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Carbon Footprint Reduction Measures for a Higher Educational Institution: Lessons Learned from COVID-19 Pandemic

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Carbon Footprint of Organization (CFO) is a vital tool for helping promote higher education institutions towards green university and carbon neutrality. This study assessed the carbon footprint of a faculty at a large university located in north-eastern Thailand. The goal of this study was to estimate carbon footprints from 2015 to 2021 and to see how the COVID-19 pandemic affects carbon footprints in order to find greenhouse gas (GHG) emission reduction measures for the post-COVID-19 period. It was found that, before the pandemic, electricity use was the most significant GHG emissions-contributing activity. During the COVID-19 period, students' commute reduction causes a substantial decrease in carbon footprint. After the pandemic, the institutions should prioritize measures to reduce electricity consumption, further expand online learning opportunities, encourage telecommuting for staff, and optimize transportation logistics to minimize GHGs.

1. Introduction

Climate change is a vast global problem that has received significant attention internationally. The Thai government has set a goal to achieve carbon neutrality by 2050 and net-zero GHG emissions by 2065 (ONEP, 2023). Therefore, all sectors need to work together to achieve this goal. The higher education sector is one of the critical sectors in the country, educating students and providing academic services to the community. This sector can potentially participate in reducing greenhouse gas (GHG) emissions, helping achieve Thailand's carbon neutrality goal. Mahasarakham University (MSU) is a large university located in the north-eastern region of Thailand. It hosts more than 40,000 students. This university has a green university policy where the carbon footprint is one of the indicators to be implemented for a green university (MSU, 2024).

Carbon Footprint of Organization (CFO) is the amount of greenhouse gas (GHG) emissions and removals along the life cycles caused by an organization's operations and is measured in terms of tons or kilograms of carbon dioxide equivalent (TGO, 2018). Carbon footprint is a complementary tool to Life Cycle Assessment (LCA), which is a tool to assess potential environmental impacts along the life cycle of a product/service or organization. Carbon footprint evaluates a single impact category, i.e. GHG emissions, while LCA assesses several impact categories. CFO can be used to help identify measures to reduce GHG emissions, leading to the Thai government's goal of carbon neutrality. In the higher education sector, the CFO has been widely used in Thailand and international universities (Li et al., 2021). This study assessed the carbon footprint of the Faculty of Environment and Resource Studies, MSU, as a case study. The results of the study can provide recommendations to reduce GHG emissions for other departments with similar activities. The tools used for this study can also guide other departments to assess their carbon footprints.

In the past few years, we have faced the epidemic of COVID-19, which has caused universities to change activities drastically. In early 2020, MSU was closed and offered online teaching. In the later stage, employees switched working days to reduce social distancing. In 2021, staff were allowed to work full-time while the

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university still provided online teaching. Most students did not travel to the university during that period, except those who needed to work in a laboratory. The situation changed as a result of the outbreak of COVID-19 should affect the amount of carbon footprint of the organization to some extent. The Faculty of Environment and Resource Studies, MSU, started to assess the organization's carbon footprint in 2015. Therefore, this research examines the carbon footprint from 2015 to 2021. The study identifies the primary sources of GHGs caused by the organization in different years. It also assesses the impact of the COVID-19 epidemic on the organization's carbon footprint. Finally, it provides measures to reduce GHG for the organization after the pandemic.

2. Methodology

This research assesses CFO following the guidelines of TGO (2018), covering the years 2015 to 2021. The number of students enrolled in each academic year is shown in Figure 1.

2.1 Organizational boundary

This study sets organizational boundary using the control approach. This means a corporation is responsible for all GHG emissions released from operations it controls. This control approach was chosen because the study's results will better reflect the faculty's management. The organization's carbon footprint is expressed in tons of carbon dioxide equivalent per fiscal year (covering September to October of the following year). For example, fiscal year 2015 covers September 2014 to October 2015). Since the organization under study is a governmental agency, its data are recorded every fiscal year.

2.2 Operational boundary

This step defines the scope of direct and indirect emissions within the organizational boundary. The operational boundary is classified into three scopes, which are scope 1: direct GHG emissions, scope 2: indirect GHG emissions, and scope 3: other GHG emissions. A list of activities contributing to GHG emissions for different scopes is presented in Table 1. Activities in scopes 1 and 2 are compulsory to be implemented as suggested in the guidelines, while data for scope 3 is optional. In this study, the activity data included in scope 3 were those recorded by the organization. Note that the faculty does not own the plantation area. Hence, GHG absorption by trees is excluded from the organizational boundary.

Table 1: List of activities along the value chain by scope

Scope	Item	Activity data	Unit	Type of data	Source of data
Scope 1: Direct GHG emissions	1.1	On-road vehicular fuel consumption	L/year	Annual report	Facilities division of the faculty
	1.2	Refrigerant	kg/year	Annual report	Building division of the university
	1.3	CH4 from wastewater treatment (Septic tank)	kg/year	Statistics	Estimated using IPCC guidelines and the number of staff and students
Scope 2: Indirect GHG emissions	2.1	Electricity consumption	kWh/year	Annual report	Building division of the university
Scope 3: Other indirect GHG emissions	3.1	Water use	m^3/year	Annual report	Building division of the university
	3.2	Paper use	kg/year	Annual report	Facilities division of the faculty
	3.3	Commute for staff	km/year	Survey	Staff
		Gasoline used in passenger cars	L/year		Estimated using average distance, number of staff, and rate of fuel consumption
		Diesel used in pick-up trucks	L/year		Estimated using average distance, number of staff, and rate of fuel consumption
		Gasoline used in motorcycles	L/year		Estimated using average distance, number of staff, and rate of fuel consumption
	3.4	Commute for students	km/year	Survey	Students
		Gasoline used in passenger cars	L/year		Estimated using average distance, number of students, and rate of fuel consumption
		Diesel used in pick-up trucks	L/year		Estimated using average distance, number of students, and rate of fuel consumption
		Gasoline used in motorcycles	L/year		Estimated using average distance, number of students, and rate of fuel consumption

2.3 Inventory analysis

The activity data in Table 1 includes information that can be collected from annual reports and estimates. Data such as fuel, refrigerant, electricity, water and paper consumption were obtained directly from the annual reports.

Methane emissions from wastewater treatment (Septic tank) were estimated following IPCC guidelines (Equation 6.1) (IPCC, 2006), using the number of staff and students per year. The commute of staff and students was calculated using surveys and the number of staff and students per year. The travel distances of students/staff in the unit of km/year were estimated using surveys. The average round-trip distance for each type of vehicle was calculated using the formula below:

$$\text{Avg D} = \frac{\sum_{i=0}^{n} Di}{n} \quad (1)$$

where; Avg D = Average distance for each vehicle type (km); Di = distance for round-trip to work for staff/student i (km); n = number of staff/students interviewed (persons).
After getting the average distance traveled for each type of vehicle, the total distance traveled by each type of vehicle is calculated each year using the formula below:

$$\text{Dty} = \text{Avg D} \times N \times d \quad (2)$$

where; Dty = total distance for each vehicle type per year (km); Avg D = average distance for each vehicle type (km); N = number of total staff/students registered in a year (persons); d = number of working days in a year (days).
After the total travel distance of each type of vehicle per year is calculated, it is used to estimate the amount of fuel consumption of each vehicle type using the formula below:

$$\text{Fq} = \text{Dty} / \text{Fcr} \quad (3)$$

where; Fq = total quantity of fuel consumption for each vehicle type per year (L); Dty = total distance for each vehicle type per year (km); Fcr = Fuel consumption rate for each vehicle type per year (km/L). The fuel consumption rate is obtained from TGO (2022).

2.4 Carbon footprint assessment

After obtaining the activity data in Table 1, the carbon footprint can be calculated using the formula below (TGO 2018):

$$\text{GHG emissions} = \text{Activity data} \times \text{Emission factor} \quad (4)$$

Emission factors were obtained from TGO (2022).

2.5 GHG reduction measurement plan

After getting the carbon footprint from the previous step, the sources contributing to GHG emissions in each scope were considered to identify measures to reduce GHG emissions for the organization after the COVID-19 period.

3. Results and Discussion

The first part of this section presents the amounts of GHGs from the organization's activities for the years 2015-2021. The second part discusses the impacts of the COVID-19 outbreak on carbon footprints.

3.1 Organizational carbon footprint per capita

The estimated annual carbon footprints, encompassing both direct and indirect emissions, prior to the first confirmed death from COVID-19 in 2020 (years 2015 to 2019), ranged from 0.35 to 0.37 t CO_2eq per capita (see Figure 1). This value is comparable to the carbon footprint of Huachiew Chalermprakiet University, Thailand (0.42 t CO_2eq per capita) (Rodtusana, 2013). However, the average carbon footprint per capita of other Thai universities appears to be higher than that reported in this study. For instance, Aroonsrimorakota (2019) reported it as 1.85 t CO_2eq per capita, and Janangkakan et al. (2019) reported it as 1.08 t CO_2eq per capita. Scope 3 GHGs significantly influence these variations. Since scope 3 indirect GHG emissions consist of 15 categories, which are complex and so far have not yet been mandatory for CFO certification by TGO (2018), the inclusion of activity data within scope 3 may vary across different organizations. The incorporation of more activity data will result in higher carbon footprint values. Nevertheless, organizations stand to benefit from including additional activity data in their assessments, as it provides valuable information for devising effective GHG reduction plans.

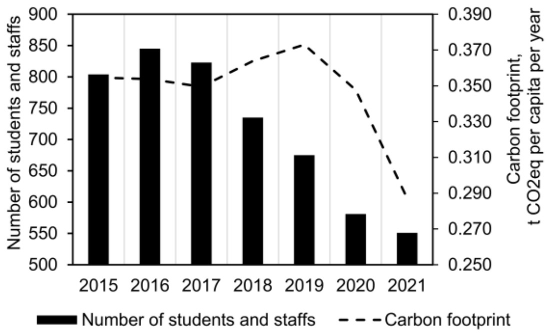


Figure 1: Number of students registered and staff and carbon footprint per capita in different academic years

Electricity consumption stands out as the primary contributor to greenhouse gas emissions. As depicted in Figure 2, scope 2, representing electricity consumption, accounted for the largest proportion (39 % to 41 %) of the total carbon footprint emissions during normal years (2015 to 2019). This finding aligns with results from carbon footprint studies conducted at other universities both within and outside Thailand. These studies consistently identified electricity consumption as the predominant source of GHGs for their respective organizations. For instance, Clemson University, USA (Clabeaux et al., 2020), University of the Punjab, Pakistan (Haseeb et al., 2022) and Sakarya University, Turkey (Yigit and Şeneren, 2023). Similar findings were reported for other Thai universities, such as Mahidol University (Aroonsrimorakota, 2019) and Chulalongkorn University (Janangkakan et al., 2019).

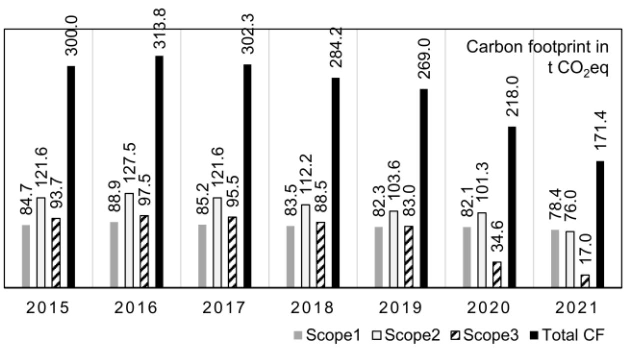


Figure 2: Carbon footprints (CF) of the faculty categorized into different GHG emission scopes for 2015-2021

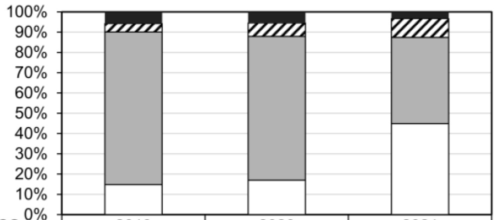
3.2 Effects of the COVID-19 pandemic on the carbon footprints of the faculty

In early 2020, MSU closed its campus, allowing staff and students to work remotely for three months, followed by a transition to online teaching for the rest of the year. Concurrently, support staff adjusted their schedules to facilitate social distancing measures for the remainder of 2020. In 2021, the university sustained online teaching throughout the year, while support staff returned to full-time on-site work. Lecturers had the option to teach online either from their workplace or home between 2020 and 2021. Throughout this period, laboratory services continued operating to facilitate on-site practices for both students and staff. Despite the persistent COVID-19 outbreak in 2021, the carbon footprint decreased to 0.29 t CO2eq per capita (Figure 1), reflecting a reduction of approximately 17% to 22%. This decline was slightly less pronounced than that reported for a UK University, which saw a nearly 30% decrease during the COVID-19 lockdown (Filimonau et al., 2021).

As shown in Figure 2, direct GHGs in scope 1 accounted for 28% to 31% of the total carbon footprint during normal years. However, during the COVID-19 pandemic, scope 1 GHGs notably increased to 38% of the total in 2020 and 46% in 2021. In contrast, indirect GHGs in scope 3—including water consumption, paper usage, and transportation of staff and students—experienced a significant reduction from 83 to 97 t CO2eq per year during normal years to 35 t CO2eq in 2020 and 17 t CO2eq in 2021.

Figure 3 illustrates that from 2019 to 2020, student transportation was the largest GHG contributor for scope 3. While, in 2021 when online teaching was practiced for the entire year, staff transportation accounted for the largest fraction of scope 3 GHGs. Online teaching, eliminating the need for student travel to campus, significantly contributes to GHG reduction. Similarly, El Geneidy et al. (2021) observed that travel-related emissions are the

primary GHG sources for knowledge organizations. This is similar to an onsite conference setting; Polgar and Elekné Fodor (2023) reported that participant transportation is the largest GHG source for the conference, accounting for almost 70 percent of the total carbon footprint of the national scientific student conference in Hungary. Online teaching during the pandemic also reduces electricity, paper, and water usage at the faculty, although electricity consumption has shifted to home use. However, this is excluded from our study's calculations as it falls outside the organizational boundary. It is crucial to carefully consider the carbon footprint of online learning at home when devising policies (Filimonau et al., 2021).
The decline in GHGs from 2020 to 2021 could be attributed to demographic shifts towards an aging society and the COVID-19 outbreak. The decrease in student numbers from 2017 to 2019, is not directly linked to the pandemic, but is likely due to a low birth rate (Prasartkul et al., 2019). Based on the coefficient of determination, R^2, for linear regression models between student and staff numbers and carbon footprint emissions for normal years (2015 to 2019) in Figure 4, the decline in students and staff could explain approximately 75.5%, 98.5%, and 99.9% of the variations in scope 1, 2, and 3 GHG emissions, respectively. Assuming student enrollment remained unaffected by the pandemic, the impact of organizational behavior changes attributed to COVID-19 on GHG emissions could account for small fractions, as implied from the linear model in Figure 4. Notably, GHG per capita per year during normal years tended to increase with decreasing student and staff numbers, indicating poorer energy efficiency. These findings underscore the significant role of students and staff in GHG emissions reduction and advocate for adopting energy-efficient approaches after COVID-19 to enhance institutional low-carbon plans.



Carbon footprint in kg CO_2eq	2019	2020	2021
Water consumption	4,822	1,896	560
Paper consumption	3,440	2,286	1,589
Transportation for students	62,458	24,555	7,251
Transportation for staffs	12,303	5,884	7,649

Figure 3: Breakdown of scope 3 carbon footprints for 2019-2021

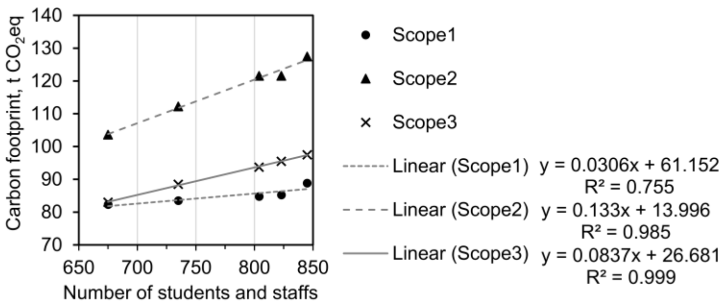


Figure 4: Linear regressions models and corresponding coefficients of determination (R^2) between the number of students and staff for the pre-epidemic period (2015 to 2019) and carbon footprints (CF) for different scopes

4. Conclusions

This study assessed the carbon footprint of the Faculty of Environment and Resource Studies, Mahasarakham University, Thailand, to identify measures to reduce GHG emissions for teaching units in the university after the pandemic. This research examined the carbon footprints from the fiscal years 2015-2021. During 2020-2021, universities were affected by the COVID-19 outbreak, causing changes in teaching modes. The results found that between 2015 and 2019, the total carbon footprints tended to decline over the years. However, in 2020 and 2021 (during the pandemic), the total carbon footprint has significantly decreased. During 2015-2019, the leading cause of GHGs is electricity use. During the course of online teaching throughout 2021, electricity consumption was reduced by more than 25 percent of the pre-epidemic period. This is due to the shift to home electricity usage. In 2021, the scope 3 carbon footprint decreased from 2019 by almost 80 percent, mainly due to the reduction of students' commutes. The university has returned to work on-site since 2022. Therefore, the most critical GHG reduction measure that the university should take is to reduce electricity consumption, such as implementing energy-efficient technologies, optimizing building energy management systems, promoting energy conservation behaviors among staff and students, and investing in renewable energy sources like solar or wind power. Educational institutions can consider integrating pandemic-induced changes, such as online teaching and remote work arrangements, to minimize GHGs from commuting. This could support the green university and lead to carbon neutrality.

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