# Carbon footprint of Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Thailand in the year 2010- 2012

Sayam Aroonsrimorakota

Faculty of Environment and Resource Studies, Mahidol University, Salaya campus, Nakhonpathom 73170 Thailand

## Abstract

Greenhouse gas emissions, a significant amount of which come from corporate organizations, is widely seen as the main cause of global warming. Global warming is widely thought of as being one of the main factors threatening the survival of humanity at present [1]. In order to attempt to reduce green house gas emissions they must first be measured. This study focuses on the estimating m of greenhouse gas production from the Faculty of Environment and Resource Studies, Mahidol University. This is also known as the Carbon Footprint. Greenhouse gas emissions arising from the activities of the faculty were estimated using data such as electricity and water supply consumption, wastewater and garbage production and the amount of fuels used. These data were then, multiplied by internationally recognized emission factors in order to give a result in terms of carbon dioxide equivalent (CO2e). The results showed that the GHGs emissions from the Faculty of Environment and Resource Studies in the years 2010, 2011 and 2012 were 1091.85, 1485.79 and 1210.80 ton CO2e, respectively. This means that the average GHG emission per head of the student and staff population was 1.479, 2.156 and 1.903 tonCO2e, respectively. Sources that emit the most greenhouse gases in order of ranking were found to be the use of electric energy, followed by the use of chemicals and the production of solid waste. It was therefore concluded that power consumption and the amount of solid waste generated in the faculty should be reduced with the use of current energy-saving technologies. Campaigns to reduce the power consumption of the students and staff population should be carried out in addition to encouraging waste separation for recycling.

## 1. Introduction

The first carbon footprint challenge for companies is to assess the greenhouse gas emissions resulting from their activities. These are both produced directly and indirectly. They include the burning of fuel, electricity consumption, waste management and transport. Emissions can be estimated from measurable parameters to give the amount of greenhouse gas emissions in units of carbon dioxide equivalent ($CO_2e$). Six types of greenhouse gas are considered as vitally important under the Kyoto Protocol and are used to assess the carbon footprint of organizations. These are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydro fluoride per fluorocarbons (HFCs), perfluoro carbons (PFCs) and sulfur hexafluoride ($SF_6$) [2, 3].

The carbon footprint of an organization can be calculated using the life cycle assessment (LCA) process. This is explained in the international standard ISO 14040, 14044 and is used for the assessment of environmental impact of products throughout their life cycles [4]. It can be calculated from the following formula. $CO_2$ equivalent of process = Amount of activity x $CO_2$ emission intensity. The total amounts of each of the six types of greenhouse gases were calculated from all activities. Finally these results were converted into units of carbon dioxide equivalents by multiplying total emissions of each type of greenhouse gas with its global warming potential (GWP). This gave the overall Carbon Footprint of the organization [5, 6, 7].

## 2. Methodology

*2.1 Setting Organization Boundaries*

The Faculty of Environment and Resource Studies, Mahidol University, Salaya campus consists of four buildings as follows: Buildings 1-2, Environmental information building, and Singwaedlom Phattanadon building. These buildings were selected for estimating the carbon foot print.

**Table 1**: eEmission factor used in the study [8]

| GHGs Sources | Unit | Emission Factor$(kgCO_2e)$ | References |
|:---:|:---:|:---:|:---:|
| Water Supply | $m^3$ | 0.0264 | Metropolitan Waterworks Authority (Thailand) |
| Electricity | kWh | 0.5610 | TC Common data |
| Paper | kg | 0.7350 | SimaPro |
| Diesel | kg | 0.5200 | BUWAL250   (D=0.839 kg/l) |
| Gasohol | L | 2.93 | TGO CFP Guideline |
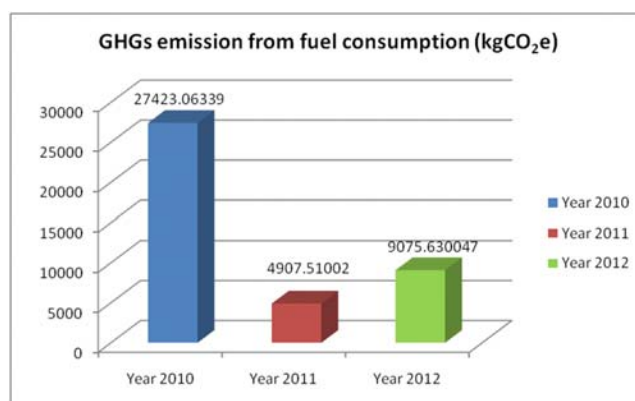


**Figure 1** GHGs emissions from fuel consumption (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 –2012

### 2.2 Setting Operational Boundaries

All sources of greenhouse gas emissions both direct and indirect sources were identified which could be divided into 3 scopes as follows:

Scope 1: Travel in terms of fuel consumption and amount of greenhouse gases generated by sewage treatment processes.

Scope 2: Emissions from energy imports and the purchase of utilities such as electricity and water.

Scope 3: Indirect greenhouse gases emissions, such as use of paper, solid waste generation, amount of chemicals used in the laboratory, and use of laboratory supplies.

### 2.3 Data Inventory

The data in this study was collected from relevant documents. It came from both primary data (solid waste occurred) and secondary data ( electricity and water supply, quantity and quality of wastewater, fuel consumption, paper consumption, and the use of chemicals).

### 2.4 Calculation of GHG Emission

GHG emissions can be estimated by multiplying a quantifiable measurement, such as $m^3$ water used, with the relevant emission factor. This is in accordance with the guidelines of the Intergovernmental Panel on Climate Change (IPCC) or from a national database of each country and is commonly used internationally. The emission factors that were used in this study are shown in Table 1.

## 3. Results

**Scope 1: Calculated in terms of fuel consumption and amount of greenhouse gases generated by sewage treatment processes.**

### 3.1 GHGs emission from fuel consumption

The GHG emissions were estimated from fuel consumption of two types of fuel that are used at the faculty. These were diesel oil and gasohol. Amount of greenhouse gases generated by fuel consumption of the Faculty of Environment and Resource Studies, Mahidol University in the years 2010 – 2012 is shown in Figure 1 (Note:  the fuel consumption does not include use of rental cars).

The amount of greenhouse gas emissions from fuel used in the years 2011 and 2012 was seen to be lower than 2010. The highest carbon footprint was 27,423.06 kgCO₂e. In the year 2012 emissions were 9075.63 kgCO₂e and the year 2011, there was a much lower emission of GHGs, only 4907.51 kgCO₂e. [9, 10]

### 3.2 GHGs emission from wastewater treatment

The amount of GHGs arising from wastewater treatment in the years 2010, 2011 and 2012 were found to be 2793. 02, 2424. 78 and 2937. 64 kgCO₂e, respectively. It can be seen that the amount released
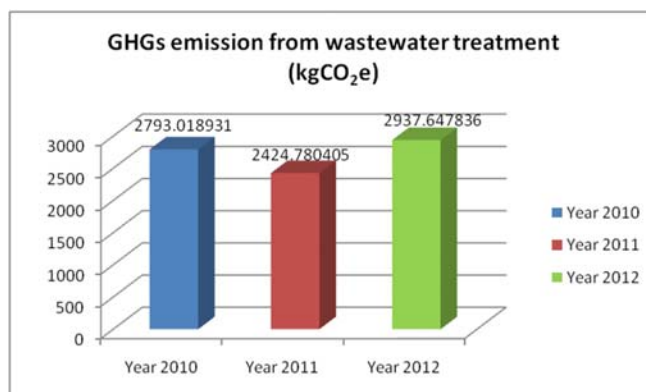
**Figure 2:** GHGs emissions from wastewater treatment (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 –2012
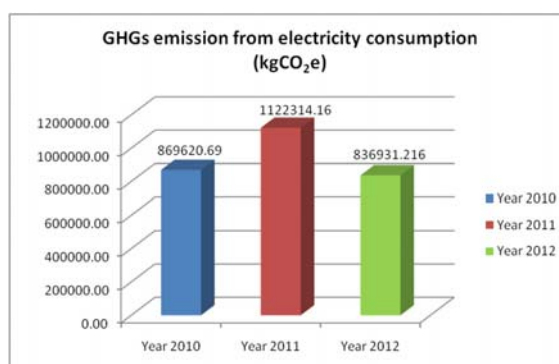


**Figure 3**: GHGs emission from electricity consumption (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 – 2012

remained relatively constant in each year. This is because the volume of wastewater in the calculations is based on the amount of water used within the faculty which remained relatively constant [10, 11].

**Scope 2: Emissions from energy imports and the purchase of electricity and water supply.**

*3.3GHGs emission from electricity consumptions*

Most electricity consumption of the Faculty of Environment and Resource Studies result from activities of teaching and learning. The use of electrical equipment in the offices also leads to some consumption. The amount of GHGs emitted through the use of electricity in the years 2010, 2011 and 2012 were found to be 869,620.69, 1,122,314.16 and 836,931.21 kgCO₂e respectively. These results are shown in Figure 3. The year 2011 had the highest emissions, while the remaining two years were found to be similar.

It can be seen that the amount of GHGs, that resulted from the use of electricity are very high. It is the highest source of GHGs in the faulty. The implementation of projects to reduce the electricity consumption should be the first step for any GHG reduction programs.

*3.4GHGs emission from water supply used*

The majority of water supply used in the faculty was found to be used for washing. Water was seen to be used for washing glassware in laboratories, cleaning the office buildings and in the faculty toilets. The amount of greenhouse gases that were emmited as a result of water use in the years 2010, 2011 and 2012 were found to be 508.81, 441.72 and 535.15 kgCO₂e respectively. These results are shown in Figure 4.

It can be seen from the table that the release of greenhouse gases as a result of water use is similar in each year. They are also small in comparison to the other sources such as electricity consumption. Only 0.0264 kgCO₂e is produced per cubic meter of water used.

**Scope 3: Indirect greenhouse gases emissions, such as the use of paper, waste generated, amount of chemicals used in the laboratory, and the use of laboratory supplies.**
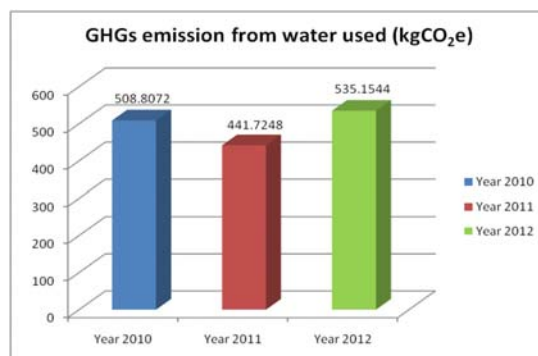
**Figure 4**: GHGs emission from water supply used (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 –2012
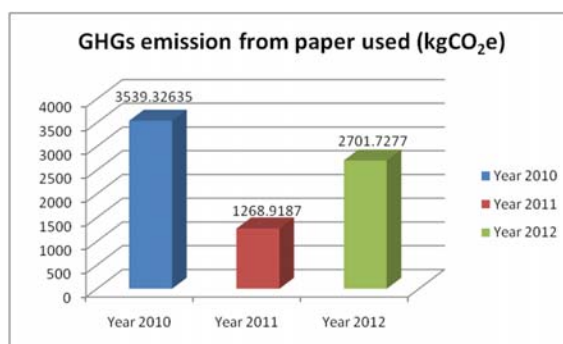


**Figure 5**: GHGs emission from paper used (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 - 2012

*3.5 GHGs emission from paper used*

Paper that is used in then faculty includes copier paper, KTV copier paper, printing and writing paper, duplicating paper A4/70g, duplicating papers A4/80g, white cardstock paper and toilet paper (jumbo rolls).

The amount of greenhouse gases that resulted from the use of paper in the faculty in the years 2010, 2011 and 2012 were 3539.32, 1268.91 and 2701.72 kgCO₂e respectively. These results were calculated from the amount of paper used by multiplying it with the Emission factor of 0.7350 kgCO₂e. The amounts of greenhouse gases emitted indirectly due to the use of paper in the faculty are shown in Figure 5.

The year 2010 was found to have the highest emissions. This was followed by the year 2012, while year 2011 has the lowest indirect GHGs emissions as a result of paper use. The Faculty of Environment and Resource Studies should consider minimizing the amount of paper used through proper planning and by taking steps to reduce wastage such as using both sides of the paper and using paper only when it is absolutely necessary.

*3.6 GHGs used by multiplying it by the Emission emission from chemicals used*

Chemicals that are used in the Faculty of Environment and Resource Studies were found to be sodium chloride, sodium hydroxide, anhydrous sodium sulfate, potassium hydroxide, acetic acid, citric acid, nitric acid, hydrochloric acid, sodium hypochlorite, sulfuric acid, ethyl alcohol and methyl alcohol.

The amount of greenhouse gases that resulted from the use of these chemicals in the years 2010, 2011 and 2012 was 95,486.79, 236,563.95 and 236,575.88 kgCO2e respectively. These were calculated from the amount of chemicals factor for each chemical. The amounts of greenhouse gases indirectly generated through the use of the chemicals are shown in Figure 6.

The results of the calculations show that in the years 2011 and 2012, release of greenhouse gases are very similar in quantities. They show an increase in amount from the year 2010. The faculty should investigate the reasons for the increased use of chemicals and measures should be taken up to minimize their unnecessary use.

*3.6 GHGs emission from laboratory supplies used*

Laboratory supplies that are used in the Faculty of Environment and Resource Studies include PP bags, aluminum foil, rubber gloves size S, rubber gloves size M and rubber gloves size L. The amount of indirect
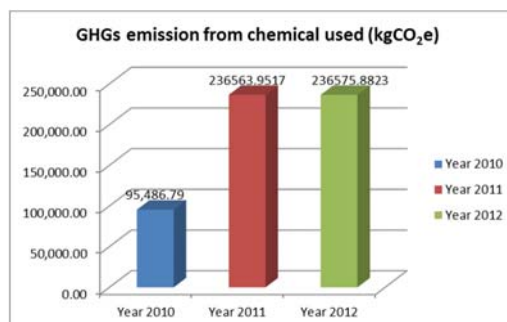
**Figure 6:** GHGs emission from chemical used in laboratory (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 –2012
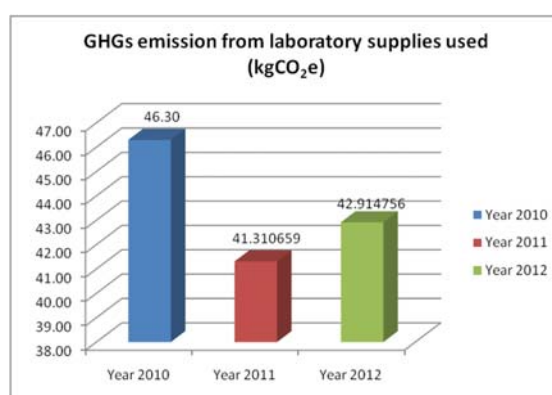


**Figure 7:** GHGs emission from laboratory supplies used (kgCO₂e) of Faculty of Environment and Resource Studies, Mahidol University in the year 2010 - 2012

greenhouse gas emissions from these supplies in the years 2010, 2011 and 2012 were found to be 46. 30, 41. 31 and 42. 91 kgCO₂e respectively. This was calculated by multiplying the quantity of supplies with the emission factor of each material. The amount of greenhouse gases caused by the use of the laboratory supplies in the years 2010-2012 is shown in figure 7. It can be seen that the amount of greenhouse gas emissions are relatively stable. It should also be noted that it is a minimal source of greenhouse gas emissions when compared to the other sources identified in this study.

*3.7 GHGs emission from waste generated*

The amount of greenhouse gases generated through waste disposal by the Faculty of Environment and Resource Studies was found to be roughly the same between the years 2010 and 2012 as shown in figure 8. (FIGURE 8: GHGs emission from wasted disposal is missing. Please check.) This is thought to be due to the number of students and staff being quite stable.

The amount of greenhouse gases generated by solid waste disposal in the year 2011, including the session and vacation period equals 112,971. 83 kgCO₂e. Solid waste that occurs within the Faculty of Environment and Resource Studies comprises plastic PET bottles ( clear bottle) , HDPE plastic bottles ( opaque bottles) , PP plastic bags (clear bags), PE plastic bags (opaque bags), paper, glass and aluminum ( can) , foam boxes ( Polystyrene) , textiles, diapers and sanitary napkins, rubber, leather and plastic boxes (Polypropylene).

**4.  Discussion and Conclusions (PLEASE CHECK THE CONSISTENCY OF THESE FOLLOWING FIGURE NUMBER IN A SEQUENCE CONSECUTIVELY)**

The total amount of greenhouse gas emissions that resulted from the activities of the Faculty of Environment and Resource Studies in the year 2010 was found to be 1,091.85 tonCO₂e as shown in Figure 8. The percentages of greenhouse gases generated by each activity can be seen in Figure 9.

The total greenhouse gas emissions that resulted from the activities of the Faculty of Environment and Resource Studies in the year 2011 was found to be 1,480.93tonCO₂e as shown in Figure 10. The
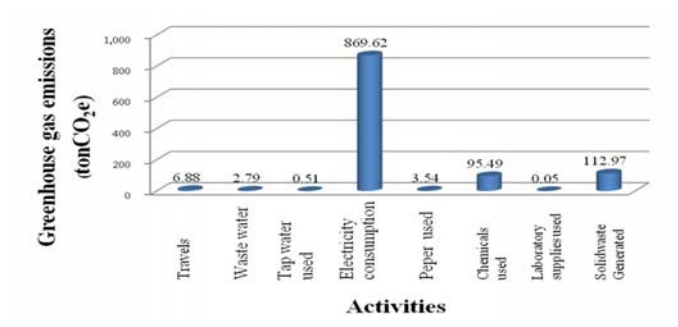
**Figure 8**: The amount of greenhouse gases resulting from the activities of Faculty of Environment and Resource Studies in the year 2010
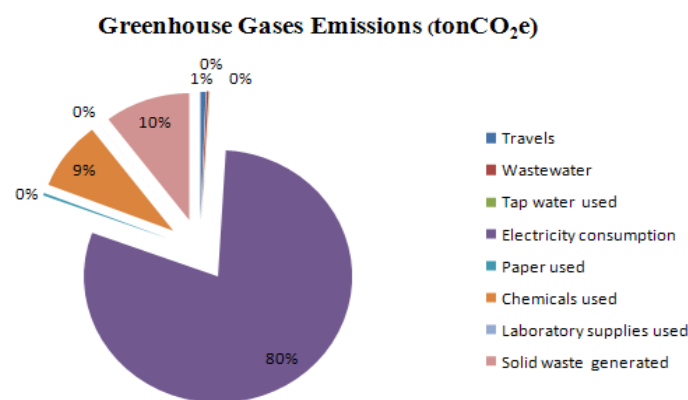


**Figure 9**:  Percentage of greenhouse gases emissions of each activity in the year 2010

percentages of greenhouse gases generated from each activity can be seen in Figure 11.

The total greenhouse gas emissions that resulted from the activities of the Faculty of Environment and Resource Studies in the year 2012 was found to be 1,201. 77tonCO$_2$e as shown in Figure 12.The percentages of greenhouse gases generated from each activity can be seen in Figure 13.

• The total amount of the greenhouse gas emissions from the Faculty of Environment and Resource Studies in the years 2010, 2011 and 2012 were found to be 1 0 91. 85, 1485. 79 and 1210. 80 tonCO$_2$e respectively. The amount of greenhouse gases generated through all the activities of the Faculty of Environment and Resource Studies in the years 2010-2012 are shown in Table 2 and Figure 14.

• It can be seen from the figures that the year 2011 generated the most greenhouse gas emissions. This was followed by year 2012. The least emissions occured is the year 2010. The results were divided by the number of students and staff in the faculty. Per person greenhouse gas emissions were found to be 1.479, 2.156 and 1.903 tonCO$_2$e for the years 2010, 2011 and 2012, respectively.  It should be noted that although the

number of students and staff of the faculty have steadily decreased but the amount of GHG emissions increases. This may indicate that the rate of emissions is not directly correlated to the number of students and staff in the faculty.

• The source of greenhouse gases that accounts for the highest emissions is electricity consumption. This is followed by indirect emissions from the chemicals used in laboratory and indirect emissions from the solid waste generated in the faculty. The source that was studied with the lowest indirect emissions was found to be the use of laboratory supplies, such as rubber gloves and plastic bottles.. It is therefore suggested that the planning and implementation of projects to reduce greenhouse gas emissions should initially be focused on reducing the amount of electricity consumption in the faculty.  A campaign to reduce the amount of garbage, for example by discouraging the use of plastic bags, and a campaign to segregate waste for recycling should also be carried out as a high priority.

• The Faculty of Environment and Resource Studies is an educational organization that has high consumption of electricity and water. It generates waste from its teachers, staff, and students. It was noticed that
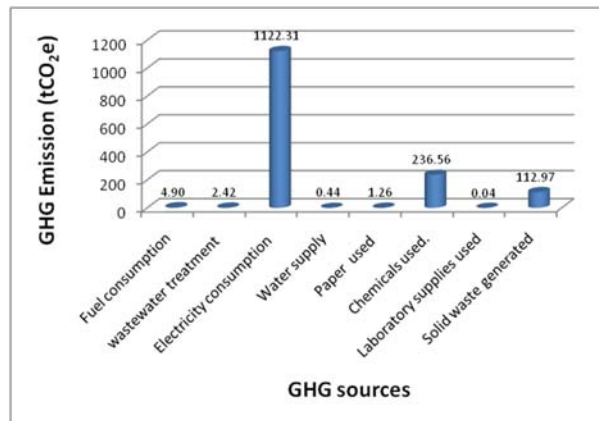
**Figure 10**: The amount of greenhouse gases resulting from the activities of Faculty of Environment and Resource Studies in the year 2011
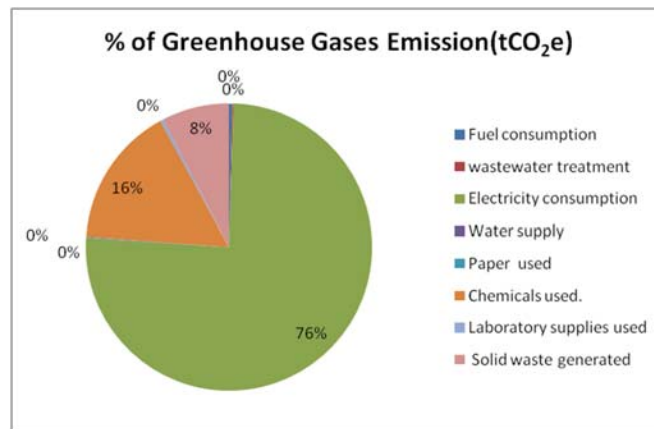


**Figure 11:** Percentage of greenhouse gases emissions of each activity in the year 2011
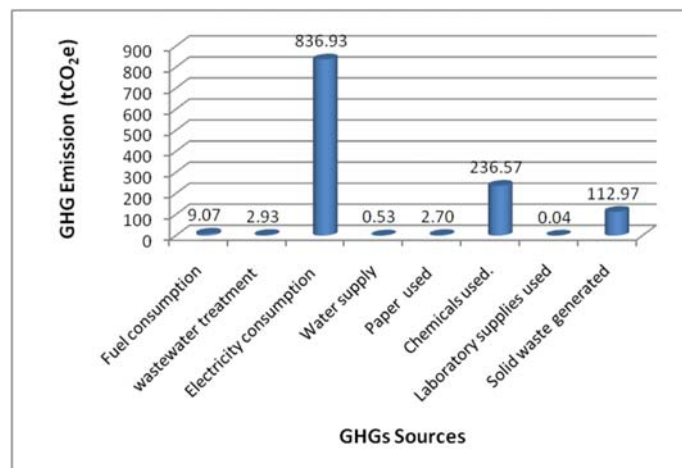


**Figure 12:** The amount of greenhouse gases resulting from the activities of Faculty of Environment and Resource Studies in the year 2012
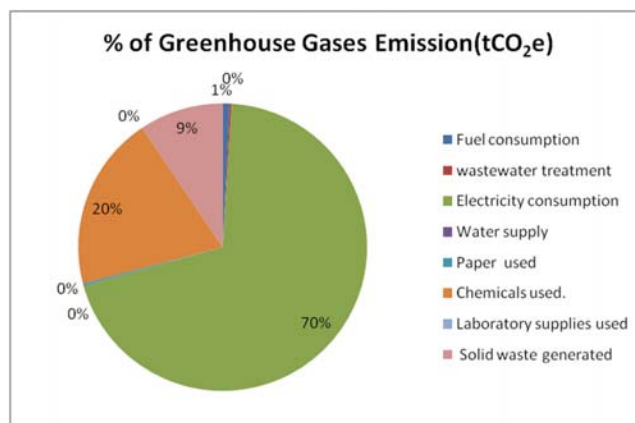
**Figure 13:** Percentage of greenhouse gases emissions of each activity in the year 2012

**Table 2:** Summary of trends of greenhouse gas emissions from Faculty of Environment and Resource Studies in the year 2010-2012

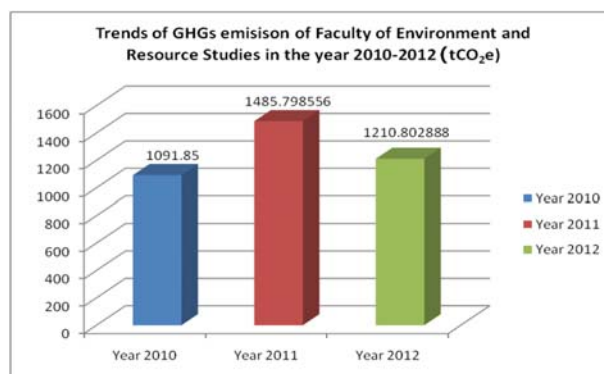| GHGs emission (tCO$_2$e) | Year 2010 | Year 2011 | Year 2012 |
|---|---|---|---|
| | 1091.85 | 1485.798556 | 1210.802888 |
| Number of students | 607 | 559 | 501 |
| Number of staffs | 131 | 130 | 135 |
| Total | 738 | 689 | 636 |
| **GHG emission per head** | 1.479471545 | 2.156456539 | 1.903778126 |



**Figure 14**: Trends of GHGs emission of Faculty of Environment and Resource Studies in the year 2010-2012 (tCO$_2$e)

the amount of waste increased every Friday of each week. This was thought to be due to there being a weekend market under the building of the faculty each Friday which attracted other staff and students. This caused an increase in the amount of greenhouse gases from waste disposal each week.

• When estimating green house gas emissions it is important to note that the amount of greenhouse gas emissions is not only determined by the amount of resources used or the amount of wastage that occurs but it also depends on the Emission Factor. Sources that appear to be smaller may in fact be larger if they have a higher emission factor. The time of year is another factor that affects the amount of greenhouse gas emissions from the faculty. It was observed that that the in-class semester period and the vacation period lead to different levels of emissions. It was therefore concluded that the types of activities the students and staff are

carrying out have an impact on the direct and indirect green house gas emissions of the faculty.

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