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# 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

*The knowledge of carbon footprint evaluation cooperation have since been striving to set an example of environmental responsibility by establishing environmentally sound policies and practices, and by developing curricula and research initiatives to support an environmentally sustainable future. One of the most recent efforts in this quest was the urge to create awareness and evaluate carbon footprint for the Federal University of Agriculture Abeokuta (FUNAAB) for the period August, 2011 to July, 2012. It stressed the need to conduct a detailed and comprehensive carbon footprint analysis for the whole University. 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.*

*In this paper, boundary conditions were set out to identify the various emission sources on campus using international standards like the GHG emission factor. Using a genuinely analytical questionnaire, surveys, and interviews, data on the various emission sources were collected. The data collected was analyzed and used for the calculation of $CO_2$ emissions in FUNAAB using the appropriate emission factors from the Department for Environment, Food and Rural Affairs (DERFA) guidelines and GHG emission data respectively. 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 contribute about 55% of all the 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. By this study, FUNAAB contributes a total of 5,935 tons of $CO_2$ for all emissions released into the atmosphere yearly.*

*These $CO_2$ emissions contribute to the depletion of the ozone layer causing Greenhouse effects and global warming. FUNAAB can reduce her carbon footprint by introducing green energy sources such as solar energy in place of the standby diesel generators that contributes an estimated 84 tons of $CO_2$ monthly. Also, transportation emissions can be reduced by implementing a transportation routine programme to reduce the amount of cars that commute to the University daily.*

**Keywords:** *Greenhouse Gas Emissions, Carbon Footprint, FUNAAB, Emission Reduction*

## 1.0 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 (Wiedman*et al.*, 2007). According to the Intergovernmental Panel on Climate Change (IPCC), there are a total of 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 (Hall, M. *et al.*, 2008).

The determination of the carbon footprint of the 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 by developing curricula, research initiatives and operational systems to support an environmentally sustainable future (IPCC, 1990).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 (Rippan, 2008).

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

## 2.0 LITERATURE REVIEW

In this literature review, an overview is given of previous research in the field of calculating carbon footprints. This had to be done for two reasons: to gather information about the subject and to know which topics have already been investigated.

For the literature review, various pieces of scientific literature were used:

- General literature about keeping track of $CO_2$ footprints
- Literature about information systems required for calculating $CO_2$ footprints.
- Literature about allocation of $CO_2$ emissions.

Furthermore, multiple sources were consulted for the literature review:

- Books
- Websites
- Scientific papers
- Reports of Universities
- Standards.

A search was done for reliable standards in the field of carbon foot printing - the ISO 14064 standard was found (ISO, 2006) - this standard is about the quantification and reporting of GHG emissions. This standard was used together with the GHG Protocol (WBCSD/WRI, 2003). The Campus Carbon Calculator was found in a paper about the methods of estimating the carbon footprint but has a lot of parameters that were not included in this paper (Pandey*et al.*, 2011).

Keeping track of the carbon footprint is one way to keep track of non-monetary environmental data. Carbon footprint can be defined as "a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product" (Wiedmann*et al.*, 2007). Carbon Trust (2007) defines the carbon footprint as "a technique for identifying and measuring the individual greenhouse gas emissions from each activity within a supply chain process step and the framework for attributing these to each output product" . Environmental Technologies Action Plan (ETAP, 2007) states that "the 'Carbon Footprint' is a measure of the *impact* human activities can have on the environment in terms of the amount of greenhouse gases produced, measured in tonnes of carbon dioxide".

Greenhouse gas emissions are often measured in kg $CO_2$ or kg $CO_2e$. There is an important difference between these two units. The unit "kg $CO_2$" only deals with the weight of the carbon dioxide emissions while the unit "kg $CO_2e$" (kg carbon dioxide equivalents) is a number that also incorporates greenhouse gases like $CH_4$ and $N_2O$. The global warming potential (GWP) indicates the degree of harm to the environment of a unit of a certain greenhouse gas relative to $CO_2$. This number can be used to calculate the emission in terms of $CO_2$ equivalents ($CO_2e$). The carbon footprint definition used in this paper is the definition by Wiedmannet *al.* (2007). The focus in this paper is on carbon dioxide rather than GHG emissions in general.

The ISO 14064 (2006) classifies greenhouse gas (GHG) emissions into different types viz:

- Direct GHG emissions
- Energy indirect GHG emissions and
- Other indirect GHG emissions

A direct greenhouse gas emission is defined as a "GHG emission from greenhouse gas sources owned or controlled by the company". An energy indirect greenhouse gas emission is defined as a "GHG emission from the generation of imported electricity, heat or steam consumed by the organization". And other indirect GHG emission is defined as a "GHG emission, other than energy indirect GHG emissions, which is a consequence of an organization's activities, but arises from greenhouse gas sources that are owned or controlled by other organizations". In most cases, it consists majorly of transportation sources.

Operational boundaries can be defined by companies on what emissions to include in their assessment. Emissions can be categorized into scopes viz:

- Scope 1 (direct GHG emissions)
- Scope 2 (electricity indirect GHG emissions) and
- Scope 3 (other indirect GHG emissions).

Scope 1 and 2 are mandatory for companies to be compliant with the specified standards (WRI/WBC, 2004). Different types of emissions can be attributed to these three different scopes. The following emissions are emissions of scope 1:

- Generation of electricity, heat or steam
- Physical or chemical processing
- Emission resulting from combustion of fuels in company owned/controlled mobile combustion sources that are used for transportation of materials, products, waste and employees.
- Fugitive emissions which are the result of certain emission releases of the organization, like air-conditioning or refrigerators

**Scope 2** contains purchased electricity, which is used as "shorthand for electricity, steam and heating/cooling".

**Scope 3** contains the following activities:

- Extraction and production of purchased materials and fuels

- Transport-related activities
- Electricity-related activities not included in scope 2
- Leased assets, franchises and outsourced activities
- Use of sold products and services
- Waste disposal
- Commuting

On examination, scope 1 has similar listings as scope 3 but the difference between scope 1 and 3 is that scope 1 is about emission sources that are owned by the company, and scope 3 is about emission sources that are owned or not owned but can be controlled by the company. Reporting scope 3 emissions is not mandatory according to the GHG Protocol. Furthermore, some emission sources may be present in both scope 1 and scope 3. For example, scope 1 emissions include emissions from combustion of fuels in cars, while scope 3 includes emissions of the production of purchased fuels that may be used for cars.

Transport-related activities are a very important source of $CO_2$ emissions for universities. The GHG Protocol provides some more explanation about this category. The following activities in scope 3 are transport-related: transportation of purchased materials or goods, transportation of purchased fuels, employee business travel, employees commuting to and from work, transportation of sold products and transportation of waste. The "waste disposal" category (which may also be relevant to universities) can include waste of operations, waste of production of purchased goods and waste of disposal of solid products.

According to ISO 14064 (2006), three different methodologies of quantifying greenhouse gases (GHGs) can be used: calculation, measurement and a combination of calculation and measurement. Measurement can either be continuous or intermittent. Calculation can be based on the following:

- GHG activity data multiplied by GHG emission or removal factors
- The use of models
- Facility-specific correlations
- Mass balance approach

Two basic types of data are necessary to calculate the $CO_2$ emissions of a company or product. First activity data is necessary which provide more detailed information on the activities that lead to emissions. Examples of activity data can be the amount of gasoline used in a certain time frame (in liters), or the amount of paper consumed (in kilograms). Emission factors can be used to convert activity data to $CO_2$ emissions. Emissions can be expressed into $CO_2$ emitted per unit of measurement (kg, km, l, etc.). For example, an emission factor could state the amount of $CO_2$ that is emitted per kilogram of paper which makes emission factors source specific. Also, the emissions of electricity produced by coal will be different from emissions of electricity produced by nuclear power. In general, the formula for calculating an emission is given as (Put del Pino et al, 2002; Carbon Trust and Crown, 2008; BSI(2008)PAS2050:2008):

To begin calculation, the following should be considered (Put del Pino*et al.*, 2002);

(i) Creating a process map as the first step to give a guide that contains all of the different processes, materials and activities of the product's life cycle that could possibly result in emissions.

(ii) The second step is defining the boundaries of the analysis. The system boundary defines the scope for the product carbon footprint i.e. which life cycle stages, inputs and outputs should be included in the assessment.

(iii) Collecting the data necessary for calculating the carbon footprint is the third step. Data should be relevant, complete, consistent, accurate and transparent according to GHG Protocol standards. Activity data and emission factors are the data that is necessary for calculating the carbon footprint as discussed earlier.

(iv) The fourth step is the actual calculation of the footprint. The equation for product carbon footprinting is the sum of all materials, energy and waste across all activities in a product's life cycle multiplied by their emission factors. So activity data should be multiplied with the emission factors for all activities, and then all of these calculated $CO_2$ emissions should be added up(Schatteggeret *al.*, 2000).

The concept of UCSI University GCI was prepared by the Corporate Affairs Teams to present a proposal that will be implemented in the aim to reduce the environmental impact caused by UCSI University's business operations. The concept provided basic ideas, analysis, data and action plans to undertake a university's greening initiative. The Figure 1 shows the methodology used to collect data and determine the total carbon footprint for the year 2008.

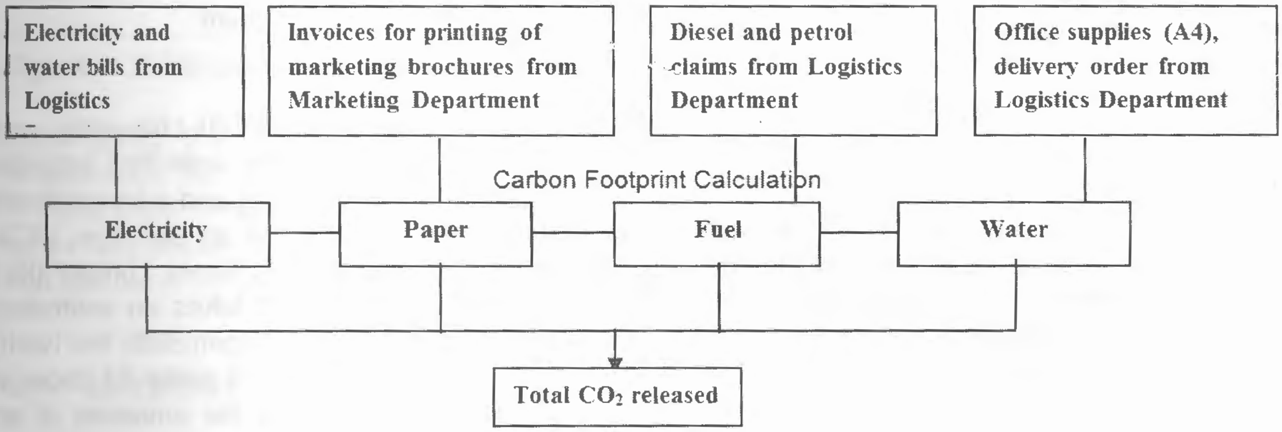


***Fig. 1: UCSI University's Carbon Footprint Measurement Methodology***

Carbon footprint is a measure of the exclusive total amount of $CO_2$ emissions that is direct and indirectly caused by an activity or is accumulated over the life stage of a product (Wiedmann*et al.*, 2007). The $CO_2$ emission at UCSI University comes mainly from the use of electricity, fuel, paper and water. These four resources shown in Figure 1 cause a significant environmental impact that required attention. The electricity generation process which is using oil and natural gas results carbon monoxide (CO) and carbon dioxide ($CO_2$) as well as the gas produced by the fuel combustion. CO and $CO_2$ gas are considered as toxic and can cause greenhouse effect if release excessively into the air. This is the main reason of using these four factors as a measurement. In order to reduce the environmental impact at UCSI University, the measurement of the $CO_2$ emission was a very important starting point. The carbon footprint for the year 2008 was calculated using the formulas detailed in Table 1. The carbon footprint formula for the water is not available and there is no $CO_2$ release from water used at UCSI University.

Table 1:Carbon footprint measurement formula

| Variables | Carbon Footprint Formula | Notes |
|---|---|---|
| **Electricity** | $CO_2$ = AME x EEF<br>• AME: Average Monthly Electricity used (kWh) | It is better to use the average EEF of West Malaysia 0.585 CO2e/mWh |

| Variables | Carbon Footprint Formula | Notes |
|---|---|---|
| | • EEF: Electricity Emission Factor (CO2e/kWh) | |
| **Fuel** | $CO_2$ = AMF x FEF<br>• AMF: Average Monthly Fuel used (Liters)<br>• FEF: Fuel Emission Factor (CO2e/Liters) | • Every liter of gasoline burnt releases 2.5 kg of $CO_2$.<br>• Every liter of diesel releases 2.8 kg of $CO_2$. |
| **Paper** | $CO_2$ = AMP x PEF<br>• AMP: Average Monthly Paper used (Kg)<br>• PEF: Paper Emission Factor (CO2e/Kg) | • 1 Kg of virgin paper produces 3.24 Kg of $CO_2$.<br>• 1 Kg of recycle paper produces 1.76 Kg of $CO_2$.<br>• The weight of one A4 standard paper is 5 gram |
| **Water** | N/A | N/A |

The data used to calculate the total carbon footprint produced by UCSI University wa collected from Logistics and Marketing Department. The primary data collected include electricity, fuel, and water bills. Also the invoices for printing the marketing and advertiseme tools as the data source for paper was used. Table 2 shows that, on an average, UC University uses 280,805 kWh of electricity per month in the South Wing Kuala Lumpur (K Campus alone. This releases an estimated 150 ton of $CO_2$ monthly. It takes an estimate 1,000 trees to offset the release of UCSI's $CO_2$ emission with clean oxygen.Both the Nor Wing and South Wing KL Campus of UCSI University utilize 800 reams of white A4 paper month. This is equivalent to 1600kg of paper or 18 trees and causes the emission of a estimated 5 tons of $CO_2$/month as can be seen in Table 2.

**Table 2: UCSI University resource usage**

| Resource | Average Monthly Use |
|---|---|
| **Electricity** | 280,805 kWh |
| **Transport Fuel** | • Diesel: 15660.96 liters<br>• Staffs and students mileage: 320,000 km |
| **A4 Cut Paper** | 16000 kg |
| **Water** | 4338.20 liters |

This figure does not yet include the use of other paper materials such as envelops, notepac brochures, etc. UCSI University's fleet of diesel vehicles used an estimated 3132.1 liters/month, which causes the emission of an estimated 8.2 tons of $CO_2$ per month. estimated 800 vehicles commute to UCSI KL campus daily. Assuming that on an averag each staff and student will need to travel 20km daily, this amounts to a cumulative total 16,000km a day or 320,000km a month (excluding Saturday and Sunday). This gave estimated $CO_2$ released of 71.5 tons a month.

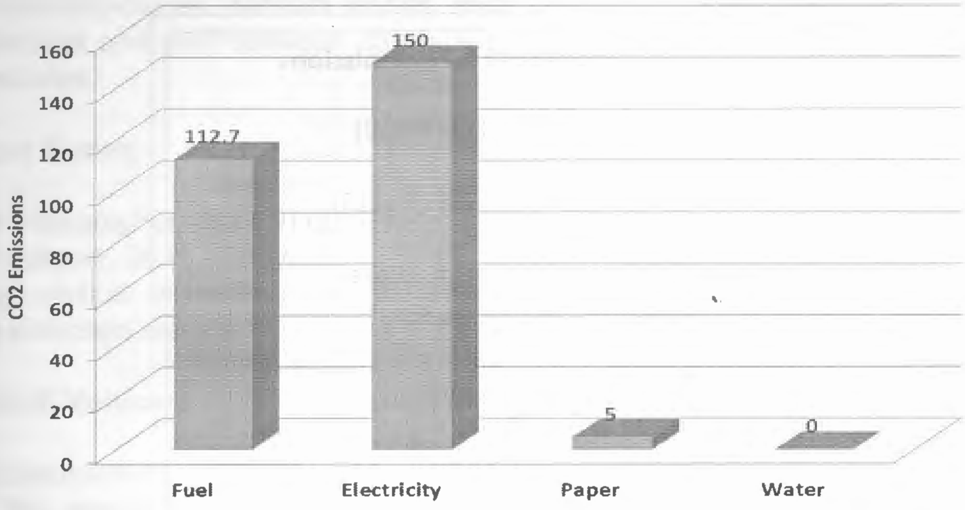


***Figure 2: UCSI University's monthly $CO_2$ emission***

Conclusively, the green campus program provides legitimacy to the environmental education programmes that will assist staff and students in getting the sustainability initiatives. In order to make UCSI University a Green campus, various initiatives and actions are being taken. As far as $CO_2$ emission is concerned, UCSI University has started to reduce the use of resource that has been presented earlier, mainly electricity, fuel and paper.

## 3.0 MATERIALS AND METHOD

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 (Wood Land Trust, 2005).

### 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 Department for Environment, Food and Rural Affairs (DEFRA) guidelines in evaluations for electricity emission sources(Department for Environment, Food and Rural Affairs, 2009). Table 3 shows the Carbon Footprint Analytical Framework for FUNAAB.

**Table 3: FUNAAB's Carbon Footprint Analytical Framework**

| Transportation Emissions | Campus Energy Emissions |
|---|---|
| ROAD | ELECTRICITY (PHCN) |
| Student & Staff Commuting | GENERATORS (FUELS) |
| ▪ Mancot buses<br>▪ Private transport<br>▪ Public transport | • Petrol, Diesel<br>▪ University generators(Diesel/petrol)<br>▪ GSM operators generators(Diesel)<br>▪ Small Business operators generators (private-Petrol) |

### 3.1.1 Electricity

FUNAAB gets electricity from two major sources: the purchased electricity from the public utility company (PHCN) and electricity from emergency generators located at strategic places and the power house 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 also considered. Data for the fuel consumption was also provided by the Works and Services Department, Mechanical Department of the University. 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 fuel consumed as provided by the operators on a monthly basis.

### 3.1.3 Private Small Business Operators Generators

These generators are privately owned by individuals that have business ventures within the University. 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 also emissions 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

Data on fuel consumption (diesel) quantity of the Mancot buses fleet owned by FUNAAB was obtained for August, 2011 – July, 2012. GHG emission factors were then used to determine the resulting carbon emissions (World Resources Institute GHG Calculation Tools for Determining Emission Sources, 2012).

### 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. A total number of the vehicles were provided by the Works and Services Department. Using the GHG emission factor, the amount of $CO_2$ released could therefore be calculated.

## 4.0 RESULTS AND DISCUSSIONS

### 4.1 Campus Energy Emissions

### 4.1.1 FUNAAB Generators

Figure 3 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 generatorcontributing 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.

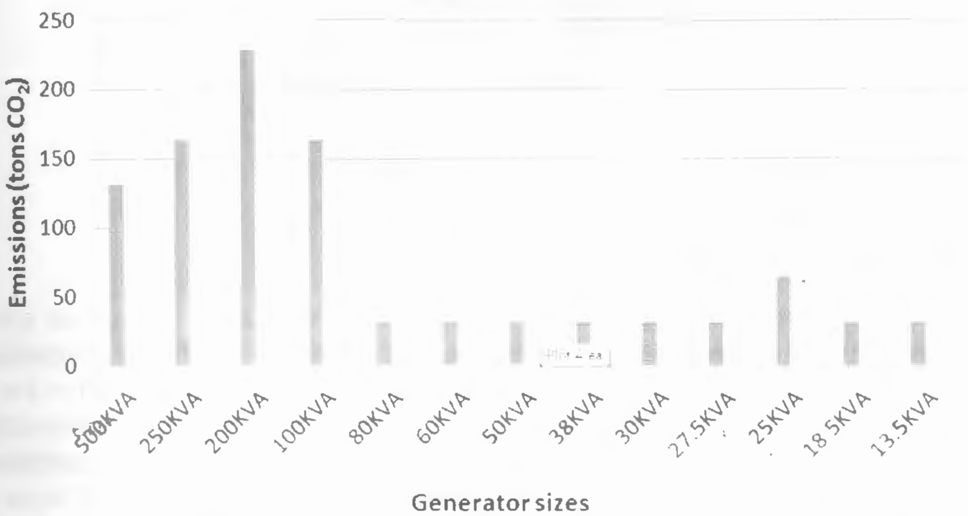


**Figure 3: Distribution of $CO_2$emissions from the generators owned by FUNAAB**

### 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 estimated145.8 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, a total of 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 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.

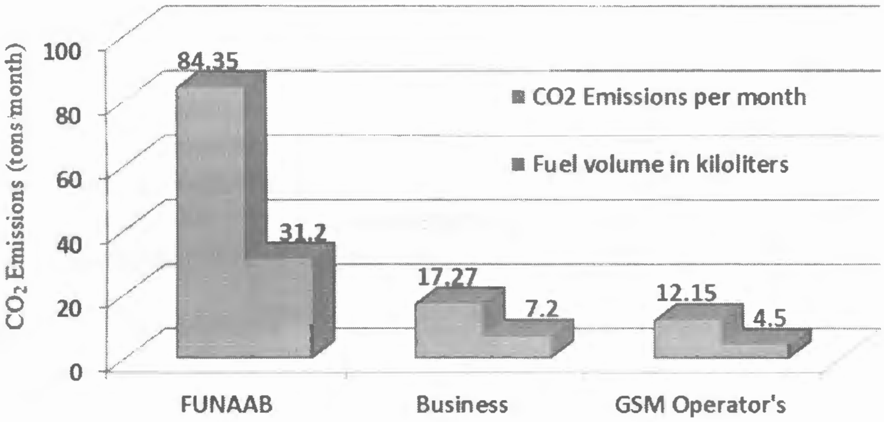


*Figure 4: Distribution of generator emissions in FUNAAB*

### 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 totally dependent on season which accounts for the rate of grass growth in the University. The tractors and lawn mowers are less operational 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 5 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.

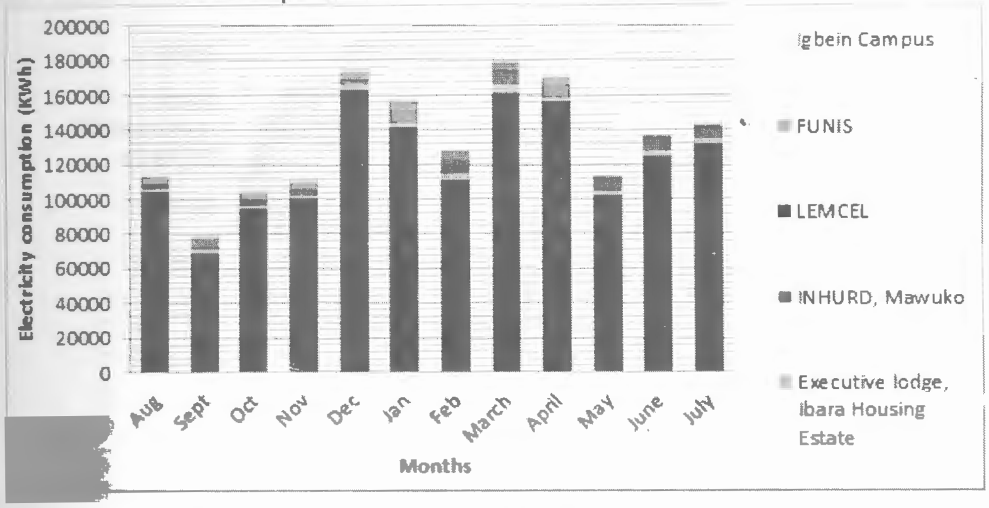


**Figure 5:Trend of electricity consumption of FUNAAB**

Figure 6 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 INHURD, while the Executive lodge,FUNIS, LEMCEL and Igbein Campus contributed the rest.

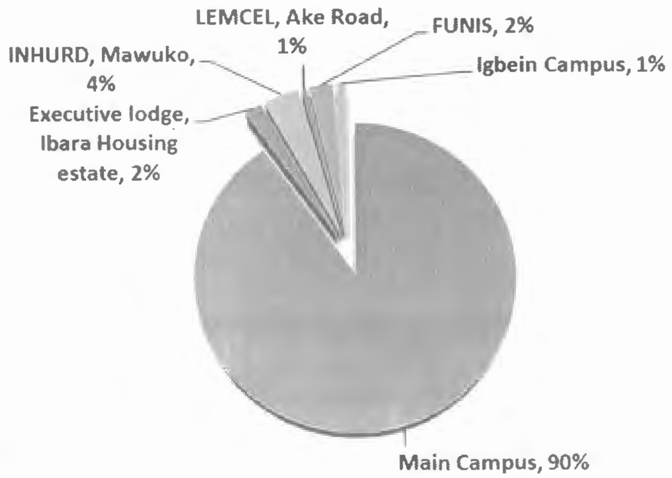


***Figure 6: Distribution of carbon emissions from electricity usage at FUNAAB***

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 communitydrives to campus daily and 26% use the public transport.

Figure 7 shows the distribution of major modes of transport used daily for commuting to and from the University campus.Figure 6 gives the carbon emission due to daily commuting by the various transportation modes. The total emissions resulting from the commuting o 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 transpo (buses and taxis) making up for the rest.

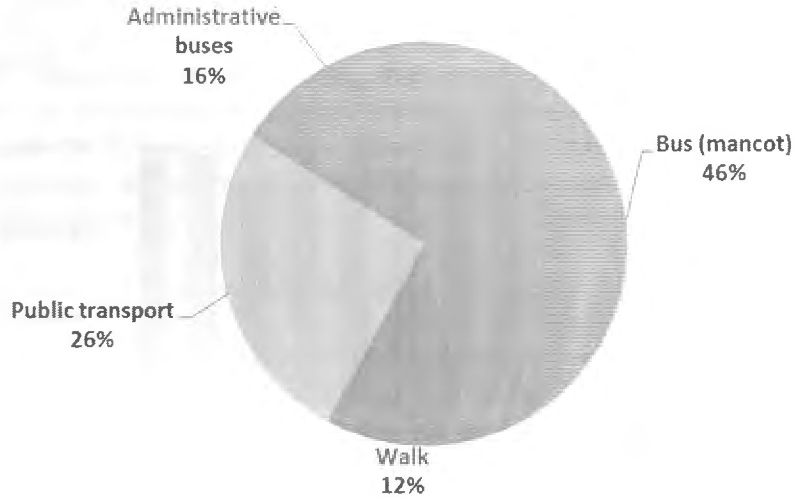


*Figure 7: Distribution of daily commuting modes by students and staff*

The FUNAAB owned vehicles were found to contribute a total of 2,738.5 tons of $CO_2$ to th University's emissions. The total petrol and diesel consumed by the University amounts t about 1,563 tons of $CO_2$ or 74% and 544 tons of $CO_2$ or 26% respectively as shown in Figu 8.

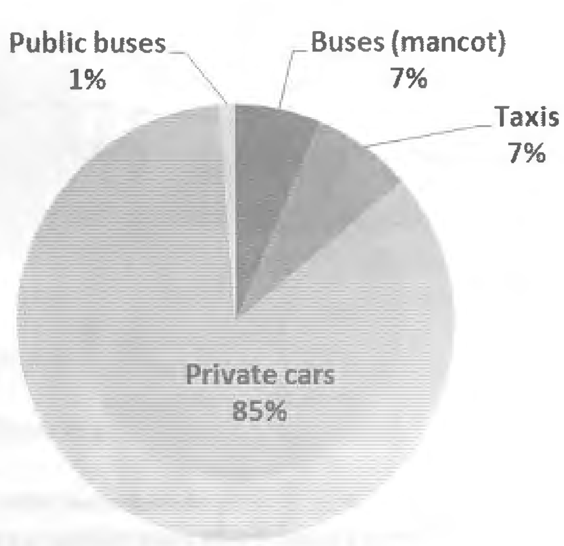


**Figure 8:Distribution of carbon emissions due to daily commuting to the university**

## *4.0 TOTAL CARBON FOOTPRINT FOR FUNAAB*

Table 3 shows the total carbon footprint of the Federal University of Agriculture Abeokuta f the year 2011/2012. University activities for the year of 2011/2012 led to the release of ab

5,935 tons of $CO_2$emissions into the atmosphere, with about 55% of those emissions coming from staff and student commuting alone (Figure 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.

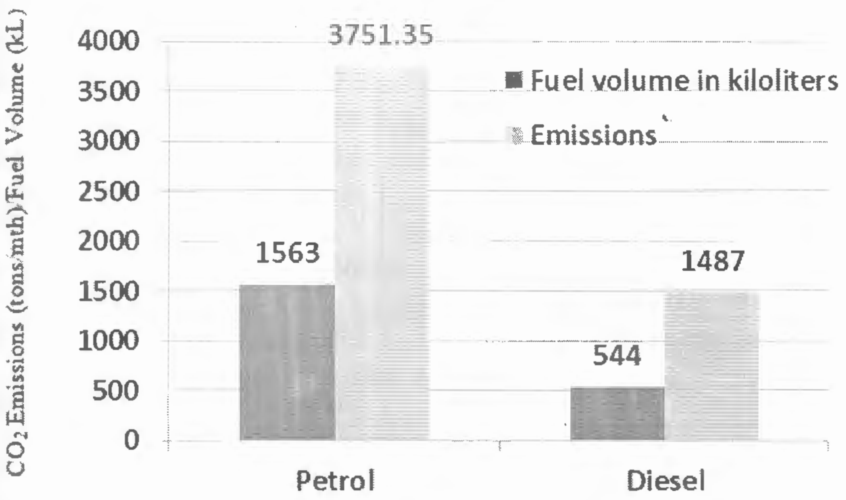


**Figure 9: Fuel quantities and resulting emissions from the university's combustion activities for the year 2011/2012**

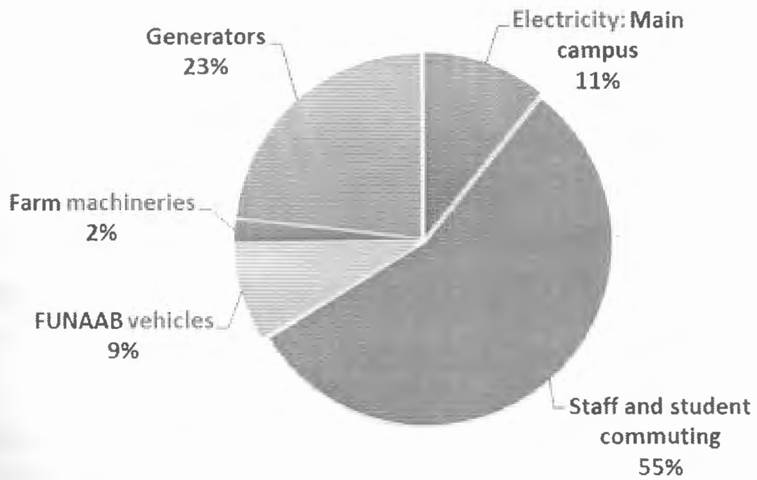


**Figure 10:Overall funaab$CO_2$emissions**

Figure 10 is an overview of the carbon footprint of the Federal University of Agriculture Abeokuta highlighting only the most significant contributors (greater than 1% contributions).In Figure 11, 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%.

Table 4: FUNAAB's Carbon Emissions for the Year 2011/2012

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

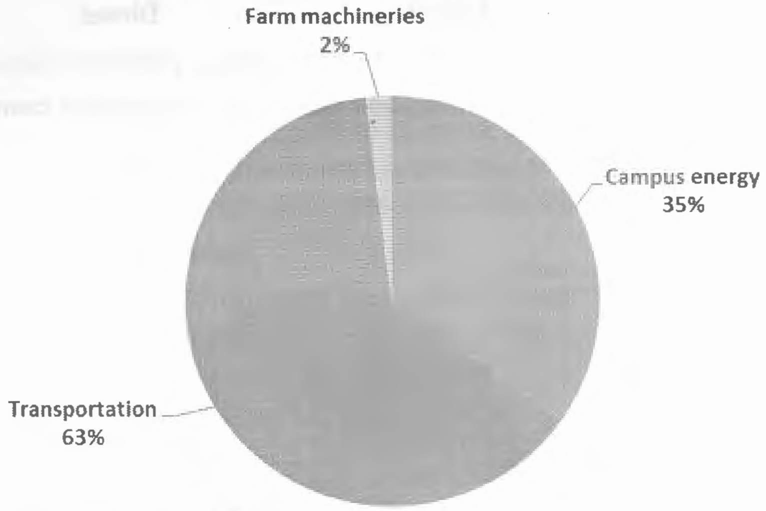


***Figure 11: Distribution of FUNAAB's carbon footprint by emission category***

## 5.0 CONCLUSION AND RECOMMENDATIONS

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

Staff and student commuting to and fromFUNAAB campus is the largest sole contributor t the University's carbon footprint. In the estimated year, about 55% of FUNAAB's carbo footprint resulted from staff and student commuting.

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) contribute 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 hence reducing the number of cars that commute to the University.

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 favour 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 endeavour 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 (Woodland Trust, 2005)

## REFERENCES


1. BSI, (2008), *PAS 2050:2008. Specification for the assessment of the life cycle greenhouse gas emissions of goods and services.*

2. Carbon Trust & Crown, (2008), *Guide to PAS 2050. How to assess the carbon footprint of goods and services*

3. Carbon Trust (2007), *Carbon Footprint Measurement Methodology, Version 1.1".*

4. D. Pandey, M. Agrawal, J.S. Pandey (2011), *Carbon footprint: current methods of estimation*, Environmental Monitoring and Assessment, Vol. 178, No. 1-4

5. DEFRA, (2009), 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. Version 2.0.London, UK, Department for Environment, Food and Rural Affairs.

6. ETAP, (2007), *The Carbon Trust Helps UK Businesses Reduce their Environmental Impact*

7. Hall, M. and N. Murray, (2008), "Green Campus Policy Framework for the University of Cape Town".University of Cape Town, Cape Town.

8. IPCC, (2006), 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change,

H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds.). Hayama, Kanagawa, Japan.

9. ISO (2006), *Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*

10. Rippon, S., (2008), Green Campus Action Plan.University of Cape Town, Cape Town.

11. S. Putt delPino, P. Bhatia, (2002), *Working 9 to 5 on Climate Change: An Office Guide*, World Resources Institute

12. S. Schaltegger& R. Burritt, (2000), *Contemporary Environmental Accounting*, Greenleaf Publishing, ISBN: 1874719349

13. T. Wiedmann, J. Minx, (2007), *A Definition of 'Carbon Footprint'*,

14. Woodland Trust (2005) Position statement on climate change www.woodlandtrust.org.uk/campaigns

15. World Business Council for Sustainable Development (WBCSD) & World Resources Institute (WRI), 2003, *The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard*

16. World Resources Institute(WRI)/World Business Council(WBC) for Sustainable Development The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. March 2004 http://www.ghgprotocol.org/files/ghgp/public/ghg-protocol-revised.pdf.