Carbon Footprint Evaluation and Reduction as a Climate Change Mitigation Tool - Case Study of Federal University of Agriculture Abeokuta, Ogun State, Nigeria

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Abstract- In this paper efforts were made to create awareness and evaluate carbon footprint for the Federal University of Agriculture Abeokuta (FUNAAB) for the period August 2011 to July 2012. The aim of this analysis was to determine the carbon footprint of FUNAAB, not only to give a tangible number with which the University's carbon sustainability level can be compared with other academic Institutions, but also to provide the much-needed baseline against which future mitigation efforts on the university campus can be measured. FUNAAB's carbon footprint for the 2011/2012 session was found to be about 5,935 tons CO_2, with transportation, campus energy consumption and farm machineries contributing about 63%, 35% and 2% respectively. Staff and student commuting alone contributed about 55% of all emissions associated with University activities. FUNAAB's per-capita emissions with a total of about 10,256 students for the 2011/2012 session amount to about 0.6 tons CO_2 emissions per student.

Keywords- Carbon footprint, FUNAAB, per-capita emissions, CO_2

1. Introduction

A carbon footprint can broadly be defined as a measure of the greenhouse gas emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product or service, expressed in carbon dioxide equivalents [1]. According to the Intergovernmental Panel on Climate Change (IPCC), there are 18 greenhouse gases with different global warming potentials. But under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, only Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6) are considered for the purposes of carbon accounting, with others being regulated elsewhere [2].

The determination of the carbon footprint of the Federal University of Agriculture Abeokuta (FUNAAB) was a project work wherein the results was committed to setting an example of environmental responsibility by establishing environmentally sound policies and practices, and developing curricula, research initiatives and operational systems to support an environmentally sustainable future [3]. While the effort to evaluate carbon footprint for the University proposed a number of carbon emission reduction intervention plans, it also stressed the need to conduct a detailed carbon footprint analysis for the entire University [6].

This paper presents results of the Federal University of Agriculture Abeokuta's carbon footprint analysis emphasizing all significant contributing sources.

2. Problem Statement

Carbon footprint has been deemed partly responsible for climate change in recent times. The global community now recognizes human induced climate change as the greatest environmental threat of the 21st century. Countries, organizations and individuals alike are starting to take responsibility for making the emission reductions necessary to stabilize global warming gases in the atmosphere. These changes in climate and ozone layer depletion by the activities of man have been predicted to be at exponential rate. It then becomes apparent to analyze a model to serve as a standard to cub damages caused to the environment.

When calculating a carbon footprint, many questions arise. Organizations can have many activities that cause CO_2 emissions. Examples of possible emission sources are transport, electricity, paper, manufactured products, clothing, food, drink, health, hygiene and many more [4]. It can be hard for an organization to decide which emission sources to account for in their carbon footprint. There are so many possible sources of emissions in companies that it seems impossible to exactly calculate the carbon footprint of a company. However, if calculating the exact carbon footprint is impossible, what rules should be used to calculate a carbon footprint? What information systems should be available for this? Which emission sources should be included in calculating the carbon footprint? How are boundaries set to cater for the size of carbon footprint to be calculated? How can the emissions of an organization be allocated to certain divisions of the organization? These are all relevant questions to Institutions that want to report about their carbon footprint.

3. Materials and Methods

In the starting phase of this project, a carbon footprint boundary was set. This helped to define a framework that was developed to give comprehensive characteristics of all activities within the University that evidently contribute to her carbon footprint. The boundary definitions were used to clearly group all components of the carbon footprint for analysis and the footprint of the University was determined.

Several tools could have been employed to evaluate the carbon footprint of the University, but some of these tools had parameters that were irrelevant to estimating the carbon footprint of FUNAAB. These tools include Campus carbon calculator, Inventory calculators, Inventory management plan, and goal proposal templates [7, 9].

3.1. Emission Factors

This project made use of the relevant standards and methods such as the Greenhouse gas (GHG) emission factors in evaluations for combustion of common fossil fuels and DEFRA guidelines in evaluations for electricity emission sources [5,11]. Table 1 shows the Carbon Footprint Analytical Framework for FUNAAB.

Table 1. Carbon footprint analytical framework for FUNAAB

Transportation Emissions	Category 1	Category 2	Category 3
Road (student & staff commuting)	Mancot buses (bus rapid transport)	Private transport	Public transport
Campus Energy Emissions	Electricity (PHCN)	Generators (petrol)	Generators (diesel)

3.1.1. Electricity

FUNAAB gets electricity from two major sources: the purchased electricity from the public utility company, Power Holding Company of Nigeria (PHCN), and electricity from emergency generators located at strategic places and the powerhouse of the University. Electricity data for PHCN bills in KWh from August 2011 to July 2012 were obtained from the Works and Services, Electrical Department of the University. The University controls five other facilities outside the main campus and their bills in KWh were considered. The Works and Services Department and the Mechanical Department of the University also provided the data for fuel consumption. Other small petrol powered generators owned/operated by the university were not considered in this study.

3.1.2. GSM Operators' Generators

There are three different cell sites (Base Transmission Stations, (BTS)) within the campus and these sites run on generators to provide services. The generators use diesel and the CO_2 emissions were calculated using the quantity of fuel consumed as provided by the operators on a monthly basis.

3.1.3. Private Small Business Operators' Generators

Individuals that have business ventures within the University privately own these generators. The generators make use of petrol and a survey on the quantity of fuel consumed daily was used with the appropriate emissions factor to determine the CO_2 emissions.

3.2. Transport Emissions

This covers all emissions from vehicles commuting to and from FUNAAB and emission from vehicles owned by various University departments and student bodies. The emissions from the University-owned Mancot buses fleet, which provides commuting services for FUNAAB students and staff between campuses and within areas close to the main campus were also included.

3.2.1. Mancot Buses (bus rapid transport)

Data on fuel consumption (diesel) quantity of the Mancot buses fleet owned by FUNAAB were obtained for August 2011 – July 2012. GHG emission factors were then used to determine the resulting carbon emissions [4].

3.2.2. FUNAAB vehicles

A genuine questionnaire and survey was used to determine the fuel consumption quantity (petrol) for the emissions from FUNAAB vehicles. The Works and Services Department provided a total number of the vehicles. Using the GHG emission factor [4], the amount of CO_2 released could therefore be calculated.

3.3. Carbon Footprint Formulas

It is possible to measure actual greenhouse gas emissions associated with some activities such as industrial processes and transport. Emissions from, for example, cars, airplanes and electricity generation are well understood and documented. Standard emission factors have been calculated for these activities so that actual emissions do not always have to be measured, but can be calculated from other data - such as amount of fuel used [11].

$$GHG = A \times EF \quad (1)$$

Where,

GHG = emissions (amount of CO_2 or CH_4, etc.)
A = activity data (liters of fuel, kg of cement)
EF = emission factors (kg CO_2/liter of fuel, kgCO_2/kg cement)

3.3.1. Activity Data, A

This is the data on a human activity which results in emissions or removals that take place during a given period of time for example the liters of fuel consumed.

3.3.2. Emission Factors, EF

These are researched coefficients that relate the activity data to the amount of chemical compound which is the source of later emissions. The factors are often based on a sample of measured data averaged to develop a specific rate of emission for a given activity level under a given set of operation conditions [10].

4. Results

4.1. Campus Energy Emissions

4.1.1. FUNAAB Generators

Figure 4.1 gives the CO_2 emissions contributed by the different generators in operation controlled by the University for the estimated year. The total CO_2 emissions by the generators amount to about 1,012.3 tons with the 200KVA generator contributing an estimated 228.61 tons of CO_2 emissions to give the highest generator emission for the estimated year with diesel consumption at an estimated 7,056 liters/month.

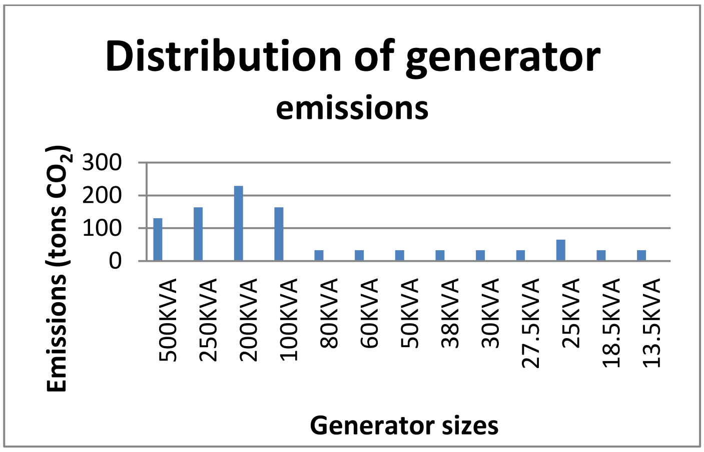

Fig. 4.1. Distribution of CO_2 emissions from the generators owned by FUNAAB

4.1.2. GSM Operators' Generators

There are three different cell sites owned by GSM operators within the University. These operators power their equipment using generator sets that run for nearly 24 hours a day. It is assumed that these generators work for 24 hours a day to provide for optimal efficiency by the GSM operators. The sizes of the generators determine the fuel consumption rate during operation. It is also assumed from survey that each generator consumes about 3000 liters/month of diesel for operation. In the case where there is a generator set on site, each generator will consume 1500 liters/month of diesel for operation. This fuel consumption by the generators contributes an estimated 145.8 tons of CO_2 emissions to the University's carbon footprint for the estimated year.

4.1.3. Private Small Business Operators' Generators

In the survey for the total number of privately owned generators used for businesses in University, 49 generators were counted. It is assumed that these operators work 21 days in a month and about 12 hours a day. It is also assumed that the generators consume 7 liters/day of petrol with the stated working hours. These generators contribute about 4.32 tons of CO_2 emissions to the University's carbon footprint monthly. Figure 4.2 shows the CO_2 emissions for the generator sources present in the University. FUNAAB's generators contribute the highest CO_2 emissions at 84.35 tons per month followed by business generators and GSM operator's generators at 17.27 tons and 12.15 tons respectively.

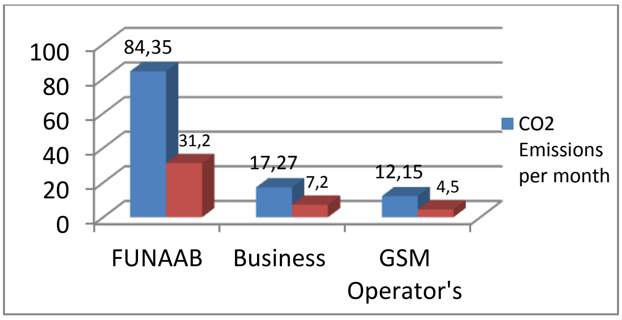

Fig. 4.2. Distribution of generator emissions in FUNAAB

4.1.4. Tractors and Lawn Mowers

The Department of Environmental Management (DEM) was able to provide some details on the tractors and lawn mowers used in the University. The rate of activity by these machineries is very dependent on season, which accounts for the rate of grass growth in the University. The tractors and lawn mowers are less functional during the dry seasons in which there are fewer rainfalls and lesser growth of grass. It is assumed that the same condition applies for every month for the calculated year. The tractors account for about 83.52 tons of CO_2 while the lawn mowers account for 29.03 tons of CO_2 emissions for the period of August 2011- July 2012.

4.1.5. Electricity

Figure 4.3 presents the electricity consumption by the different units of the University. The electricity consumptions in KWh are plotted on the vertical axis and the months for the baseline year of calculation are plotted on the horizontal axis.

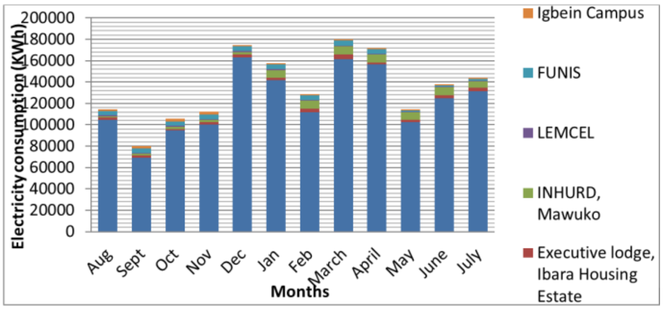

Fig. 4.3. Trend of Electricity Consumption of FUNAAB

Figure 4.4 shows the distribution of carbon emission from electricity usage controlled by the University. Electricity consumption contributed a total of 696.45 tons of CO_2 emissions to the University's carbon footprint for the estimated year, 90% of which was from the Main Campus, 4% from Institute for Human Resources Development (INHURD), while the

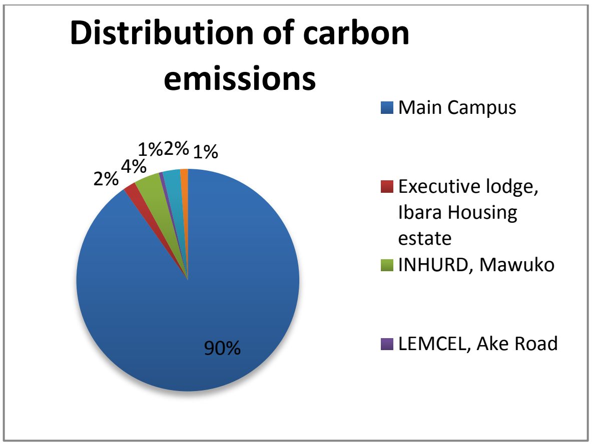

Fig. 4.4. Distribution of Carbon Emissions from Electricity Usage at FUNAAB

Executive lodge, FUNAAB International School (FUNIS), Leventis Memorial Centre for Learning (LEMCEL) and Igbein Campus contributed the rest. Only about 12% of the FUNAAB community commutes to campus carbon-free – those that stay in the school hostels, while about 46% use the Mancot bus. More than 16% of the FUNAAB community drives to campus daily and 26% use the public transport.

Figure 4.5 shows the distribution of major modes of transport used daily for commuting to and from the University campus. Figure 4.6 gives the carbon emission due to daily commuting by the various transportation modes. The total emissions resulting from the commuting of students and staff for 2011/2012 were found to be about 3,217.66 tons of CO_2 of which 92% are attributable to the use of private vehicles and the Mancot buses with public transport (buses and taxis) making up for the rest.

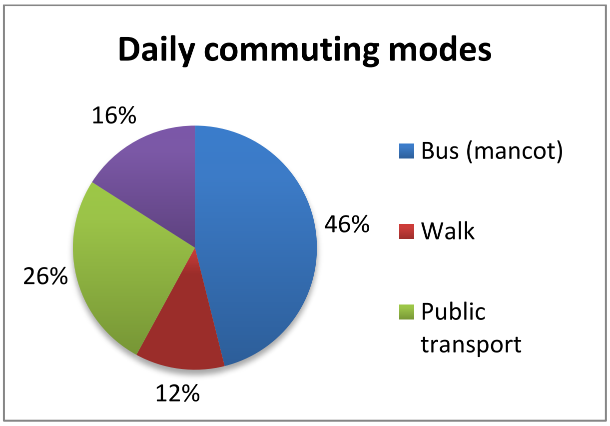

Fig. 4.5. Distribution of Daily Commuting Modes by Students and Staff

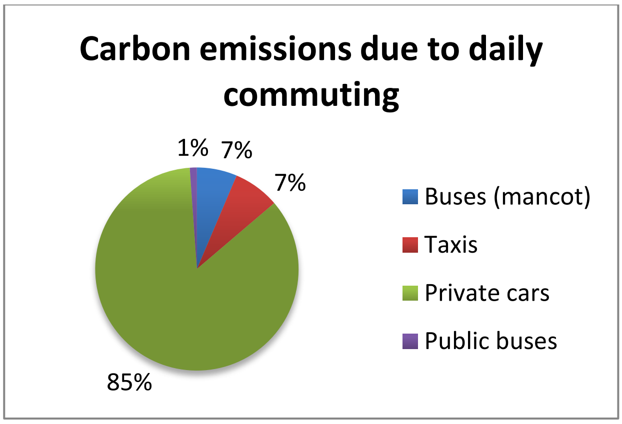

Fig. 4.6. Distribution of Carbon Emissions due to Daily Commuting to the University

The FUNAAB owned vehicles were found to contribute a total of 2,738.5 tons of CO_2 to the University's emissions. The total petrol and diesel consumed by the University amounts to about 1,563 tons of CO_2 or 74% and 544 tons of CO_2 or 26% respectively as shown in Figure 4.7.

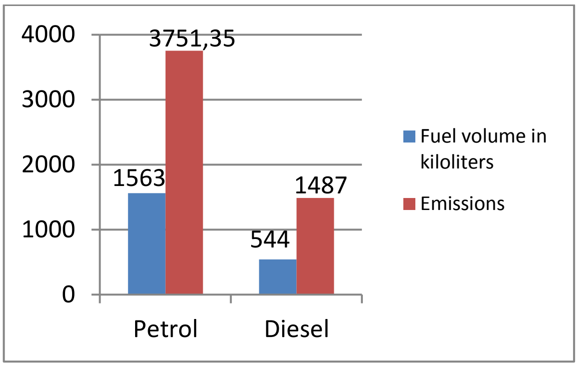

Fig. 4.7. Fuel Quantities and Resulting Emissions from the University's Combustion Activities for the Year 2011/2012

4.2. Total Carbon Footprint for FUNAAB

Table 4.1 shows the total carbon footprint of the Federal University of Agriculture Abeokuta for the year 2011/2012. University activities for the year of 2011/2012 led to the release of about 5,935 tons of CO_2 emissions into the atmosphere, with about 55% of those emissions coming from staff and student commuting alone (Figure 4.8). Generators and consumption of electricity were the second and third most carbon-intensive activities at the University in 2011/2012with contributions of 23% and 11% respectively.

Figure 4.8 is an overview of the carbon footprint of the Federal University of Agriculture Abeokuta highlighting only the most significant contributors (greater than 1% contributions).

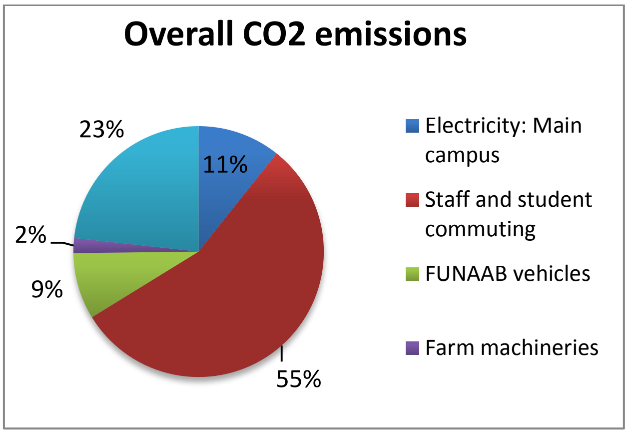

Fig. 4.8. Overall FUNAAB CO_2 Emissions

In Figure 4.9, of the three categories, Transport has the largest share of GHG emissions at 63% followed by Campus energy at 35% and lastly farm machineries at 2%.

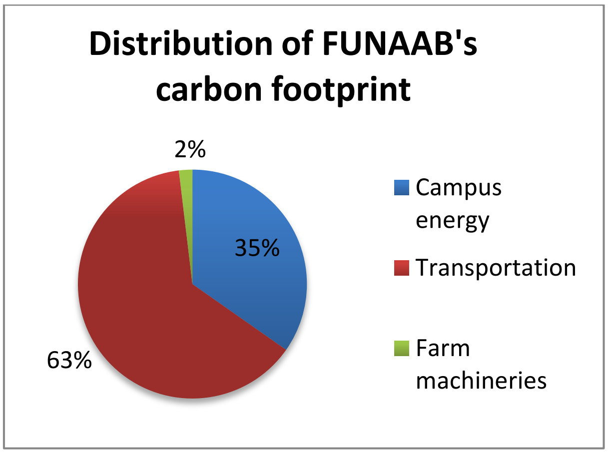

Fig. 4.9. Distribution of FUNAAB's Carbon Footprint by Emission Category

Table 4.1. FUNAAB's Carbon Emissions for the Year 2011/2012

Category	**Emission source**	**Emissions (tons CO_2/yr.)**	**% contribution**
Campus energy	Electricity: Main Campus	628.7	10.59%
	Electricity: Executive lodge	12.9	0.22%
	Electricity: INHURD	25.9	0.43%
	Electricity: LEMCEL	3.8	0.06%
	Electricity: FUNIS	17.8	0.30%
	Electricity: Igbein Campus	7.7	0.13%
	FUNAAB generators	1 012.3	17.05%
	GSM operator generators	145.8	2.45%
	Business generators	207.3	3.49%
Transportation	Staff and student commuting	3 257.2	54.88%
	FUNAAB vehicles	503.1	0.13%
Farm machineries	Tractors & Lawn mowers	112.53	0.02%
TOTAL		**5 935**	**100%**

5. Conclusion and Discussion

5.1. Conclusion

The total carbon emissions for the Federal University of Agriculture Abeokuta for the year 2011/2012 were estimated at 5,935CO_2. Although this value is an underestimation because of unavailability of some of the activity data, it is the best estimation that was possible with the data available, and it gives a good idea of the size of the University's annual carbon footprint.

Staff and student commuting to and from FUNAAB campus is the largest sole contributor to the University's carbon footprint.

In the estimated year, about 55% of FUNAAB's carbon footprint resulted from staff and student commuting.

5.2. Discussion

5.2.1. Reducing the Climatic impact of campus energy and private consumption

The University should begin a Green Campus Initiative; ideas that can help minimize the carbon emissions from the University. Observing the results from the analysis, cars (both private and University owned) contributes about 3,241.69 tons of CO_2 emissions – 54% emissions. The level of this emission can be controlled or reduced by introducing more staff buses (bus rapid transport scheme) hence reducing the number of cars that commute to the University.

With the rapid growth and contribution of renewable energy sources to power consumption and zero emission, the University should invest in renewable energy projects to generate tangible amount of power consumed. It was observed that one of the GSM operators within the University is now switching to solar energy to power its cell site located inside the University. This idea is positive towards reducing carbon footprint. The cell sites by the various GSM operators within the University should be compelled to use green energy (solar energy) to reduce the constant emission from their generators per year.

The Federal University of Agriculture Abeokuta has tree preservation principles that favor the natural reduction of carbon emissions by the trees. Trees absorb CO_2 and release oxygen as they grow. Trees and forests are crucial to the global carbon cycle and a tree can absorb about 1 metric ton of CO_2. FUNAAB should endeavor to plant more trees to offset more carbon emissions per year.

Generally, mitigation of climate change through reduction of CO_2 emissions should be tackled through a hierarchy of actions, the most important being reduced energy use, followed by increased energy efficiency, use of renewable energy resources, product substitution, protection of carbon stores, carbon sequestration and carbon offsets [8].

References

[1] Wiedmann T, and Minx JC, "A definition of 'carbon footprint'". In:Petsovam CC (ed) Ecological Economic Research Trends, 1st edn. Nova Science Publishers, Hauppauge, New York, pp. 55–65, 2008.

[2] Hall, M. and N. Murray (2008). Green Campus Policy Framework for the University of Cape Town. University of Cape Town, Cape Town. Available at: http://www.erc.ac.za/Research/publications/10Thapeleetal-UCT_footprint.pdf, Accessed 16 June 2012

[3] IPCC (2000) Land use, land-use change and forestry. IPCC Special Report, Cambridge University Press, Cambridge. Available at: http://www.grida.no/climate/ipcc/land_use/157.htm Accessed 11June 2012

[4] *World Resources Institute GHG Calculation Tools for Stationary Emission Sources available at: http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAx,*Accessed 10 June 2012

[5] DEFRA 2009: Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. Version 2.0.London, UK, Department for Environment, Food and Rural Affairs. Retrieved from http://www.forestry.gov.uk/pdf/FCRP018.pdf/ Accessed 13 April 2012

[6] Rippon, S. (2008). Green Campus Action Plan. University of Cape Town, Cape Town. Available at: http://www.erc.ac.za/Research/publications/10Thapeleetal-UCT_footprint.pdf, Accessed 16 June 2012

[7] US EPA, 2006: A Program Guide for Climate Leaders. Available at : http://www.epa.gov/climateleaders/documents/cl_programguide_508.pdf, Accessed 15 June 2012

[8] Woodland Trust (2005) Position statement on climate change. Available at: http://www.woodlandtrust.org.uk/en/campaigning/, Accessed 14 April 2012

[9] Hogne N. Larsen, Johan Pettersen, Christian Solli, and Edgar G. Hertwich, "Investigating the Carbon Footprint of a University - The case of NTNU", *Journal of Cleaner Production*, DOI: http://dx.doi.org/10.1016/j.jclepro.2011.10.007*Vol 48, June 2013, pp. 39-47.*

[10] "Lidija Čuček, Jiří Jaromír Klemeš, and Zdravko Kravanja, "A Review of Footprint analysis tools for monitoring impacts on sustainability", *Journal of Cleaner Production*, DOI: http://dx.doi.org/10.1016/j.jclepro.2012.02.036*Vol. 34, October 2012, pp. 9-20.*

[11] Sayam Aroonsrimorakot, Chumporn Yuwaree, Chumlong Arunlertaree, Rungjarus Hutajareorn, and Tarinee Buadit, "Carbon Footprint of Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Thailand", 4th International Conference on Environmental Science and Development- ICESD, *APCBEE Procedia, Vol. 5, 2013, pp. 175-180.*