Carbon Footprint in the Faculty of Public Health, Mahidol University During Lockdown and Non-Lockdown Periods

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Abstract

Climate change and its effect caused by excessive anthropogenic greenhouse gas emission is a major crisis that is affecting to be severely environmental problems economic and social development around the world. Furthermore, from the end of 2019 (Dec, 2019), the COVID-19 pandemic is impacting human activities, particularly energy use and carbon dioxide (CO_2) emissions. Carbon footprint for the organization is the method used to identify direct and indirect carbon emissions from various activities of the organization and is considered as the first step towards sustainability. This study aimed to compare the carbon footprint of the Faculty of Public Health Mahidol University in the 2020 fiscal year (October 2019 – September 2020) between non-Lockdown period (196 business days: 1 October 2019 – 22 March 2020, and 1 June – 30 September 2020) and Lockdown period (47 business days: 23 March – 31 May 2020). The study covered three categories of emissions including direct carbon emission (fuel consumptions, fertilizer use and wastewater treatment process), indirect carbon emission from purchased energy (including work/study from home while Lockdown period) and other indirect emissions (water consumption, paper use, LPG and plastic bag use in cafeteria and market, waste management and commuting) related to the energy and resources used. The results showed that the carbon footprints during non-Lockdown and Lockdown periods in the Faculty of Public Health, Mahidol University were 20,594.32 $kgCO_2e$/day/period equivalent to 19.78 $kgCO_2e$/capita/day, and 15,151.03 $kgCO_2e$/day/period equivalent to 14.55 $kgCO_2e$/capita/day, respectively. The main carbon emission source in both periods was electricity consumption followed by commuting and waste management respectively. The effectively alternative implementation for minimizing the carbon footprint of this organization is energy conservation. The use of high energy-efficient appliances such as air conditioning and lighting as well as energy-saving campaigns to reduce the power consumption such as turning off the appliance when not use were introduced. The overall carbon footprint achieved during Lockdown period was lower than that of the prior.

Keyword: Carbon Footprint for Organization/ Faculty of Public Health/ Mahidol University/ Non-Lockdown period, and Lockdown period

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1. Introduction

Greenhouse gas emissions continue to rise and accumulate in the atmosphere, causing the increasing global average temperature of at least 1°C warmer than pre-industrial level. The climate change situation is a major crisis that is affecting to be severely environmental problems such as biodiversity loss, extreme weathers events, causing severe impacts on economic and social development around the world. Furthermore, the coronavirus COVID-19 pandemic is the defining global health crisis of this time. The COVID-19 pandemic is impacting human activities, and in turn energy use and carbon dioxide (CO_2) emissions. The COVID-19 pandemic has imposed a number of dramatic impacts on all sectors of the global economy (Filimonau et al., 2020). The sector of higher education is also affected from government Lockdown in part of teaching and learning and administrative system. All campuses are closed and prohibited student and staff mobility, coupled with teaching, and learning system delivered completely online.

Thailand as a party to the UNFCCC intends to cooperate through various national plans and policies on the climate change dimension by encouraged all Thai sectors into a low-carbon society (NESDB, 2020). In its

Nationally Determined Contribution (NDC), Thailand committed to reducing 20-25% of emissions from the energy, transport, waste, and industry sectors by 2030 below business as usual. (ONEP, 2019). In the same way, all types of organizations are significant contributors to international greenhouse gas emissions including academic institutions.

Mahidol University has established a strategy for sustainable management by creating a policy to promote the creation of an Eco University. Accordingly, the evaluation of the Carbon Footprint Organization has been introduced as a method that can be used for identifying directly and indirectly carbon emissions from various activities of the organization. Furthermore, it can identify the main significant source of carbon emission from an organization's activities and their relevant mitigation schemes to minimize the carbon emission. However, during Lockdown situation, the teaching and other relevant activities in the faculty was changed to online. Therefore, the carbon emission is also altered. The comparative of carbon emission of online and face-to-face education was evaluated for discovery the appropriate practice to reduce the carbon emission. The carbon footprint can also expand its role to promote a low-carbon concept for the organization by improving its facilities and practice as well as carbon offsetting. Accordingly, it can be considered as the first step towards sustainability and can be suggested as the guideline for the management of carbon emission reduction (TGO, 2020). Additionally, the results of this study can be revealing the main activities of the faculty with the highest carbon emissions. This leads to appropriate and effective measures to minimize greenhouse gas emissions, also being a guideline for other academic institutions. Also served the country's target of Paris agreement in reducing 20-25% of emissions by 2030 below business as usual, as previously ratified with the UNFCCC.

2. Methodology

2.1 Faculty of Public Health, Mahidol University

Located at Mahidol University Phayathai Campus, Bangkok Thailand. Consists of 13 departments with 9 buildings. In addition to learning/teaching, there are also other role such as center of health and public health and environmental services for general health promotion service and environmental health promotion including safety in work job and industrial hygiene. The faculty has a health promotion center that provides health promotion and patients' screening diseases prevention for people and being the practice center on promotion of students' health. Moreover, also being the academic leader for country development, provide academic assistance, academic services, and short training for Asia Pacific countries. In terms of academic services, the faculty has operated in urban, rural, and industrial areas. (Mahidol University, 2020)

In the academic year 2019, the Faculty of Public Health has graduates in several majors from bachelor, master, and doctoral degrees 361, 299 and 66 students respectively, and 315 academic and support staffs (updated 31 January 2019). (Mahidol University, 2019)

2.2 Mahidol University Lockdown

The Bangkok Lockdown was ordered on 22 March 2020. As a part of the order, the Faculty of Public Health, Mahidol University had moved all learning working and operation to online system and not allowed to access University facilities since 23 March - 31 May 2020 (47 business days). While 172 support staff remained on campuses for administrative, security, and maintenance only as necessary.

2.3 Study design

This study was designed as analytical survey research to evaluate the carbon footprint of the Faculty of Public Health, Mahidol University under two periods including non-Lockdown and during Lockdown period. The carbon emission was analyzed following the carbon footprint organization guidelines of Thailand Greenhouse Gas Management Organization (TGO), which is based on the ISO 14064-1 (2006), GHG Protocol (2001 and 2004) and some examples from ISO/PDTR 14069 (2013) adopt to the Thai context.

2.3.1 Setting Organization/Operational Boundaries

The system boundaries were set up based on an operational control approach for the department which is able to response for their emissions and control. Consist of 9 buildings and common areas such as garden and car parking. Therefore, the carbon footprint of non-Lockdown period was compared with during Lockdown period due to the most of activities changed. Carbon emission of all resources collected in both direct and indirect sources was identified. The activity data was divided into 3 scopes due to the resources and energy used in the faculty and data availability, according to TGO guidelines as follows: direct carbon emission, indirect carbon emission from purchased energy, and other indirect emissions. (TGO, 2018)

2.3.2 Data Collection

The Resources and energy data were collected in the 2020 fiscal year (October 2019 – September 2020) separated into non-Lockdown period (196 business days: 1 October 2019 – 22 March 2020, and 1 June – 30 September 2020) and during Lockdown period (47 business days: 23 March – 31 May 2020) from both in primary and secondary data. The methods and sources of data collection were showed in Table 1.

Table 1. Summary of data collection methods and sources

Activities	Unit	Collection method	Source
Non-Lockdown period			
Scope 1 Direct carbon emission			
1.1 Fuel consumption	L	Receipt	Division of finance, supplies and property
1.2 Fertilizer use	kg	Report	Division of finance, supplies and property
1.3 Wastewater treatment process	m^3	Lab Report	Division of physical, environment and safety
Scope 2 Indirect carbon emission from purchased energy			
2.1 Electricity consumption	kWh	Receipt	Division of physical, environment and safety
Scope 3 Other indirect emissions			
3.1 Water consumption	m^3	Receipt	Division of physical, environment and safety
3.2 Paper use	kg	Report	Division of finance, supplies and property
3.3 LPG use in cafeteria and market	kg	Questionnaire	Seller
3.4 Plastic bag use in cafeteria and market	kg	Questionnaire	Seller
3.5 Waste management	kg	Report	Department of Environmental Health Sciences
3.6 Commuting	L	Questionnaire	Staff and students
Work/Study from home during Lockdown period - Air condition (8 hr.) - Light bulb (8 hr.) - Laptop (8 hr.) - Smartphone (charge) (1 hr.) - Electric rice cooker (40 mins.) - Microwave (15 mins.) - Kettle (15 mins.)	kWh	Estimation	Estimation

A random sampling method will be used in this study for the questionnaire collection. This study will be focused on the student and staff of 1,041 mans (66 doctoral degree's students, 299 master degree's students, 361 bachelor degree's student, and 315 academic and support staffs (updated in January, 2019). Therefore, the sample size in this study will be calculated following the Krejcie and Morgan's equation.

$$n = \frac{x^2 Np(1-p)}{e^2(N-1) + x^2 p(1-p)}$$

Where, n is the required sample size, x^2 is the value of chi-square where the df = 1 (2.71),

N is the population, p is the population proportion (assumed to be 0.5), e is the degree of accuracy expressed as proportion (0.1)

2.3.3 Calculations of carbon emissions

Carbon emission was calculated based on the Process–Analysis (PA) or Bottom–Up, the calculation method referring to each step or process of activity, which is suitable for medium scale scope such as an organization or building level. The emission values gain from multiplying a quantity measurement with the relevant emission factor, which is mostly from TGO guidelines. The data were interpreted in the form of unit measurement of mass carbon dioxide equivalent (CO_2e).

$$CO_2 \text{ emission} = AD \times EF$$

Where,CO_2 emission is the amount of carbon emission (kg/tones CO_2e), AD is the activities that cause carbon emission., EF is the constant value for changing the activity data into the amount of carbon emission

2.3.4 Uncertainty analysis

The uncertainty arising from the preparation of the greenhouse gas accounting demonstrate quality of carbon emission data collected. The uncertainty can be estimated by multiplying the data quality level from the data collection method with the data quality level from the source of emission factor used. The data quality level from the data collection method, the data quality level from the source of emission factor used, and the uncertainty analysis descriptions of the score ranging as described in Table 3, 4, and 5 respectively.

Uncertainty analysis = A x B

Where, A is the data quality level from the data collection method, B is the data quality level from the source of emission factor used

3. Results and Discussion

The average activity data of resources and energy used occurred in the Faculty of Public Health, Mahidol University in non-Lockdown and Lockdown period per day illustrated in table 6.

Table 2. The emission factor used in this study

Resources	Unit	Emission factor ($kgCO_2e$/unit)	Reference
Diesel	L	2.74	TGO, 2020
Gasohol 95	L	2.24	TGO, 2020
Fertilizer	kg	1.51	TGO, 2020
Electricity	kWh	0.49	TGO, 2020
Paper	kg	2.10	TGO, 2021
Water	m^3	0.79	TGO, 2020
LPG	kg	3.11	TGO, 2020
HDPE	kg	6.71	TGO, 2021
PP	kg	1.81	TGO, 2021
Waste management (Open dump)			
Food waste	kg	2.53	TGO, 2020
Paper	kg	2.93	TGO, 2020
Plastic	kg	2.32	TGO, 2020

Table 3. The data quality level from the data collection method.

Data collection method (A)	A = 6 point	A = 3 point	A= 1 point
	Data collected by CEMs	Data collected by meter or receipt	Data collected by estimation

Table 4. The data quality level from the source of emission factor used.

Emission factor source (EF) (B)	B = 4 point	B = 3 point	B = 2 point	B = 1 point
	Measurement EF	National EF	Regional EF	International EF

Table 5. The uncertainty analysis description of the score ranging.

Level	Range point	Description
1	1 – 6	High uncertainty/Low data quality
2	7 – 12	Medium uncertainty/Medium data quality
3	13 – 18	Low uncertainty/Good data quality
4	19 - 24	Low uncertainty/Very good data quality

Table 6. The average activity data of resources and energy used in the Faculty of Public Health, Mahidol University during non-Lockdown and Lockdown period.

Activity	Unit/Day	Average Activity Data (Day)	
		Non-Lockdown period	Lockdown period
Scope 1 Direct carbon emission			
1.1 Fuel consumption			
1.1.1 Diesel	L	69.799	9.842
1.1.2 Gasohol 95	L	2.546	1.012
1.2 Fertilizer use	Kg	0.936	0.638
1.3 Wastewater treatment process			
1.3.1 Flow rate	m^3	197.920	32.701
1.3.2 Average BOD_{inf}	mg/L	105.250	17.390
1.3.3 Average BOD_{eff}	mg/L	10.000	1.652
Scope 2 Indirect carbon emission from purchased energy			
2.1 Electricity consumption	kWh	20,660.494	10,290.574
Scope 3 Other indirect emissions			
3.1 Water consumption	m^3	168.992	97.340
3.2 Paper use	Kg	4.108	2.809
3.3 LPG use in cafeteria and market	Kg	46.089	7.605
3.4 Plastic bag use in cafeteria and market			
3.4.1 Poly propylene	Kg	5.738	0.947
3.4.2 High density polyethylene	Kg	13.707	2.262
3.5 Waste management			
3.5.1 Food waste	Kg	128.870	21.264
3.5.2 Paper	Kg	33.968	5.605
3.5.3 Plastic	Kg	66.899	11.038
3.6 Commuting			
3.6.1 Diesel	L	1,812.767	236.150
3.6.2 Gasohol 95	L	1,845.096	315.835
Work/Study from home (869 mans)			
Air condition (8 hr.)	kWh	-	15,642.000
Light bulb (8 hr.)	kWh	-	111.232
Laptop (8 hr.)	kWh	-	364.980
Smartphone (1 hr.)	kWh	-	5.214
Electric rice cooker (40 mins.)	kWh	-	430.155
Microwave (15 mins.)	kWh	-	119.488
Kettle (15 mins.)	kWh	-	135.781

3.1 Scope 1 direct carbon emission

Scope 1 emissions are direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by an organization. The carbon emissions in scope 1 are generated from the fuel consumption by Faculty's vehicles which held the largest share in this scope, followed by wastewater treatment process of the faculty, and the fertilizer uses in garden care.

3.2 Scope 2 indirect carbon emission from purchased energy

Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity and energy. The highest carbon emission of this scope under non-Lockdown period caused by purchased energy for education, academic services, research, administrative, and others activities in the faculty.

3.3 Scope 3 other indirect carbon emission

Other indirect carbon emission of the faculty also focuses on this scope including water consumption, paper use, waste management, student and stuff commuting, and the LPG and plastic bag use in cafeteria and market under the supervision of the faculty.

Since scope 3 (indirect emissions) held almost half of overall carbon footprint emissions of the faculty (48.87%) and decreased 38.49% during the Lockdown period, this information may assist organizations to pursue emissions mitigation projects not only within the organization but also across indirect emission activities (Awanthi and Navaratne, 2018).

3.4 Carbon emission from work/study from home

During lockdown period, student and staff work/study from home by using their own electricity appliances considered with the following pattern: worked/study from home 08.30 am - 05.30 pm, 5 days a week, from Monday to Friday. As the Lockdown period (March-May) in Thailand is characterized by hot weathers. An air condition, light bulb, and laptop was in constant use 8 hours a day. Smartphone also included for the communication. Lunch was included so the electric rice cooker, microwave, and kettle were assumed to preparation with 40 mins., 15 mins., and 15 mins. a day respectively. Other activities at home were excluded due to not related to the faculty business and the data availability. The results showed that the electricity used for air condition was the largest amount of carbon emission (93.06%).

This result indicated that the overall carbon footprint occurred during Lockdown was lower than the non-Lockdown period. The main sources of carbon emission under non-Lockdown period in descending order are the electricity consumption, followed by commuting and waste management, respectively. Whereas the key source of carbon emission during COVID-19 Lockdown period was the electricity use at home for online teaching/learning and work operation. From COVID-19 situation, work/study from home is the alternative way to reduce overall carbon emission due to no commuting of staffs and students. The results showed that all activities occurred during work/study from home generates lower carbon footprint than only University commuting. As part of an eco-university drive, finding measures to minimize carbon emissions from these main activities will help resource conservation of the country and reduce the effect form global warming. Reduce greenhouse gas emissions from the energy sector, support national policies aimed at a low-carbon society. Filimonau et al. (2020) reported that a large share of the carbon savings achieved by moving education online to avoided student and staff mobility. Additionally, work/study from home can be a reasonable option for local institutions of higher education. Not only non-commuting can contribute to the reduction of air pollution in these areas, but it will also save time for staff/students due to avoid traffic crowding.

Overall carbon emission during lockdown period was decreased by around 26.43% compared with non-Lockdown. This was mainly due to a significant reduction in the fuel consumption and electricity used. Rugani and Caro (2020) reported that the CF in the Lockdown period is about 20% lower than the mean CF calculated for the past in Italy. The higher reduction in carbon emissions found in our study may be due to the changing of working scheme to work/study from home operation.

The results showed that the carbon footprints during non-Lockdown and Lockdown period in the Faculty of Public Health, Mahidol University were 20,594.32 $kgCO_2e$/day/period equivalent to 19.78 $kgCO_2e$/capita/day, and 15,151.03 $kgCO_2e$/day/period equivalent to 14.55 $kgCO_2e$/capita/day, respectively. The main carbon emission source in both periods was electricity consumption followed by commuting and waste management respectively as presented in Table 7 and figure 2

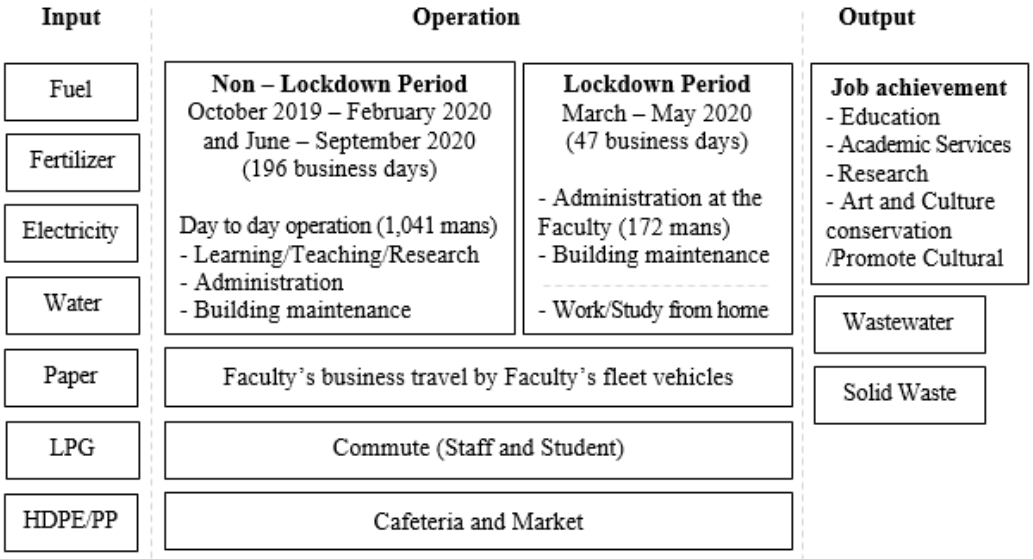

Figure 1. Operational boundaries of the Faculty of Public Health, Mahidol University

Table 7. Carbon footprint of the Faculty of Public Health, Mahidol University

Activities	Carbon footprint ($kgCO_2e$/day)	
	Non-Lockdown period	During Lockdown period
Scope 1 Direct carbon emission		
1.1 Fuel consumption		
1.1.1 Diesel	191.27	26.97
1.1.2 Gasohol 95	5.70	2.26
1.2 Fertilizer use	1.41	0.96
1.3 Wastewater treatment process	2.67	0.44
Scope 2 Indirect carbon emission from purchased energy		
2.1 Electricity consumption	10,328.18	5,144.26
Scope 3 Other indirect emissions		
3.1 Water consumption	134.31	77.37
3.2 Paper use	8.64	5.90
3.3 LPG use in cafeteria and market	143.49	23.68
3.4 Plastic bag use in market		
3.4.1 Poly propylene	10.38	1.71
3.4.2 High density polyethylene	91.93	15.17
3.5 Waste management	580.78	95.83
3.6 Commuting	9,095.55	1,353.74
Work/Study from home (869 mans)		
Air condition (8 hr.)	0	7,819.44
Light bulb (8 hr.)	0	55.60

Table 7. Carbon footprint of the Faculty of Public Health, Mahidol University

Activities	Carbon footprint ($kgCO_2e$/day)	
	Non-Lockdown period	During Lockdown period
Laptop (8 hr.)	0	182.45
Smartphone (1 hr.)	0	2.61
Electric rice cooker (40 mins.)	0	215.03
Microwave (15 mins.)	0	59.73
Kettle (15 mins.)	0	67.88
Total ($kgCO_2e$/day/period)	20,594.32	15,151.03
Carbon footprint ($kgCO_2e$/capita/day) (1,041 mans)	19.78	14.55

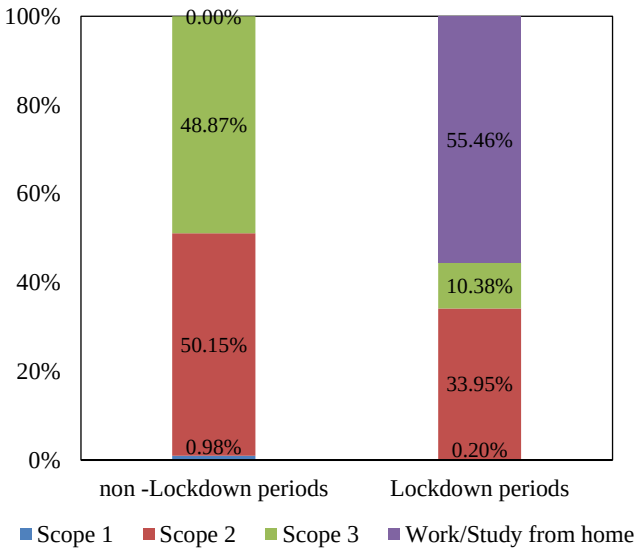

Figure 2: Carbon emissions comparison between non-Lockdown and Lockdown period.

As part of an eco-university drive, finding measures to minimize carbon emissions from these three main activities will be most effective and help the country conserve resources. Reduce greenhouse gas emissions from the energy sector, support national policies aimed at a low-carbon society. From COVID-19 situation, the teaching and learning online was the alternative way to reduce overall carbon emission.

For assessing the uncertainty, most activities were at a high uncertainty/low data quality because of the data collected by receipt and the estimation by questionnaires. To have low uncertainty with high quality of information, it is necessary to collect activity data with a continuous emission monitoring system (CEMS). The uncertainty data was illustrated in Table 8.

Table 8. Uncertainty data analysis

Activities	Data collection method (A)	Emission factor source (B)	Result (AxB)	Data quality
Scope 1 Direct carbon emission				
Fuel consumption	3	3	9	Medium uncertainty/medium data quality
Fertilizer use	1	3	3	High uncertainty/Low data quality
Wastewater treatment process	6	1	6	High uncertainty/Low data quality
Scope 2 Indirect carbon emission from purchased energy				
Electricity consumption	3	3	9	Medium uncertainty/medium data quality

Table 8. Uncertainty data analysis

Activities	Data collection method (A)	Emission factor source (B)	Result (AxB)	Data quality
Scope 3 Other indirect emissions				
Water consumption	3	3	9	Medium uncertainty/medium data quality
Paper use	1	3	3	High uncertainty/Low data quality
LPG use in cafeteria and market	1	3	3	
Plastic bag use in cafeteria and market	1	3	3	
Waste management	1	3	3	
Commuting	1	3	3	
Work/Study from home	1	3	3	

4. Conclusions

The results indicated that the carbon footprints in the Faculty of Public Health, Mahidol University decreased by almost 26.43% during the Lockdown period. The main sources of carbon emission under non-Lockdown period in descending order are the electricity consumption, followed by commuting and waste management, respectively. The highest carbon emission represents the electricity use because many activities need to use electricity, reduction strategies should be highly focused on this issue. Additionally, the key source of carbon emission during COVID-19 Lockdown period was the electricity use at home for online teaching/learning and work operation. Therefore, the use of high energy-efficient appliances such as air conditioning and lighting equipment as well as energy-saving campaigns to reduce the power consumption such as turning off the appliance when not use were introduced. However, the commuting during non-lockdown also generated the high amount of carbon emission similar to the electricity use. Thus, the carbon savings by moving working and education online to avoided student and staff mobility should be considered.

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