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Greenhouse gas emission: A case in the University of Science and Technology of Southern Philippines-Oroquieta

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Abstract

The COVID-19 pandemic has temporarily decreased the greenhouse gas emissions of the University of Science and Technology of Southern Philippines-Oroquieta. However, as the pandemic became manageable, face-to-face classes were reimplemented in 2022, therefore utilizing laboratories and facilities to comply with the respective course requirements of the students, which caused an increase in emissions. Using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, this study estimates the total entity-level greenhouse gas emission of the campus for the base year 2022 under business-as-usual economic activity. This study investigates the comparison between emissions of mobile and stationary sources and the Scope 1 and Scope 2 emissions. The results revealed that the majority (96.18%) of Scope 1 emission was contributed by stationary combustion sources followed by mobile combustion sources with 0.3494 tCO_2e and 0.01388 tCO_2e, respectively, indicating a statistically significant difference. The Scope 2 emission contributes to the majority (99.07%) of the greenhouse gas emission with 38.5277 tCO_2, while the Scope 1 emission only contributes 0.93% with 0.3633 tCO_2e, further indicating a statistically significant difference. Based on the results, the greenhouse gas emission of the campus was 38.8910 tCO_2e with an emission per capita of 0.0311 tCO_2e, which was below the national average. Generally, there is a need for the campus to intensify commitments to climate actions, particularly in energy conservation, as this scope contributes to the majority of greenhouse gas emissions.

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Introduction

Climate change is one of the global issues of utmost concern at present. It is due to the high concentration of greenhouse gas (GHG) emissions in the atmosphere, which are primarily emitted by nature and anthropogenic activities (Yue and Gao, 2018), thereby resulting in global warming, ecological imbalance, and technological, economic, and societal issues (Liu *et al.*, 2019). The World Resources Institute Climate Analysis Indicator Tool (WRI CAIT) reported increased global greenhouse gas emissions from 1990 to 2019 and a decrease in 2020.

Specifically, the emission, which excludes the land-use change and forestry (LUCF), ranges from 30.63 $GtCO_2e$ to 48.09 $GtCO_2e$ in 1990 and 2019, respectively, and it decreased to 46.12 $GtCO_2e$ in 2020. Similarly, the Philippines had an increasing greenhouse gas emission ranging from 95.36 $MtCO_2e$ to 235.30 $MtCO_2e$ in 1990 and 2019, respectively, then decreased to 224.97 $MtCO_2e$ in 2020 (Climatewatch, 2023). Although the Philippines contribute a relatively small amount of carbon footprint, it is among the countries with economic development greatly affected by the impacts of climate change (Tribe, 2018; Durana, 2017). Having the lowest carbon dioxide emission among other developing countries in Asia in 2020, obtaining 133.47 $MtCO_2$ compared to Pakistan, Malaysia, Thailand, and Vietnam, which emitted 184.11 $MtCO_2$, 245.14 $MtCO_2$, 265.48 $MtCO_2$, and 355.32 $MtCO_2$, respectively (Climatewatch, 2023), the country was stricken by several natural disasters such as sea-level rise, coastal flooding, typhoons, earthquakes and volcanic eruptions (World Bank, 2005; Bollettino *et al.*, 2020). Tribe (2018) further emphasized other observed climate change impacts, such as temperature rise, decreased regularity of precipitation, decreased quantity of surface water due to higher air temperatures, and a northward shift of marine species due to increased temperature in the ocean.

Over the years, the pressing issue of climate change, which has been very much contributed to by anthropogenic activities, has encouraged leaders worldwide to develop a global action known as the Paris Agreement (Denchak, 2021). Its main objective is to limit the increase in global temperature below two degrees Celsius, hence urging nations to reach global peaking of greenhouse gas emissions as soon as possible (UNFCCC, 2020). Aside from the long-term temperature goal, the Paris Agreement aims to strengthen the global response to climate change threats and impacts by providing countries with financial, technical, and capacity-building support to countries (Raiser *et al.*, 2020; UNFCCC, 2020). Dagnachew (2021) emphasized that climate measures are urgently needed to achieve and realize the Paris Agreement and some sustainable development goals (SDG).

Climate change impacts primarily caused growing attention, which led several researchers to quantify global carbon dioxide emissions (Liu and Liang, 2017). Estimating emissions could serve as a baseline in climate policy formulation, thereby addressing some sustainable development goals such as SDG 3, which refers to good health and well-being; SDG 7, which refers to affordable and clean energy; SDG 11, which refers to sustainable cities and communities; SDG 12, which refers to responsible consumption and production; SDG 13, which refers to climate action; and SDG 17, which refers to partnerships for the goals (Murshed *et al.*, 2022; WHO, 2018; United Nations, n.d.). Countries use national greenhouse gas emission inventories as the primary tool for reporting emissions while ensuring the overall quality of results by carefully considering data consistency, accuracy, transparency, and completeness (Amon *et al.*, 2021). According to IPCC (2022), the 2006 IPCC Guidelines for National Greenhouse Gas Inventories is an internationally agreed guideline in estimating GHG emissions adopted by 195 IPCC member countries, including the United States of America, China, India, and the Philippines.

Increasing greenhouse gas emissions in the atmosphere, which significantly contribute to climate change, have been an issue for several years. Hence, this study was undertaken to estimate the greenhouse gas emissions of the University of Science and Technology of Southern Philippines-Oroquieta for the base year 2022 under business-as-usual economic activity to serve as a basis for climate change reduction and mitigation strategies specific to the campus. Specifically, the study aims to a) compare the emissions between mobile and stationary sources; b) compare Scope 1 and Scope 2 emissions; c) calculate the greenhouse gas emission as contributed by electricity consumption (tCO_2); d) determine the total entity-level greenhouse gas emission (tCO_2e); and e) estimate the greenhouse gas emission per capita (tCO_2e).

Hypothesis

In the present study, the following hypotheses were formulated:

H01: There is no significant difference between the emissions from mobile and stationary sources.

H02: There is no significant difference between Scope 1 and Scope 2 emissions.

Materials and methods

The present study utilized a quantitative research design, particularly the descriptive research design since quantitative data were involved in gathering, analyzing, and interpreting the results. The study was conducted at the University of Science and Technology of Southern Philippines-Oroquieta, as presented in Fig. 1.

The campus is composed of one (1) Administration Building, one (1) Information Technology (IT) Building, one (1) In-house Practicum Laboratory, one (1) covered court, one (1) school canteen, and seven (7) makeshift rooms. The food, dressmaking, and computer laboratories are within the IT building, and the electrical and Shielded Metal Arc Welding (SMAW) laboratories are within the makeshift rooms. In this study, only the school canteen and the covered court were not included in the greenhouse gas accounting since these were yet to be operational and, therefore, have not contributed to the emission in 2022.

Fig. 1. Map of Oroquieta City

The historical time-based activity data, specifically the fuel consumption and the number of students and employees, were obtained from the campus collecting officer, campus registrar, and human resource staff of USTP-Oroquieta, respectively. Moreover, the data on electricity consumption were obtained from the electricity provider of the campus, namely the Misamis Occidental Electric Cooperative, Inc. – 1 (MOELCI-1) Oroquieta Office.

Methods of data analysis

This section discusses the formulas and methods used to obtain the entity-level greenhouse gas emission of USTP-Oroquieta.

Calculation of scope 1 emission

Scope 1 emission was estimated from the mobile and stationary combustion on the campus. For mobile combustion, gasoline was used for the campus-owned motorcycle, and for stationary combustion, gasoline and propane were used for the lawn mower and food laboratory activities, respectively. Generally, Scope 1 emission is estimated by the equation:

Emission = (Activity Data) (Emission Factor) Eq. 1

Here, emission refers to the CO_2 emission expressed in tons CO_2 (tCO_2); Activity Data refers to the amount of fuel consumption in liters (L); and Emission Factor refers to a value that relates the quantity of a pollutant emitted to the atmosphere relative to its activity (US EPA, 2023).

According to Republic Act No. 9367, also known as the "Biofuels Act of 2006," all gasoline sold throughout the Philippines is currently blended with 10% by volume bioethanol (Official Gazette, 2007). Because of this, a separate calculation for gasoline emission was carried out to account for the correction factor and exclude the biofuel from the total CO2 emission, as these are considered biogenic (DENR-EMB 10, 2020).

Calculation of equivalent carbon dioxide emission

Before estimating the total greenhouse gas emission of the campus, CH_4 and N_2O emissions, contributed by gasoline and propane, were accounted for using the formula:

Emission = (Activity Data) (Emission Factor)(GWP) Eq. 2

Here, GWP, or the global warming potential, relates the global warming impacts of different greenhouse gases by serving as a factor that allows the conversion of one gas to an equivalent mass of CO_2 (DENR-EMB 10, 2020). The GWP values for the three greenhouse gases considered in this study, based on the IPCC Fifth Assessment Report, are presented in Table 1 (IPCC, 2014).

Table 1. Global warming potentials

Greenhouse gas	GWP values for 100-year period
CO_2	1
CH_4	28
N_2O	265

Calculation of scope 2 emission

Scope 2 emission primarily refers to the total electricity consumption of USTP-Oroquieta. Here, only the CO_2 emission was determined, assuming that the electrical energy generated by power plants and distributed in Misamis Occidental undergoes complete combustion. This means that during the reaction, the reactant was all converted into carbon dioxide and water vapor through sufficient air (DENR-EMB 10, 2020; Ghasemzadeh *et al.*, 2018). Shown below is the formula used to determine Scope 2 emission:

Emission = (Activity Data) (Grid Emission Factor) Eq. 3

Here, the Grid Emission Factor refers to the national grid emission factor (NGEF) equivalent to 0.7921 tCO_2/MWh for Mindanao (Department of Energy, n.d.), where USTP-Oroquieta is located.

Calculation of total entity-level greenhouse gas emission

Once all three greenhouse gases had similar units, these were added together to obtain the total greenhouse gas emission (in tCO_2e).

Calculation of greenhouse gas emission per capita

In order to estimate the greenhouse gas emission per capita of USTP-Oroquieta, the total number of employees and students for 2022 was obtained from the Human Resource Office and Registrar's Office, respectively, as shown in Table 2. Since the number of people varies every semester, the average number of students and employees was obtained and used for the calculation.

Table 2. Population in USTP-Oroquieta (2022)

Category	2nd Sem AY 2021-2022	1st Sem AY 2022-2023	Mean
Students	1077	1297	1187
Employees	57	72	65
Total			1252

Validity and reliability of the instruments

The quality of data was anchored on the reliability and qualitative estimation of Olatayo *et al.* (2021), as presented in Table 3. Here, the data were assessed based on its source and rated from low to very high uncertainty. Low uncertainty refers to data directly available and collected from its source; medium uncertainty refers to data that were indirectly available and collected from proxy statistics; high uncertainty refers to projections based on factual data; and very high uncertainty refers to data computed by balancing input and output values.

Table 3. Assigned uncertainty to collected data

Scope	Activity data	Degree of uncertainty	Reason
1	Fuel consumption	Low	The data were obtained directly from USTP-Oroquieta with official receipts.
2	Electricity consumption	Low	The data were obtained directly from the electricity provider.

Statistical techniques

This study utilized inferential and descriptive statistics to analyze and meet the objectives of the study. The first two objectives applied inferential statistics. Specifically, the one sample t-test was used to determine the significant difference between the emissions from mobile and stationary sources of USTP-Oroquieta and the analysis of variance (ANOVA) was used to determine the significant difference among the emissions from the fuel consumption, both mobile and stationary, and electricity consumption, which comprise the Scope 1 and Scope 2, respectively. The third objective applied descriptive statistics, particularly the frequency distribution, to show the monthly greenhouse gas emissions of the campus as contributed by electricity consumption using a scatterplot. Meanwhile, the last two objectives do not require the application of any statistical technique, as these can be obtained directly.

Results and discussion

Presented in Table 4 is the greenhouse gas emission from mobile combustion sources, particularly the gasoline-fed motorcycle owned by the campus. From the total gasoline consumption in 2022, 10% bioethanol was deducted since it is biogenic. For the remaining 90% of gasoline consumption, the carbon dioxide emission from mobile combustion was obtained by multiplying the activity data and the emission factor of gasoline, as expressed in Eq. 1. Additionally, the methane and nitrous oxide emissions were obtained using Eq. 2. As a result, carbon dioxide contributes the highest emission with 0.01383 tCO_2, followed by nitrous oxide and methane with 0.00003339 tCO_2e and 0.00001676 tCO_2e, respectively, resulting in the total greenhouse gas emission of 0.01388 tCO_2e. Since Roa (2022) obtained the emission from the mobile combustion source of the campus as 0.0895 tCO_2e in 2020, the observed decrease in 2022 could be attributed to the minimal utilization of the campus vehicle. Additionally, the emission of the campus is lower than the emission of Northwestern Mindanao State College of Science and Technology (NMSCST) in Tangub City during the same period, with 91.75 tCO_2e, which could relatively be attributed to the high number of vehicles in the College.

The greenhouse gas emission from stationary combustion sources of the campus, such as the gasoline used for the lawn mower, is shown in Table 5.

Here, carbon dioxide contributes the highest emission with 0.1904 tCO_2, followed by nitrous oxide and methane with 0.0004598 tCO_2e and 0.0002308 tCO_2e, respectively, resulting in the total greenhouse gas emission of 0.1911 tCO_2e.

Liquified petroleum gas (LPG) is another fuel used in stationary combustion, mainly for food laboratory activities, as presented in Table 6. Here, carbon dioxide contributes the highest emission with 0.1576 tCO_2, followed by nitrous oxide and methane with 0.0004411 tCO_2e and 0.0002175 tCO_2e, respectively. This results in a total greenhouse gas emission of 0.1583 tCO_2e. Overall, the GHG emission from stationary sources is 0.3494 tCO_2e, resulting in a total Scope 1 emission of 0.3633 tCO_2e.

Based on the result obtained by Roa (2022), the emission from stationary combustion of the campus in 2020 was 0.1390 tCO_2e. Hence, an increase was observed in 2022, possibly due to the LPG consumption when food laboratory activities were conducted during face-to-face classes aside from the beautifying and landscaping activities regularly performed with or without the pandemic. Moreover, while the campus emitted 0.3494 tCO_2e as contributed by stationary combustion sources, the NMSCST had a higher emission of 117.36 tCO_2e during the same period (Paculba *et al.*, 2023). This could be attributed to the broader land area of the College, which requires higher fuel consumption when grass cutting and the utilization of its generator set, which is unavailable in USTP-Oroquieta.

Table 4. Emission from mobile combustion

Fuel consumption (L)		tCO_2	tCO_2e from CH_4	tCO_2e from N_2O	Total tCO_2e Emission
Gasoline	Bioethanol				
6.624	0.6624	0.01383	0.00001676	0.00003339	0.01388

Table 5. Emission from stationary combustion (Gasoline)

Fuel consumption (L)		tCO_2	tCO_2e from CH_4	tCO_2e from N_2O	Total tCO_2e Emission
Gasoline	Bioethanol				
91.208	9.1208	0.1904	0.0002308	0.0004598	0.1911

Table 6. Emission from stationary combustion (LPG)

Fuel consumption (L)		tCO_2	tCO_2e from CH_4	tCO_2e from N_2O	Total tCO_2e Emission
LPG	105.0131	0.1576	0.0002175	0.0004411	0.1583

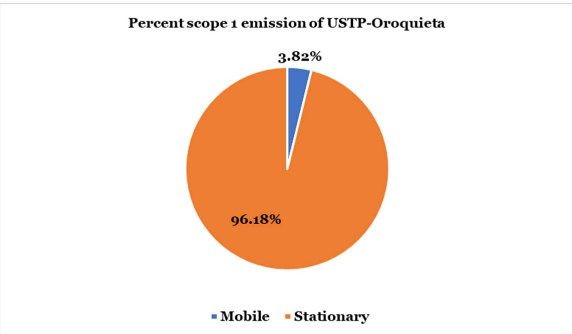

Fig. 2. 2022 Scope 1 Emission of USTP-Oroquieta

Fig. 2 shows a visual representation of the emissions from mobile and stationary combustion sources of USTP-Oroquieta under Scope 1. The majority (96.18%) of the emission is contributed by stationary sources, specifically the fuel consumption of the gasoline-fed lawn mower and the LPG for food laboratory activities, as the mobile source contributes 3.82% of the total Scope 1 emission only. Similarly, the stationary combustion sources of the campus also contributed higher emissions in 2020, with 61%, while the mobile combustion source only contributed 39% of the total Scope 1 emission. This is consistent with the findings obtained by Paculba *et al.* (2023), in which stationary combustion sources of NMSCST contributed higher emissions than the mobile combustion sources, with 53.32% and 46.68%, respectively, in 2022. Moreover, the Scope 2 emissions are also higher than the Scope 1 emissions of the University of the Philippines (UP) Cebu, with 367.5 tCO_2e and 3.4 tCO_2e, respectively, in 2019 and 179.7 tCO_2e and 10.4 tCO_2e, respectively, in 2020 (Cortes *et al.*, 2022).

Table 7. Statistical analysis for scope 1 emission

	Mobile (Gasoline)	Stationary (Gasoline+LPG)	Remarks
Mean	0.001157	0.02911	
Variance	3.1669E-06	0.001959	
Observations	12	12	
df	11		
t Stat	-2.1601		Significant
P(T<=t) one-tail	0.02684		
t Critical one-tail	1.7959		
P(T<=t) two-tail	0.05369		
t Critical two-tail	2.2010		

Note: p-value ≤ 0.05 indicates a statistically significant result

Correspondingly, Table 7 shows the t-test result between the total greenhouse gas emissions from mobile and stationary sources (tCO_2e) of Scope 1, which were not covered by the studies of Roa (2022) and Paculba *et al.* (2023). It can be observed that the mobile combustion source utilizing gasoline has a mean of 0.001157 and a variance of 3.1669E-06, and the stationary combustion sources utilizing gasoline and LPG have a mean of 0.02911 and a variance of 0.001959. Furthermore, the result shows a p-value of 0.02684, which is less than $\alpha = 0.05$, revealing a statistically significant result. It indicates strong evidence against the null hypothesis, as there is less than 5% probability that the null is correct, and the results are random. With this, the null hypothesis was rejected, therefore accepting the alternative hypothesis, which implies that there is a significant difference between the total greenhouse gas emissions from mobile and stationary sources (tCO_2e).

Based on the results, the emission from stationary combustion of USTP-Oroquieta is higher than that of mobile combustion for the base year 2022. This is contrary to the results obtained by Roa (2022), which reported that mobile combustion contributed higher emissions than stationary combustion in 2020, with 61% and 39%, respectively. The increase in emissions from stationary sources in 2022 was due to the changes in lockdown restrictions as COVID-19 became manageable. Although there were still restrictions on the modality of classes in the first half of 2022, employees already reported to work, and beautifying, cleaning, and landscaping activities were regularly conducted to maintain the campus grounds; hence, there was a monthly procurement of gasoline. Additionally, as students were allowed to report to the campus in the second half of the year compliant with Commission on Higher Education (CHED) Memorandum Order (CMO) No. 9 Series of 2022, the LPG was consumed for hands-on food laboratory activities, unlike in 2020 when there were no physical activities allowed to be conducted. On the other hand, the decrease in emissions from the campus-owned vehicle, specifically the motorcycle, was mainly due to the change in the terms of reference of the designated employee. The collecting officer covering two campuses, USTP-Panaon and USTP-Oroquieta, was now assigned to one campus only. Hence, the fuel consumption for traveling to and from Oroquieta City was minimized as the employee no longer traveled to perform his tasks.

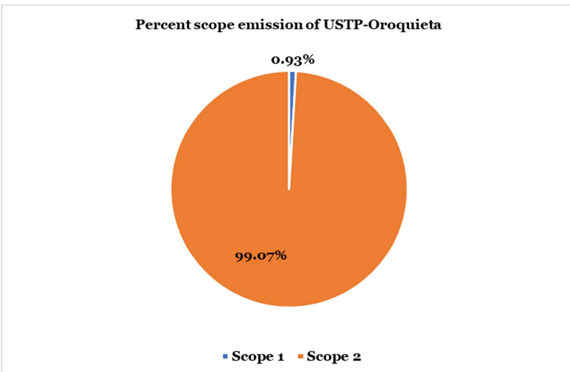

Fig. 3. Scope emission of USTP-Oroquieta

As can be gleaned from Fig. 3, the Scope 2 emission, which refers to electricity consumption, contributes the majority (99.07%) of the total greenhouse gas emission of USTP-Oroquieta. In contrast, Scope 1 emission, which refers to mobile and stationary combustion, contributes only 0.93%. This is consistent with the results of Roa (2022), which reported that the Scope 2 emission of the campus in 2020 was relatively higher than Scope 1 emissions, with 99.09% and 0.91%, respectively. Paculba *et al.* (2023) obtained a similar result, with Scope 2 contributing 68% of the total greenhouse gas emission in NMSCST and Scope 1 contributing 32%. Additionally, Cortes *et al.* (2022) reported that the Scope 2 emissions of UP Cebu were also higher than the Scope 1 emissions, contributing 25.9% and 0.2%, respectively, in 2019 and 32.3% and 1.9%, respectively, in 2020.

Table 8. Mean and variance of scope 1 and scope 2

Groups	Count	Sum	Average	Variance
Mobile	2	0.0127	0.0063	3.2E-05
Stationary	2	0.1782	0.0891	0.0033
Electricity	2	27.2482	13.6241	27.0163

Table 9. Analysis of variance of scope 1 and scope 2

Source of variation	SS	df	MS	F	*p*-value	F crit	Remarks
Between groups	245.7648	2	122.8824	13.6437	0.0312	9.5521	
Within groups	27.0197	3	9.0066				Significant
Total	272.7845	5					

Note: *p*-value ≤ 0.05 indicates a statistically significant result.

Tables 8 and 9 reveal the ANOVA result among the total greenhouse gas emissions from mobile and stationary sources of Scope 1 and the electricity consumption of Scope 2 (tCO_2e). It is evident that the mobile combustion source utilizing gasoline has a mean of 0.0063 with a variance of 3.2E-05, the stationary combustion sources utilizing gasoline and LPG has a mean of 0.0891 with a variance of 0.0033, and the electricity consumption has a mean of 13.6241 with a variance of 27.0163.

Furthermore, the result shows a p-value of 0.0312, which is less than $\alpha = 0.05$, revealing a statistically significant result. Basically, it indicates strong evidence against the null hypothesis, as there is less than a 5% probability that the null is correct and the results are random. With this, the null hypothesis was rejected, and the alternative hypothesis was accepted, implying a significant difference between the total greenhouse gas emissions of Scope 1 and Scope 2 (tCO_2e).

The results obtained are clearly due to the continuous electricity consumption in all offices on the campus with or without the pandemic, as employees were still required to come to work to perform their duties; hence, air conditioners, computers, and laptops, among all other electrical devices and equipment, were used. In addition, although monthly beautifying, landscaping, and cleaning activities were conducted, which contributed to the majority of Scope 1 emissions, the campus has a relatively small land area; hence, only a little gasoline was consumed for these activities.

In order to obtain the Scope 2 emission of USTP-Oroquieta, the monthly electricity consumption was multiplied with the grid emission factor, which was assigned for Mindanao by the Department of Energy, as expressed in Eq. 3. It can be observed from Fig. 4 that the total carbon dioxide emission of USTP-Oroquieta in 2022 ranges from 1.711 tCO_2 to 4.309 tCO_2, resulting in an overall Scope 2 emission of 38.5277 tCO_2. There was an increase in Scope 2 emissions estimated to be 24.7135 tCO_2 in 2020 (Roa, 2022). This result is relatively lower than the Scope 2 emissions of NMSCST at the same period with 446.25 tCO_2 and of UP Cebu with 367.5 tCO_2 and 179.7 tCO_2 in 2019 and 2020, respectively (Paculba *et al.*, 2023; Cortes *et al.*, 2022).

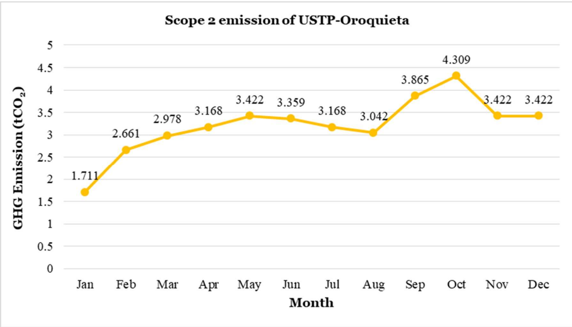

Fig. 4. 2022 scope 2 emission of USTP-Oroquieta

The relatively low emission in the first half of the year might be due to low electricity consumption caused by the online learning modality in which students were not yet encouraged to come to the campus for face-to-face classes. Hence, classrooms, computer, dressmaking, in-house practicum, food, electrical, and SMAW were less utilized. Conversely, it can be observed that there was an increase in GHG emissions for the second half of the year starting September, as students were already mandated to come to the campus for full face-to-face classes; hence, laboratories were utilized hands-on. In addition, several faculty and student activities were already conducted face-to-face. Overall, the students were not allowed to go to the campus physically as flexible learning was implemented, and employees could choose alternative work arrangements in 2020. The lockdown restrictions brought about this setup during the pandemic. However, during the second half of 2022, face-to-face classes were implemented according to CMO No. 9 Series of 2022, and all employees were requested to work onsite. Consequently, these changes in learning and working modalities have increased Scope 2 emissions.

Table 10. Entity-level GHG emission of USTP-Oroquieta (2022)

Scope	Emission (tCO_2e)
1	0.3633
2	38.5277
Total	38.8910

The entity-level greenhouse gas emission in USTP-Oroquieta was obtained by adding up CO_2, CH_4, and N_2O, which were accounted for in Scope 1, and CO_2, accounted for in Scope 2. As can be gleaned from Table 10, the total entity-level GHG emission of USTP-Oroquieta in 2022 for Scope 1 and Scope 2 emissions is 0.3633 tCO_2e and 38.5277 tCO_2e, respectively, which yields 38.8910 tCO_2e. According to Roa (2022), the entity-level greenhouse gas emission of USTP-Oroquieta in 2020 was 24.9420 tCO_2e, resulting in a 55.93% increase in 2022. Although the total entity-level greenhouse gas emissions of the campus increased, which might be due to the implementation of face-to-face classes and work setup, this is relatively lower than the emissions of NMSCST in 2022, with 655.35 tCO_2e and of UP Cebu with 1420.7 tCO_2e and 555.8 tCO_2e in 2019 and 2020, respectively.

As indicated in Table 2, the average number of students and employees of USTP-Oroquieta in 2022 is 1,252. Having an entity-level greenhouse gas emission of 38.8910 tCO_2e, as reported in Table 10, the greenhouse gas emission per capita of USTP-Oroquieta for 2022 is 0.0311 tCO_2e. Although Roa (2022) has not covered the emission per capita of the campus in 2020, the result can be compared to the emission per capita of UP Cebu reported by Cortes *et al.* (2022), which were 0.9 tCO_2e and 0.3 tCO_2e in 2019 and 2020, respectively, and the emission per capita of the Philippines in 2022, which was 2.35 tCO_2e (European Commission, 2023). Overall, the campus has considerably low GHG emissions per capita, likely due to lower fuel and electricity consumption corresponding to a smaller land area, fewer buildings and facilities, and fewer employees and students.

Conclusion

The increase in the total entity-level greenhouse gas emission of the University of Science and Technology of Southern Philippines-Oroquieta in 2022 might be attributed to the implementation of face-to-face classes during the second half of the year. This might be due to the continuous electricity and fuel consumption, as students utilize various laboratories and facilities to comply with their respective course requirements. Moreover, although an increase was observed, the campus contributes a relatively low greenhouse gas emission per capita compared to the national average.

Recommendations

In light of the findings and observations obtained in this study, the following recommendations are presented:

1. An annual report of entity-level greenhouse gas emissions may be conducted to monitor changes and enforce relevant climate actions specific to the campus.
2. The USTP System may conduct an entity-level greenhouse gas emission for a more comprehensive and impactful result.
3. Modeling greenhouse gas emissions may be performed to forecast and reinforce the climate action policies of the campus.
4. The campus may create systematic recordkeeping to estimate other emission sources, such as water consumption, air business travel, employee commutes, and solid waste disposal, especially since classes and work setup were reimplemented face-to-face.
5. Climate change adaptation and mitigation strategies may be intensified, particularly regarding electricity consumption, which contributes mainly to the overall greenhouse gas emission of the campus.
6. The campus may conduct periodic energy audits to quantify energy consumption and identify appropriate mitigating strategies.
7. The campus may consider creating and maintaining sustainable greening programs to address issues and eventually regulate greenhouse gas emissions.

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