ESTIMATION OF THE CARBON FOOTPRINT OF THE LOCAL EDUCATIONAL MANAGEMENT UNIT - LEONCIO PRADO, PERU

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ABSTRACT

This research objective is to estimate the carbon footprint of the Local Educational Management Unit - Leoncio Prado in Peru, from the city's activities and sources of greenhouse gas emissions. The study bases on the methodology of the "Greenhouse Gas Protocol" and the "Corporate Accounting and Reporting Standard," using the emission factors of the "Intergovernmental Panel on Climate Change (IPCC)." The study identified fuel consumption (Scope 1), electricity consumption (Scope 2), land travel, water consumption, and paper consumption (Scope 3). Finding that in 2018 Scopes 1 and 2 were given the highest values, being 34.65 tons of CO_2 eq of emissions, and 361.95 tons of CO_2 eq of emissions, respectively and for Scope 3, recorded a higher value in 2015, with 80.72 tons of CO_2 eq of emissions. The result of the total carbon footprint obtained, where the year 2018 recorded a higher value of 505.24 tons of CO_2 eq of emissions, and it was determined, for the year 2019, a per capita carbon footprint of 4.77 tons of CO2 eq/person.

Keywords: Carbon Footprint, Emissions, CO_2, Climate Change, UGEL, GHGs.

INTRODUCTION

This investigation shows us the increasing awareness of the prevention of global warming, generated by the increase of greenhouse gases (from now on GHG) in the atmosphere (Intergovernmental Panel on Climate Change [IPCC], 2007). The global warming problem, one of the global problems prioritized in the last few years, is considered environmental (Dávila & Varela, 2014). This investigation is deliberate as an ecological problem with implications not only on the environment or ecosystems but also on society itself and its economy (Valderrama, 2011). Therefore, it is necessary to discover tactics, techniques, and technologies to reduce concentrations and thus minimize the environmental effect caused by the development of various activities. *"System dynamics modeling is often the background of systems thinking approach and has become a paradigm of management and organizational development"* (Salamzadeh et al., 2013). The formulation of public policies and private occupations has a battle against global warming where it has to dominate the agenda of agencies worldwide. In addition, national governments, organizations, and even

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individuals and the role of combating the phenomenon in the will of institutions and individuals to produce anticipated and coordinated responses.

Methodologies such as quantifying the carbon footprint make it possible to measure the anthropogenic effect -generated by human activity- on the environment. These occupations allow specific actions to mitigate and compensate for the poorly elaborated short, medium, and long term. As mentioned,

The information makes it easier to make timely choices to maintain control of, reduce or neutralize the sources of CO_2 and compensate them through reforestation programs and rescue of protected areas.

In the Local Educational Management Unit - Leoncio Prado (From now on UGEL-LP), any organization uses resources such as vehicles for ground transportation, paper consumption, and drinking water consumption, among others. Therefore, an organization that uses these resources is notable because it influences their environment, releasing gases into the atmosphere. Consequently, it poses a question of the research project: How much is the carbon footprint of the Local Educational Management Unit - Leoncio Prado during the years 2015-2019, according to the research, will quantify the emissions of greenhouse gases emitted by the UGEL-LP, and thus the entity will take measures to minimize and eliminate emissions from sources.

This study consists of four sections; the materials and methods used are the first part. In the second part are the results; in the third section are the conclusions and discussions; finally, in the fourth section are the references used.

MATERIALS AND METHODS

For the estimate of footprint, the descriptive methodology established in the *"Greenhouse Gas Protocol Corporate Accounting and Reporting Standard"* as well as the *"Protocol for the Quantification and Reporting of Greenhouse Gas Inventories."* (World Business Council for Sustainable Development & World Resources Institute [WBCSD-WRI], 2010). As well as the *"Protocol for the Quantification of Greenhouse Gas Emissions in Activities and Emission Factors of the IPCC."* (Intergovernmental Panel on Climate Change [IPCC], 2007). The format used to identify direct and indirect emissions was the *"GHG Emission Source Identification List."* The mobile sources were classifieds in the scopes defined in the GHG Protocol. World Business Council for Sustainable Development & World Resources Institute (WBCSD-WRI), 2010.

The UGEL-LP emits greenhouse gases into the atmosphere, generated in administrative and operational activities inside and outside the institution. These emissions are caused by using fuel-consuming vehicles, land travel at the national level, electricity consumption in the facilities, consumption of drinking water, and use of paper for the administrative procedures of the institution.

To determine fuel consumption emissions, requested information from the head of the logistics area of the UGEL-LP, who provided access to the Integrated Administrative Management System [SIGA]. Developed by the Ministry of Economy and Finance (MEF), providing the *"purchase orders"* detailing the fuel requirements for the central actions of the UGEL since the base year, carried out an annual inventory of fuel consumption.

To determine the electricity consumption, requested information on the monthly electricity consumption of the central premises of the UGEL-LP from the Empresa Regional de Servicio Público de Electricidad del Centro SA (ELECTROCENTRO). Was made an annual inventory of electricity consumption (ELECTROCENTRO), made a yearly list of electricity consumption.

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To determine water consumption requested information on the monthly consumption of the central premises of the UGEL-LP from the Empresa Municipal de Servicios de Agua Potable y Alcantarillado in Huánuco S.A. (SEDA-HUANUCO SA). Made the annual inventory of drinking water consumption (SEDA-HUANUCO SA) a yearly list of drinking water consumption.

To determine paper consumption requested information from the head of the logistics area of the UGEL-LP, who provided us with the "*purchase orders*" detailing the paper requirements and their typology, where they made an annual inventory of paper consumption.

Here are the Identification and Determination of the Consumption of GHG Emission Sources

Greenhouse Gas emission sources identify and classify, considering organizational and operational limits and the list of GHG emission sources identification (Table 1).

Table 1
SOURCES OF GREENHOUSE GASES

Organizational Boundaries	Operational Limits	Type of emission source
Control approach	Scope 1	Emission from petroleum fuels
	Scope 2	UGEL electricity consumption
	Scope 3	• Overland travel • Water consumption • Paper consumption

The format used to identify direct and indirect emissions was the "*GHG Emission Source Identification List."* The mobile sources classify into the scopes defined in the GHG Protocol (World Business Council for Sustainable Development & World Resources Institute [WBCSD-WRI], 2010).

These emissions increase fuel consumption, national land travel, electricity consumption in the facilities, drinking water consumption, and paper use for administrative procedures.

Estimation of Total GHG emissions

Estimating direct GHG emissions

Quantification of GHG Emissions by Consumption: Quantified emissions according to the type of fuel required by the UGEL-LP. Will convert the fuel consumption data (L) to kilograms (kg), then the kilograms of power will be multiplied by its net calorific value. The resulting value will multiply by each CO_2, CH_4, and N_2O emission factor and their respective global warming potential (GWP) (Table 2).

Table 2
LOWER CALORIFIC VALUE, DENSITY, AND EMISSION FACTORS OF FOSSIL FUELS

Type of fuel	Caloric Value Net (KJ/Kg)	Density (kg/L)	Kg CO_2/GJ	Kg CH_4/GJ	Kg N_2O /GJ
Gasoline 90 Plus	47 697.6	0.7215	69.3	0.033	0.003
Lubricants	40 200.0	0.853	73.3	0.003	0.0006
Diesel B5	45 500.0	0.87	74.1	0.004	0.004
LPG	47 300.0	0.542	63.1	0.062	0.0002

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Finally, the total GHG emissions expressed in carbon dioxide equivalent (CO_2 eq) produced by the activity obtained with the sum of these multiplications (Table 3). As a result, summarized all the above steps in the following formula (Intergovernmental Panel on Climate Change (IPCC), 2006):

Table 3
GLOBAL WARMING POTENTIAL (GWP) OF THE MAIN GHGS

Greenhouse Gas	Global Warming Potential
CO_2	1
CH_4	25
N_2O	298

$$ED = \sum \frac{(CU_i * VCN_i * FE_c)}{10^3} + \frac{(CU_i * VCN_i * FE_m * PCG_m)}{10^3} + \frac{(CU_i * VCN_i * FE_o * PCG_o)}{10^3} \quad (1)$$

Where:
CU_i : Fuel used (Kg).
NCV: Net Calorific Value of fuel used, in GJ/Kg
EF: CO_2 Emission Factor of the fuel used, kg CO_2/GJ
EF: CH_4 Emission Factor of the energy used, in Kg CH_4/GJ
EF: N_2O Emission Factor of the fuel used, in Kg N_2O/GJ
GWP: Global Warming Potential of CH_4
Go: Global Warming Potential of N_2O

Estimation of Indirect GHG Emissions

Emissions from electricity consumption: GHG emissions from electricity consumption were estimated with the following equation:

$$ECO_2 = KWh \times F.E. \quad (2)$$

Where:
E CO_2: Direct GHG emissions, in t CO_2 eq.
KWh: It is the sum of kilowatt-hours consumed by the institution.
F.E: emission factor (0.000615 t CO_2 eq/kWh). (Ministry of Energy and Mines (MINEM), 2017).

Estimating Other Indirect GHG Emissions

Quantification of emissions from overland travel: Greenhouse gas emissions from land travel were estimated using the following equation:

$$ECO_2 = Km \times F.E. \quad (3)$$

Where:
E CO_2: GHG emissions, in t CO_2 eq.
Km: Total distance traveled, expressed in kilometers.
E.F.: Emission factor for paper (0.000184 t CO_2 eq/km) (Intergovernmental Panel on climate Change (IPCC), 2006).

Quantification of emissions from water consumption: GHG emissions from water consumption were calculated using the following equation:

$$ECO_2 = C.A * F.E. \quad (4)$$

Where:
ECO_2: GHG emissions, in t CO_2 eq.

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CA: Water consumption data, expressed in cubic meters (m^3).
EF: Emission factor for water consumption (0.0005 t CO2 eq/m^3). (Intergovernmental Panel on Climate Change (IPCC), 2006) .

Quantification of emissions due to paper consumption: Greenhouse gas emissions from stationery consumption were estimated with the following equation:

$$ECO_2 = C.P \times F.E. \quad (5)$$

Where:
ECO_2: GHG emissions, in t CO_2 eq.
C.P: paper consumption, expressed in kilograms.
E.F.: Emission factor for paper (0.00184 t CO_2 eq/kg) (Intergovernmental Panel on climate Change (IPCC), 2006).

Type and Level of Research and Variable Identification

The type of research of the present work is essential, theoretical, or pure, according to Sanchez (1998). The kind of research of the current position is fundamental, academic, or pure since it seeks to increase theoretical knowledge. It also presents a descriptive level of research since the information obtained will serve as a basis for research requiring greater depth (Canales & Alejandro, 2004).

The present research study presents a variable, defining it as a one-dimensional variable (Jacobo et al., 2012), the identified variable's carbon footprint.

RESULTS

Sources of Greenhouse Gas Emissions

Considering the corporate limits and operational limits, also using the list of identification of sources of greenhouse gas emissions, from which was obtained the information for the calculation of greenhouse gas emissions.

Table 4
SOURCES OF GREENHOUSE GAS EMISSIONS IDENTIFIED IN THE LOCAL EDUCATIONAL MANAGEMENT UNIT (UNIDAD DE GESTIÓN EDUCATIVA LOCAL)

Organizational Boundaries	Operational Limits	Type of emission source
Control approach	Scope 1	Emission from petroleum fuels
	Scope 2	UGEL electricity consumption
	Scope 3	· Overland travel · Water consumption · Paper consumption

Carbon Footprint of the UGEL- LP

Considering the emissions of scopes 1, 2, and 3, Tables 4 and 5 show the carbon footprint for the UGEL-LP from the years 2015, 2016, 2017, 2018, and 2019. Corresponding for the year 2019 about 56.13 tons of CO_2 equivalent.

Table 4
THE CARBON FOOTPRINT OF THE UGEL-LP

Year	Direct emissions of t CO_2 eq (Scope 1)	Indirect emissions of t CO_2 eq (Scope 2)	Other Indirect emissions of t CO_2 eq (Scope 3)	Total, emissions of t CO_2 eq

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2015	19.59	18.51	144.68	182.78
2016	19.88	18.81	24.20	62.89
2017	28.63	19.04	27.81	75.49
2018	34.65	20.79	39.96	95.40
2019	11.39	20.58	24.17	56.13

DISCUSSION

In accord with the Institute of Engineering of the National Autonomous University of Mexico, identified the following as sources of GHG emissions: electricity consumption, land transport, air transport, paper use, waste disposal, and shipping. Identified five sources of GHG emissions, all of which were within the three operational limits: scope 1: emissions from petroleum fuels, scope 2: electrical energy consumption, scope 3: emissions from land travel, water consumption, and paper consumption, and unlike the author cited in our work, we present scope 3, which includes water consumption, but excludes solid waste (Güereca et al., 2013). Likewise, Saavedra in 2017 mentions that the University of San Martin de Porres its sources of greenhouse gas emissions were from electricity consumption, water, paper, travel, and transport, while in the present work, we included fuel consumption (Common & Saavedra, 2017). On the other hand, it indicates that fuel consumption is the Catholic University of San Pablo de Arequipa's main source of GHG emissions. In contrast, the main source in the present work is electricity consumption (Barreda & Polo, 2012). As MINAM states in the carbon footprint calculation report, it reports that the sources of emissions are electricity consumption, local transport, air transport, land transport, paper consumption, and water consumption (Ministry of the Environment (MINAM), 2010). The carbon footprint estimation of the *"Granja Villa"* theme park reports that the sources of GHG emissions are fuel consumption, electricity consumption, land transportation, water consumption, paper consumption, and waste generation. According to the studies, unlike the present work, air transportation is not considered since it did not carry out this activity, and waste generation does not consider since no values write down for its quantification (Burga & Ordoñez, 2014). As stated by Arguedas at the Technological Institute of Costa Rica, it does estimate that 2,541 t CO_2 equations were discharging (Arguedas, 2012). Similarly, the University of Cordoba reported emissions of 1 361.98 t CO_2 eq for Scope 1, 6 632.80 t CO_2 eq for Scope 2, and 6556 t CO_2 eq for Scope 3, for a total of 14 550.78 t CO_2 equation (Jordano et al., 2013). Likewise, Hermosilla in 2014, when estimating the carbon footprint of the Polytechnic University of Cartagena, reports a total of 9088.39 t CO_2 equation (Hermosilla, 2014).

CONCLUSION

The sources of GHG emissions in the UGEL-LP identified: fuel consumption, electrical energy, land transport, water consumption, and paper consumption. The highest fuel and electrical energy consumption occurred in 2018. In 2015, a greater distance was travel using land transport, and the highest consumption of water and paper was in 2016 and 2015, respectively the highest values for scope 1 and 2. Occurred in the years 2018, and of scope 3, in 2015; whose emissions were 34.65 t CO_2 equation, 20.79 t CO_2 eq, and 144.78 t CO_2 equation respectively making the UGEL-LP had a higher carbon footprint in 2015 with 182.78 tons of CO_2 equivalent. Finally, the per capita carbon footprint value of the staff working at UGEL-LP in 2019 was 0.59 t CO_2 eq/person.

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