivered due to COVID-19. They eat organic and locally grown foods but only "sometimes". These lifestyles of the teacher-respondents contributed a total carbon footprint of 75.25 tCO2e. Taking into consideration, each teacher has an average carbon footprint of 2.15 (tCO_2e). According to Bekaroo, Bokhoree, Ramsamy, and Moedeen, (2019) that higher education institutions are often being referred as sustainability change agents, employees of such organizations have an essential role towards promoting low-carbon practices amongst students, who are also influenced by the attitudes and behaviors of teachers. For this, employees of higher education institutions need to properly understand their personal carbon emissions along with reduction mechanisms, in order to instill such knowledge and skills to students. The findings also mean that more efforts are needed at different levels in order to better engage employees of higher education institutions to reduce their personal carbon footprints.

Table 5. Level of awareness of the respondents towards solving global warming.

Respondent	Mean	Verbal Interpretation
Teachers	2.91	Average
Students		
English	3.00	Average
Filipino	2.89	Average
Science	2.98	Average
TLEd	3.25	Average
PEd	3.00	Average
Total	**3.01**	Average

This can be divided into subsections if several methods are described (Bekaroo et al., 2019).

As shown in table 5, the level of awareness of both teachers and students was on the "Average" based on the scores in the survey questionnaire. It reflected their personal way which they think can help solve global warming. However, it turned out that their responses were not the most appropriate. The student-respondents who belonged to TLEd got the highest mean score when compared to other respondents. This is contrast with the study of Freije, Hussain, & Salman,2017) that biology students were the most knowledgeable and have excellent global warming awareness among the science students of Bahrain. This can be attributed to their academic curriculum. They recommended the integration of environmental concepts into the university curriculum for all students irrespective of their academic specialization in order to increase the environmental awareness.

Awareness Campaign

The result of the study implied that there is a need to increase the awareness of the respondents in decreasing their carbon footprint and increase their knowledge in solving global warming. An information and awareness campaign recorded video clip was developed to suggest ways in reducing carbon footprint and an orientation on how to solve global warming. This was uploaded in the Face book page of the local SSC of the College of Education. This was also forwarded to the different section Brgy. Captains to be uploaded to their group chat and to the CapSU Main CoEd faculty messenger account. The informative video clip provides a

comprehensive overview of carbon footprint awareness and practical steps individuals can take to reduce their environmental impact. Using clear and accessible language, the video outlined the primary sources of carbon emissions, including transportation, energy consumption, and waste management. Through the use of data visualizations and real-world examples, viewers gain a deeper understanding of the scale and urgency of the carbon footprint challenge.

Conclusions

The different activities such as consuming foods, utilization of energy and different practices at home are great contributors of carbon footprint. The greenhouse gases including CO_2, methane and nitrous oxide are emitted as a result of the lifestyle of the student-respondents regardless of specialization. The conservation of energy has been observed by everybody. Likewise, although they belonged to different specialization, they contribute almost the same amount of carbon footprint because they have similar activities and lifestyles. Teacher-respondents also practice energy saving. However, their choices and type of food they eat have contributed much in their carbon footprint emission. All of the respondents need to enhance their knowledge in solving global warning. Thus, an information and awareness campaign recorded video clip was developed to suggest ways in reducing carbon footprint and an orientation on how to solve global warming.

Recommendations

Although, the average carbon footprint of every respondent is below 4 tons as compared globally, there is still a need to integrate environmental concepts in the curriculum and an orientation campaign using different social media platforms like the developed information and awareness campaign recorded video clip.

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Introduction

Public health nurses play significant roles and duties during all stages of catastrophes by using their scientific expertise and understanding of behavioral concerns, physiology, pharmaceuticals, cultural-family systems, and

experience, or prior knowledge
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Keywords: *Disaster Response, Di*

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