MAURITIUS RESEARCH COUNCIL

DEVELOPMENT OF A CARBON MANAGEMENT FRAMEWORK FOR THE TERTIARY EDUCATON SECTOR IN MAURITIUS

Final Report

April 2015

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Development of a Carbon Management Framework for the Tertiary Education Sector in Mauritius:

Carbon Footprint Measurement and Employee Sensitization

Final Report

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Executive Summary

Being a Small Island Developing State (SIDS), Mauritius is not invulnerable to the adverse effects of climate change on its natural flora and fauna. In recent years, several environmental indicators have revealed the detrimental changes brought by climate invariability to the island, such as increase in sea level and average temperature. These environmental changes, which are expected to worsen in the decades to come, are the outcomes of an increase in greenhouse effect. The enhanced greenhouse effect, which is specifically a rise in concentration of greenhouse gases (carbon dioxide, methane, nitrous oxide, among others) in the atmosphere, is mainly due to some very explicit anthropogenic drivers, namely economic development and population growth. Through increasing personal energy usage and other factors, human beings are tremendously contributing to the greenhouse effect, and primarily to the growth of carbon dioxide emission.

In order to alleviate the adverse effects of climate change, different key stakeholders including tertiary education institutions are actively researching into this growing concern so as to bring effective solutions. Presently, one particular tool known as carbon footprint calculator, is available to help in measuring an individual's annual carbon emission, and consequently help in keeping track and reducing the amount of carbon emitted through daily activities. Prior research has indicated that the measurement of individual carbon emissions helps people to be more environmentally conscious of their actions and to adopt a low-carbon lifestyle. Furthermore, even though the tertiary education sector is a key player for inculcating environmentally sustainable practices among its human resources along with promulgating carbon mitigation awareness to other stakeholders and sectors of the island, there exists no carbon management framework being adopted by employees of the same sector. There is also no indication whether such tool is being used by employees so as to reduce their carbon emissions to promote a greener Mauritius. As such, this research project aims to develop a carbon management framework to assess, reduce and sensitize employees within tertiary education institutions in Mauritius, after measuring their carbon emissions via the use of existing calculators.

To meet the aim of the project, 440 employees within different tertiary education institutions in Mauritius were sensitised on how to reduce their personal carbon emissions via the use of flyers. Furthermore, the carbon footprint data of the same participating employees was collected in order to create a baseline for employee carbon emission in the tertiary education sector. Based on results obtained, the carbon management framework was created.

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List of Acronyms

Acronym	Description
MMS	Mauritius Meteorological Services
SIDS	Small Island Developing State
GHG	Greenhouse Gases
ICT	Information and Communication Technology
WMO	World Meteorological Organization
CO_2	Carbon Dioxide
LPG	Liquefied Petroleum Gas
CF	Carbon Footprint
NASA	National Aeronautics and Space Administration
GWP	Global Warming Potential
NEPAD	New Partnership for Africa's Development
WAMU	West Africa Monetary Union
CDM	Clean Development Mechanism
MSI	Mauritius Strategy of Implementation
BPOA	Barbados Programme Of Action
TEI	Tertiary Education Institution

Chapter 1 - Introduction

1.1 Project Overview

During the last few decades, the Republic of Mauritius has been largely affected by the adverse effects of climate change. According to the Mauritius Meteorological Services (MMS), Mauritius and its surrounding islands have experienced a rise in temperature in recent years, along with noticeable changes in the seasonal periods of the island (Mauritius Meteorological Services, 2014). Being a Small Island Developing State (SIDS), Mauritius is more susceptible to the impacts of climate change, which are expected to intensify globally in the decades to come (Ministry of Environment and Sustainable Development, 2013). Various studies have attributed the excessive release of greenhouse gases (GHG) in the atmosphere as the main factor to cause unprecedented climate change and global warming on planet Earth (IPCC, 2007; Karl & Trenberth, 2008). The greenhouse gases are vital in keeping the climate on the planet stable, but an excessive amount of their presence in the atmosphere is leading to the warming up of the temperature on Earth. The GHG traps the radiating heat in the atmosphere and this heat warms the environment, hence increasing the global temperature. The main gases that are responsible for the greenhouse effect include carbon dioxide, methane, nitrous oxide and halocarbons. Among those gases, carbon dioxide (CO_2) is considered to be the most significant one due to its largest composition in the atmosphere.

Different studies have shown that the increase in greenhouse effect, known as “enhanced greenhouse effect”, is the result of increased destructive human activities (Jain, 1993). Since the beginning of the Industrial Revolution and urban development, human beings have caused an increase in CO_2 emission through the burning of fossil fuels such as coal or petroleum and deforestation (IPCC, 2007). Those two main causes are further enhanced at the personal individual levels. People continue to contribute to the growing carbon dioxide emission in their daily life in various ways (Padgett, 2008; Roy & Pal, 2009). The first one is their household energy use (Munksgaard, et al., 2000). The amount and type of non-renewable energy sources an individual consumes cause a certain amount of carbon to be released in the atmosphere. Similarly, their modes of travel and frequency of both local and international trips have a major contribution (Chapman, 2007; Rothengatter, 2010). Likewise, the type of diet of an individual, whether vegetarian, organic or seasonal, also affects the amount of carbon dioxide released due to their production and transport processes in industries (Berners-Lee, et al., 2012). Additionally, various other activities also add to the total carbon emission, such as frequency of waste recycling, purchase of electronic products or use of imported goods, among others (Claudio, 2007). This highlights that human beings are contributing to the increase of GHG emissions in their daily activities. As such, there is a need to adopt proper mitigation techniques to manage and reduce the emission of carbon dioxide at the individual level and create awareness so that people can opt for a greener lifestyle.

Innovations have been brought in on how to manage carbon dioxide emissions on different levels so as to focus on accurate measurements of carbon emissions. In order to track and measure the amount of CO_2 being released, the technique known as carbon footprint was introduced. Carbon footprint is the process of quantifying the whole amount of carbon emissions that are caused by various activities, e.g. global business or human activity, over an accumulated period of time. The calculated carbon emissions can be used as a reference point for emission tracking. With the help of Information and Communication Technology (ICT), online tools have been created to simplify the calculation process. Those online tools, known as carbon footprint calculators, enable businesses and individuals to calculate and track their carbon emissions for a specific period of time.

Furthermore, as tertiary education institutions have been recognised as a key stakeholder for promoting research on environmental sustainability, there has been minimal focus on the human perspectives to carbon emissions within such institutions. In Mauritius, there is no indication on whether employees within the sector are aware of carbon mitigation practices. Furthermore, there is no indication whether innovative tools in the form of carbon footprint calculators are being used by the same employees within the tertiary education sector in Mauritius so as to reduce their carbon emissions to promote a greener island. Also, there exists no carbon management framework being adopted by employees of the same sector to reduce their carbon emissions.

1.2 Project Aim and Objectives

The aim of this research project is to develop a carbon management framework to assess, reduce and sensitize employees within tertiary education institutions in Mauritius, after measuring their carbon emissions. This innovative framework can be a potential solution to alleviate climate change impacts and also helping towards a greener Mauritius. The set of objectives of the project are as follows:

- Establish a taxonomy for carbon emission management within tertiary education institutions in Mauritius,
- Measure the carbon emissions of employees within the tertiary education sector,

- Setup of awareness campaigns for carbon footprint calculation and tracking among employees,
- Establish a baseline for employee carbon emission within the tertiary education sector, with an insight for a future green ICT policy within the tertiary education sector.

1.3 Project Scope

This research project focuses on the human factor pertaining to carbon footprint management and is meant for employees in the tertiary education sector. Carbon footprint data based on key categories of human carbon emissions is expected to be collected after a taxonomical study. During the data collection process, employees within the tertiary education sector will also be sensitized on the best practises in reducing carbon emissions. The collected data will then be used to formulate the carbon management framework

1.4 Summary of Research Questions

In order to fulfil the aim and objectives of this research project, focus was on the following:

RQ 1: Which activities, based on the taxonomy being studied, have the greatest contribution to the overall carbon footprint of an individual?

RQ 2: Are employees of tertiary education institutions aware of the growing carbon emissions problems?

RQ 3: Are employees measuring their carbon footprint and keeping track of it?

RQ 4: What is the baseline for employee carbon emission within the tertiary education sector?

RQ 5: What is the average carbon footprint of employees within the tertiary education sector in Mauritius and how is this value different from the per capita carbon footprint?

RQ 6: What are the motivations and barriers involved in the reduction of individual carbon emissions?

RQ 7: Are the employees aware of the key practices of how to reduce their carbon footprint emissions?

1.5 Chapter Summary

The research report started with an insight on the project to be developed, the aim and objectives to meet and the different research questions to be tackled. The following is a summary of the different chapters in the report:

Chapter 2: The chapter discusses the impacts of global warming in Mauritius and the need for an accurate carbon measurement technique in order to mitigate the associated effects. Firstly, a detailed analysis of climate change and its impacts around the world and in Mauritius was conducted. This was followed by a review of the key contributors of climate variability, mainly the increasing presence of greenhouse gases in the atmosphere, in addition to the role of human activities in this. The human contribution to climate change was then critically reviewed from the use of energy sources of an individual. The best practices towards a more eco-friendly lifestyle were investigated and these best practices were used for creating the flyer design in the second phase of the project. As per the first objective of this project, the taxonomy for the personal carbon footprint analysis was prepared based on the different factors contributing to the carbon emission of a person. This categorisation is expected to help towards the carbon management framework development.

Chapter 3: In chapter 3, the anthropogenic emissions of carbon dioxide were further investigated and the different key stakeholders were identified. An analysis was made on how the different key stake holders, from international organisations to tertiary education institutions, were working towards a more effective carbon mitigation system. Two existing frameworks in the tertiary education sector were studied and the need for the development of a carbon management framework was identified.

Chapter 4: The approach to calculate the carbon emission from an individual was delved into and a critical review of the carbon footprint calculators that could be used in this project was done, where two free online calculators were then selected. The literature review in the first phase of the project helped to gather details to be used in the creation of the flyer for sensitizing employees within targeted tertiary education institutions on the rising carbon emissions due to human activity and the different measures to adopt in order to mitigate carbon emission. Since the aim of the flyer concept was to raise awareness towards a greener lifestyle, a list of different best practices was described to help individuals reduce carbon emission in their daily personal activities. A compressed version of the flyer is attached in Appendix A, to also indicate the completion of the third objective of this project. The technique used for data collection that is, the survey, was also discussed.

Chapter 5: The survey form was prepared for data collection (see Appendix B). The main aim of this survey was to obtain the data, in order to measure the carbon emissions of employees (as per Objective 2). The first part of the survey form focused on general questions related to carbon footprint awareness, the different motivations and barriers towards carbon footprint calculation. The survey form was also divided into four main categories outlined in the taxonomy section of the report (household energy use, travel, diet and lifestyle choices). Each category consisted of a series of questions to obtain enough data for the carbon footprint calculation of employees. A list of ten major tertiary education institutions in Mauritius was prepared to conduct the survey. The sample size in the different institutions was determined and the survey was conducted. The various challenges faced during the survey were outlined in the last part of the chapter.

Chapter 6: Data obtained from the survey forms were processed and analysed using SPSS software. The findings obtained were discussed based on the initial research questions found during literature review. The results obtained were graphically represented and analysed. As per the last objective of the research project, a baseline was developed for employees in the Tertiary Education Sector. In the last section of the chapter, a path analysis was developed for the two carbon footprint calculators used so as to quantitatively demonstrate and compare the carbon footprint results of the employees. The path analysis also helped in better understanding how much the different activities in the life of an individual contribute to the carbon emission.

Chapter 7: In the final chapter, a summary of the research findings was made. The proposed carbon management framework for the tertiary education sector was given, along with a discussion on how to implement the framework for employees of tertiary institutions. The chapter ends with a discussion of future works which can be realized based on the findings of this research study.

Chapter 2 - Climate Change and the Human Factor

2.1 The Growing Climate Change Concerns

Climate change was just a speculation until the last decades of the 20th century, but presently, concerns over climate change have risen due to its disruptive and detrimental effects experienced across the globe. Climate change is an alteration in the state of the climate which persists over an extended period, as a result of natural variability or human activity (IPCC, 2007). The statement of the World Meteorological Organisation (2014) on the status of global climate has confirmed that the consequences of climate variability have continued to be felt throughout the year 2014. Melting ice, frequent floods and droughts, disappearing of polar bears and large wildfires are some of the consequences. The unpredictability of the climate has affected the entire planet, with each particular region facing extreme weather conditions and damages to its social and economic development (Global Environment Outlook, 2012).

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and the European Environment Agency report on Climate Change, Impacts and Vulnerability in Europe showed that the European continent has experienced various climatic changes in the form of heat waves, floods, droughts and erosions from storms, as well as economic losses due to accelerating sea-level rise, reduction in crop productivity and extensive species losses (Niang & Ruppel, 2014; European Environment Agency, 2012). Similarly, the IPCC report for the North American region indicated shrinkage of snowpack in the western mountains and an increased frequency, duration and intensity of heat waves in cities (Niang & Ruppel, 2014). The Latin America region has been experiencing a gradual replacement of its tropical forest by savannah, a risk of significant biodiversity loss through species extinction in tropical areas and major water availability changes for human consumption, agriculture and energy generation (Grimm, et al., 2000). Likewise, fresh water availability was projected to decrease by 2050 in Central, South, East and South-East Asia. The coastal areas were considered to be at risk of frequent flooding and the death rate is expected to rise in some regions due to diseases associated with droughts and floods. Moreover, the same report states that climate change in the Asian continent will compound the pressures on the natural resources and environment due to rapid urbanization, industrialisation and economic development (World Bank Group, 2006).

Among all the continents, the one which is known to be the most vulnerable is Africa (Collier et al., 2008). This continent has experienced a historical climate warming of 0.5°C over most of the continent and decreased rainfall in the Saharan regions (Niang & Ruppel, 2014). This warming trend is expected to increase the sea level and cause extreme weather conditions in the African region. By 2020, yields from rain-fed agriculture could be reduced by up to 50%, hence severely compromising the agricultural production. Africa would be subject to both human and bird migration on a seasonal basis, due to lack of rainfall (Desanker, 2010).

Being part of Africa, Mauritius as well has experienced the impacts of climate change on its local natural and ecological system. Analysis of temperature recorded in Mauritius and its outer islands showed a positive warming trend. The average temperature has risen at the rate of 0.15°C per decade across Mauritius and its surrounding islands (Mauritius Meteorological Services, 2014). Data from the Ministry of Environment and Sustainable Development (2014) has shown that there is a decreasing trend in the annual rainfall and there is an increase in extreme weather events such as flash floods, droughts and frequency of storms. The rise in sea level can result in coastal inundation for Mauritius, thus causing coastal infrastructure damage and decrease in marine resources (Mauritius Meteorological Services, 2014).

There are various other indicators which show clearly that Mauritius is also facing the impacts of climate change. The Ministry of Environment and Sustainable Development (2014) has detailed out the changes, as shown below:

- Between 1998 & 2007, the local mean sea level rose by 2.1mm per year and over the last 5 years (2009 – 2014), sea level has been rising by around 3.8 mm/year.
- Decreasing trend in annual rainfall of around 8% over Mauritius since the 1950s.
- Average temperature has risen by 0.74^{0}C when compared to the 1961-90 mean.
- An increase in the annual number of hot days and warm nights.
- Flash flood in 2008 and 2013 resulting in loss of lives.
- Worst drought experienced in 1999 and 2011.
- Increase in the frequency of extreme weather events, heavy rains and storms.

The consequences of climate variability felt across the globe, including Mauritius, are proofs that climate change is not a myth and it is currently affecting the world environment and population in, often, drastic ways. These environmental changes are the results of some specific ever-increasing drivers, such as population growth and economic development, and an understanding of them will lead to possible solutions to adapt and even reduce, the impacts of climate change (Global Environment Outlook, 2012).

2.2 Key Contributors to Climate Change

The main effect of climate change, which in turn leads to other consequences, is the rise in global air and ocean temperatures (IPCC, 2007). The years 2007 and 2013, have been recorded as the sixth warmest years since 1850 (World Meteorological Organization, 2014). Since the 19th century, a rise in the mean global temperature of 0.70^0C has been recorded (Frich, et al., 2002; IPCC, 2007). This shows a warming trend globally, an effect mainly referred to as “global warming”. Figure 2.1 shows the increase in global average temperature noted by three independent analyses namely, Met Office Hadley Centre and Climatic Research Unit, NOAA National Climatic Data Centre and NASA Goddard Institute for Space Studies (World Meteorological Organization, 2014). The global temperature continues to show an increasing tendency after the year 2000, which implies that, the causes of global warming are on the rise.

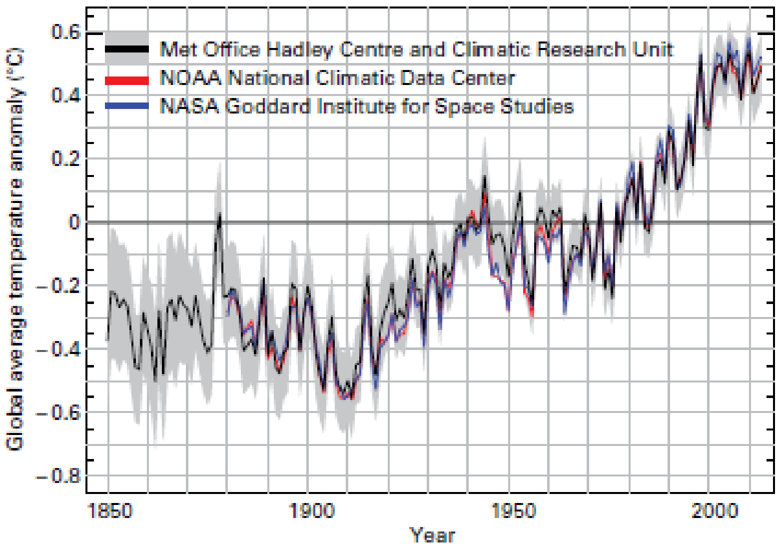

Figure 2.1: Global Average Temperature Anomaly
(Source: World Meteorological Organisation, 2014)

This warming of the planet is caused by the growing global emissions of greenhouse gases (GHG) (IPCC, 2007). The GHGs constitute of different atmospheric gases: 60% water vapour, 25% carbon dioxide (CO_2), 8% ozone and the rest are trace gases such as methane and nitrous oxide as shown in Figure 2.2 (Karl & Trenberth, 2008).

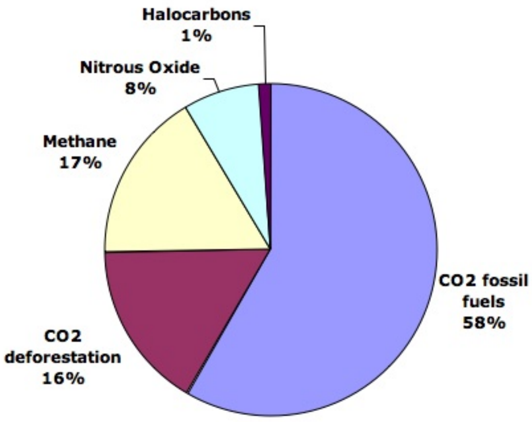

Figure 2.2: Composition of Greenhouse Gases
(Source: IPCC 2007)

GHGs absorb and emit thermal radiation from the Sun and hence contribute to the process known as the greenhouse effect, as shown in Figure 2.3. Basically, the greenhouse effect is the natural process by which the atmosphere traps some of the Sun's energy, warming the Earth enough to support life.

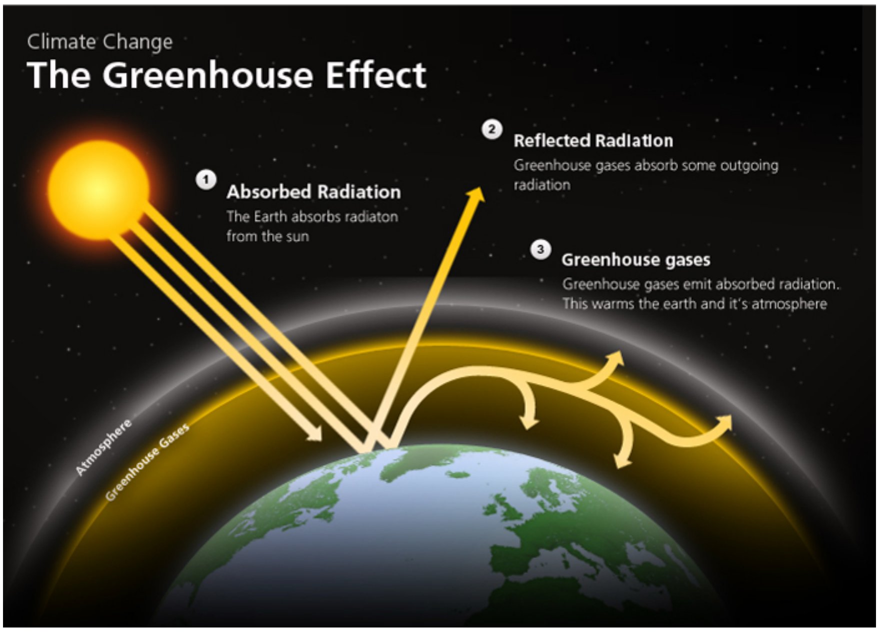

Figure 2.3: Earth Atmosphere is similar to a Greenhouse
(Source: EDF Energy, 2014[1])

But since 1750, the concentration of GHGs in the atmosphere has increased and is now greater than in the pre-Industrial period (CSIRO, 2014). The concentration of carbon dioxide has increased by 37%, methane by 150% and nitrous oxide by 18% (CSIRO, 2014). The following table shows the

[1] EDF Energy, 2014. Climate Change: The Greenhouse Effect. [Online] (1) Available at: http://www.edfenergy.com/energyfuture/energy-gap-climate-change/greenhouse-effect [Accessed 15 June 2014].

increase in the atmospheric GHG concentrations since the year 2005 (Global Environment Outlook, 2012):

	2005	2009	2010
CO_2 (ppm)	378.7	386.3	388.5
CH_4 (ppb)	1 774.5	1 794.2	1 799.1
N_2O (ppb)	319.2	322.5	323.1
CFC-11 (ppt)	251.5	243.1	240.5
CFC-12 (ppt)	541.5	532.6	530.8
HCFC-22 (ppt)	168.3	198.4	206.2
HFC-134a (ppt)	34.4	52.4	57.8

Table 2.1: Concentration of Atmospheric GHGs
(Source: Global Environment Outlook, 2012)

This increase in concentrations is due to the fact that the GHGs have long atmospheric lifetimes and hence accumulate in the atmosphere, causing an 'enhanced greenhouse effect' (Karl & Trenberth, 2008). Carbon dioxide is the most important anthropogenic greenhouse gas due to its largest contribution to global warming (Jain, 1993). According to the IPCC Fourth Assessment report, the average concentration of carbon dioxide in the atmosphere was 278 ppm before the industrial revolution with variations of not more than 7 ppm from the year 1000 to 1800 (IPCC, 2007). Concentrations have increased in past decades at an accelerating pace, at approximately 2 ppm per year in the last decade and reached almost 393.1±0.1 ppm in the year 2012 (World Meteorological Organisation; Global Atmosphere Watch, 2013). The following graph (figure 2.4) shows the trend in carbon dioxide concentration since the year 1850 and upwards (Global Environment Outlook, 2012):

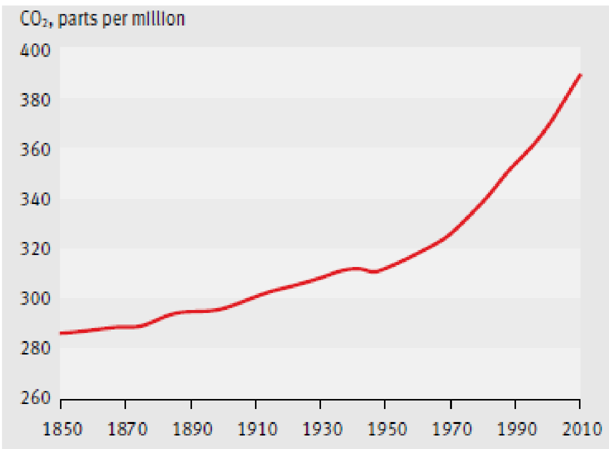

Figure 2.4: Carbon Dioxide Concentration
(Source: Scripps Institute of Oceanography, NOAA, 2012)

This research is focused on the emission of carbon dioxide solely, and thus the other greenhouse gases will be referred to as their CO_2 equivalent, which is derived from their Global Warming Potential (GWP), as displayed in the table below:

	Greenhouse Gas	Global Warming Potential (GWP)
1.	Carbon dioxide (CO_2)	1
2.	Methane (CH_4)	25
3.	Nitrous oxide(N_2O)	298
4.	Hydrofluorocarbons (HFCs)	124 – 14,800
5.	Perfluorocarbons (PFCs)	7,390 – 12,200
6.	Sulfur hexafluoride (SF_6)	22,800
7.	Nitrogen trifluoride (NF_3)[3]	17,200

Table 2.2: GHG Global Warming Potential
(Source: Greenhouse Gas Protocol[2])

The Global Warming Potential (GWP) is an index which indicates the period of time a gas causes warming. CO_2 has an index of 1, and thus, the other GHGs equivalent are obtained by multiplying their GWP with the carbon equivalent, which is 1 (Brander, 2012). The increasing rate of CO_2 concentration is largely due to human activities which have grown since the Industrial times, with an intensification of 70% between 1970 and 2004 (IPCC, 2007). As such, it becomes important to perform an in-depth study of human contribution to the growing carbon emissions.

2.3 Human Contribution to Carbon Emissions

Human activities are among the key contributors to climate change since most of the warming of the climate is the result of anthropogenic emission of greenhouse gases. The largest growth of GHG emission has come from energy supply, transport and industry and then, in a smaller amount, from residential and commercial buildings, deforestation and agricultural sectors (IPCC, 2007). Figure 2.5 shows the global anthropogenic GHG emissions among the different sectors for the year 2004:

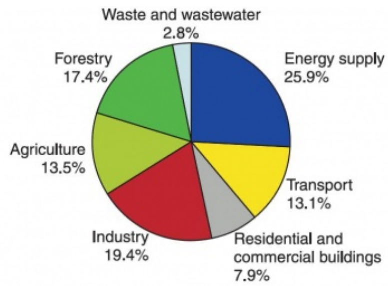

Figure 2.5: Anthropogenic GHG emissions in Different Sectors
(Source: IPCC, 2007)

[2] Brander, M., 2012. *Greenhouse Gases, CO2, CO2e, and Carbon: What Do All These Terms Mean?* Ecometrica.

Through deforestation and over-cultivation, human activities augment the greenhouse effect by permitting the soils to be more exposed to erosion and nutrient leaching. Deforestation also results in less carbon dioxide conversion to oxygen because of fewer trees (Cramer, et al., 2004). The human use of fossil fuels is another driver of global warming as well (Hook & XuTang, 2013). By driving cars, using electricity from coal-fired power plants, or heating homes with oil or natural gas, human beings release carbon dioxide and other heat-trapping gases into the atmosphere (IPCC, 2007).

Similar to the global trend, uncontrolled GHG gases, mainly carbon dioxide, are responsible for the impacts of climate change in Mauritius (Mauritius Meteorological Services, 2014). Figure 2.6 shows the carbon dioxide emissions associated with fossil fuel combustion in different sectors in the year 2012 for Mauritius.

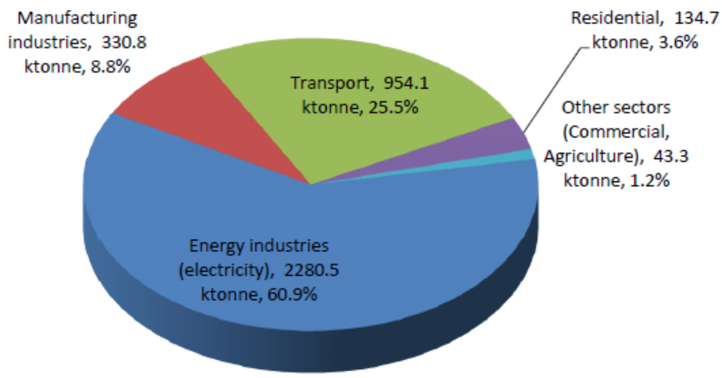

Figure 2.6: Carbon Dioxide Emissions Associated with Fossil Fuel Combustion (Source: Statistics Mauritius, 2013)

As shown in figure 2.6, residential sources account for 3.6% of the total CO_2 emissions and the total emissions from energy use result in more than 80% of CO_2 released in the atmosphere (Ministry of Energy and Public Utilities, 2013). Figure 2.7 and Figure 2.8 show the increase in carbon dioxide (CO_2) emission in the last few decades for Mauritius and the per capita estimates of CO_2.

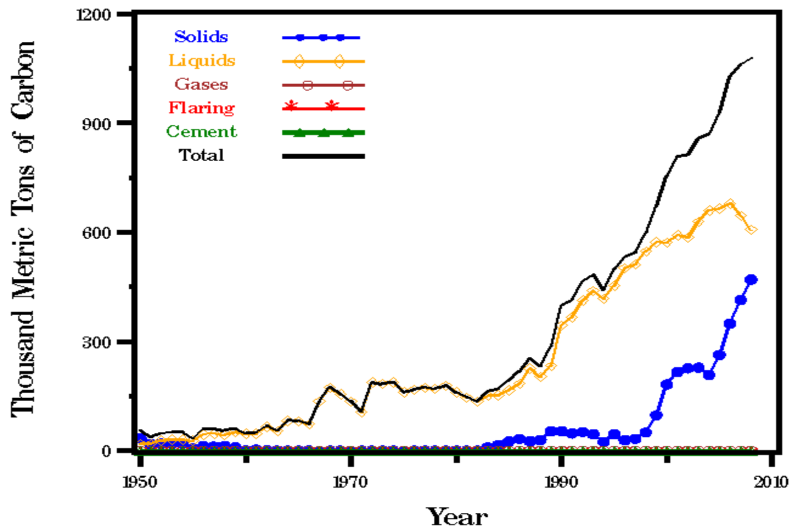

Figure 2.7: Carbon Dioxide Emissions from Mauritius
(Source: Carbon Dioxide Information Analysis Center,2014)

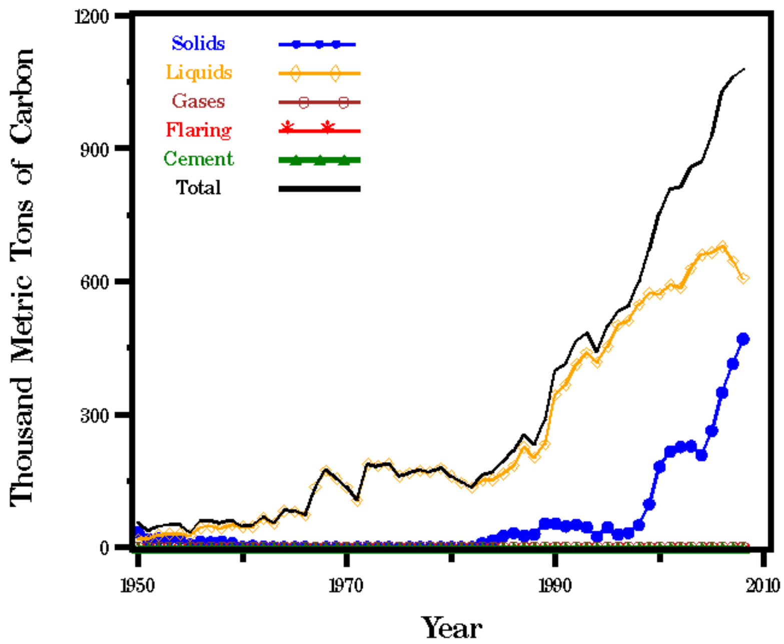

Figure 2.8: Per Capita Carbon Dioxide Emissions from Mauritius
(Source: Carbon Dioxide Information Analysis Center, 2014)

According to McKitrick et al. (2005), the determination of future carbon emission scenarios can be better examined and forecasted by converging more on the per capita carbon emissions than the global carbon emissions. Saifuddin Soz (1997), Union minister for environment and forests of India, supported this tactic at the 1997 Kyoto Conference:

"*Per capita basis is the most important criteria for deciding the rights to environmental space. This is a direct measure of human welfare''* (Soz, 1997).

The global per capita carbon emission rate has been ranging from 0.02 tonnes of CO_2e per person in some African countries to over 5.5 tonnes of CO_2e per person in the United States (McKitrick, et al., 2005). In Mauritius, the total carbon emitted per capita was 3.2 metric tonnes in the year 2010 (The World Bank Group, 2015). This figure is quite high, considering the low population and small demographic of the island, and several drivers can be related to this amount of carbon emission per capita. Since 1968, Mauritius has evolved from a low-income, agriculture-dependent economy to a middle-income diversified economy with increasing financial, industrial and tourist sectors. The Human Development Index for Mauritius for the year 2011 was 0.728, on a scale of 0 to 1 (Commonwealth Secretariat, 2013). This means that the high economic growth rate has contributed to the betterment of the well beings of the local population (Boopen & Vinesh, 2014). According to energy researchers, there is a positive association between better standard of living and higher energy consumption for both household and individuals (Roy & Pal, 2009). As seen previously, the amount of carbon dioxide emission is increasing with a higher demand for energy consumption. Therefore, it is crucial to analyse the way of living of individuals, along with a measure of the different sources of personal carbon emissions, so as to develop effective mitigation strategies for the rising carbon emissions.

2.3.1 Taxonomic Study of Human Contribution to Carbon Emissions

As stated in the previous section, in order to reduce carbon emission associated with human activities, it is important to identify the different specific sources of how the daily activities and lifestyle choices of an individual result in a rise in carbon emission. This is done by conducting a taxonomic study. Taxonomy is predominantly the science of classification according to a pre-determined system, whose resulting list is used to provide a theoretical framework for analysis (Electronic Mapping System, Inc - E-Maps, 2015). It is a better approach to categorise the different aspects of a research project and arrange the concepts to be investigated in a hierarchical way since it provides a basic structure of order in the form of higher-level and lower-level concepts (Bekaroo, et al., 2014).

Four main categories have been identified to be responsible for the individual emission of carbon related gases. The categories are: household energy use, travel, diet and lifestyle factors. These four categories have been derived from how the lifestyle choices affect the energy and material consumption and hence the emission of carbon dioxide (Chapman, 2007; Claudio, 2007; Munksgaard et al., 2000; Rothengatter, 2010; Roy & Pal, 2009; Stehfest et al., 2009). Around 45-55% of the total energy use is influenced by the way the consumers choose to travel, use household energy and other personal services (Schipper, et al., 1989). Furthermore, energy consumption is also affected by the way a household caters for its members, that is, the provision of food, personal care, clothing, leisure, furnishings, entertainment and trips (Michaelis & Lorek, 2004).

These categories are represented in figure 2.9 at a macro-level first and are further broken down to demonstrate all the factors which were investigated.

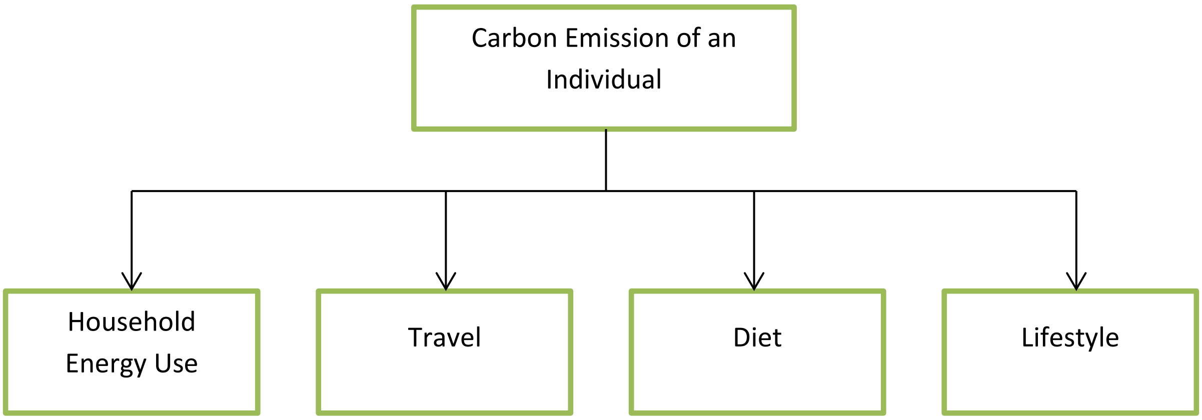

Figure 2.9: Carbon Management Taxonomy for Individuals

Each of the four categories consists of a particular aspect of the daily activities of a person, which results in some direct or indirect forms of carbon emission. Household energy use is the daily energy consumption of an individual from different energy sources. One of the main causes of individual carbon emission is through the use of non-renewable energy sources (Munksgaard, et al., 2000). Travel involves carbon emissions analysis of the modes of transport of the person, along with the frequency of local and international trips. Different vehicles and frequency of travel result in different amount of carbon emitted in the atmosphere. Diet is about carbon emissions through preferred type of food consumption of a person. It was seen in literature that food production and the different processes involved result in different amount of carbon to be released (Stehfest, et al., 2009). Lifestyle involves investigating how the general lifestyle choices, from shopping to recreational activities, affect the carbon footprint of the individual.

2.3.1.1 Household Energy Use

Individuals contribute to the increasing carbon dioxide emission through the private household energy consumption, mainly, gasoline consumption and electricity usage (Glaeser & Kahn, 2008). Energy use is responsible for 70% of the total global greenhouse gases emissions, with power generation and heat supply representing 26% in the year 2004 (K.Mideksa & SteffenKallbekken, 2010). In a typical household, there are two types of carbon emissions, the direct emission and indirect emission. The direct emission is related to the energy consumption of sources like electricity, gas, and other liquefied fuels, whereas the indirect emission involves the usage of products such as furniture, clothes, electronic products and any other products or services manufactured in various industries (Munksgaard, et al., 2000). There are different ways in which electricity and LPG are consumed in an average household, namely for cooking, air conditioning or heating system. Even though cooking does not directly cause climate change, the temperature variation between cold and hot days, which is a consequence of growing GHG emission, increases the demand for cooling and heating systems, hence the increase in electricity use (K.Mideksa & SteffenKallbekken, 2010). The following graph displays the total household energy consumption for the year 2012 in Mauritius:

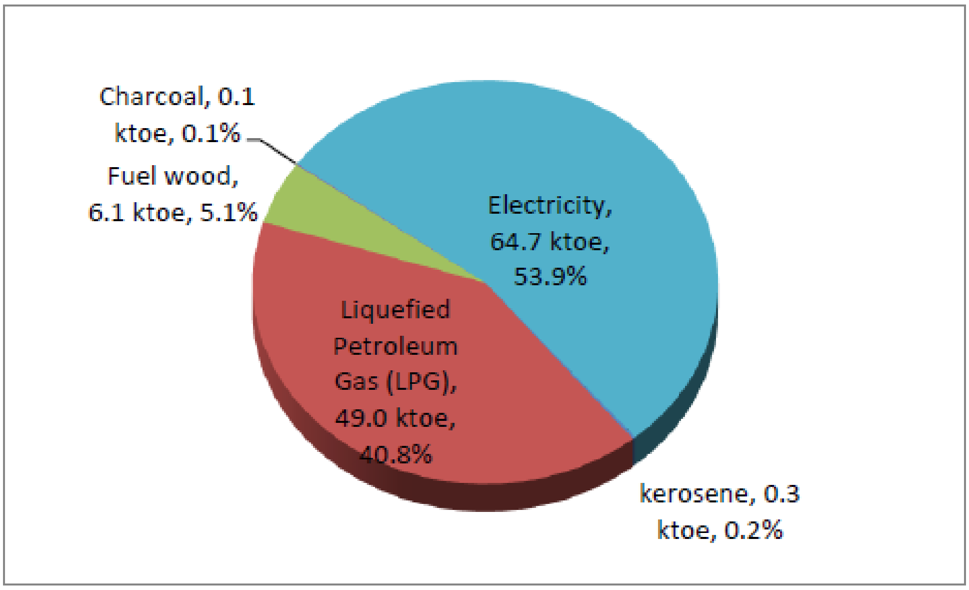

Figure 2.10: Household Energy Consumption in 2012

(Source: Energy Observatory Report, 2012)

The energy consumption for the year 2012 increased by 2.3% in 2012 as compared to the previous year (Ministry of Energy and Public Utilities, 2013). Figure 2.10 indicates that for Mauritius, the main sources of energy for the average household are electricity and Liquefied Petroleum Gas (LPG). An analysis of the domestic electricity usage is given in table 2.3:

Domestic consumers	2008	2009	2010	2011	2012
Consumption (GWh)	652.2	680.1	710.7	725.3	753.0
Number of consumers	350627	358359	364474	372315	381096
Average consumption per consumer (MWh)	1.86	1.90	1.95	1.95	1.98
Growth rate %	-0.7%	2.0%	2.7%	-0.1%	1.4%

Table 2.3: Domestic Electricity Consumption for Mauritius
(Source: Energy Observatory Report, 2012)

Table 2.3 shows there has been an increase in the average consumption per consumer from 1.86MWh in 2008 to 1.98MWh in 2012, meaning the average household electricity use is on the rise and so is the corresponding amount of CO_2 emission. According to the Ministry of Energy and Public Utilities (2013), the total CO_2 emissions from electricity generation amounted to 2 280 500 tonnes in the year 2012 and the average ratio of emissions per kWh consumed by all sources was 815.5 gCO_2/kWh. This shows an increase of 0.9 % compared to 2011, where the average ratio stood at 807.9 gCO_2/kWh. This can be credited to the rise in use of coal for electricity production. In 2012 carbon dioxide emissions have reached 954 100 tonnes of CO_2 representing an increase of 3.5% compared to 2011 in Mauritius (Ministry of Energy and Public Utilities, 2013).

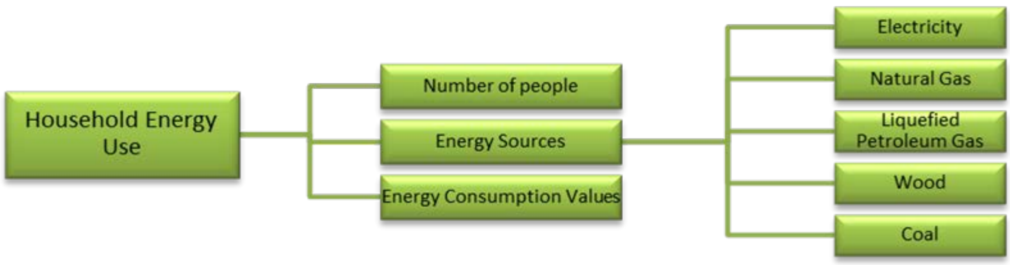

Figure 2.11: Household Energy Use Sub-categories

Figure 2.11 shows the sub-categories of the household energy use category. The total number of persons sharing the house needs to be specified in order to calculate personal household carbon footprint of an individual. The final result for energy consumption is divided by the number of persons to give an individual end result. The type of energy sources (electricity, natural gas, coal, heating oil, Liquefied Petroleum Gas (LPG), propane and wood) need to be specified, along with their monthly consumption in kWh. The resulting total energy consumption in then given in tonnes of carbon dioxide.

2.3.1.2 Travel

The second source of individual carbon dioxide emission is through transport. For the year 2003, transport was responsible for 24% of the world-wide production of CO_2, with road transport accounting for 18% to 23% of CO_2 emissions and aviation around 2% to 3% (Rothengatter, 2010). In Mauritius, the CO_2 emission has increased by 0.6%, from 25.34% in 2011 to 25.49% in 2012 (Ministry of Energy and Public Utilities, 2013). This shows that individuals contribute to an increase in CO_2 emissions by using different means of transport to travel both locally and abroad. Figure 2.12 shows the fuel consumption for the transport sector in Mauritius for the year 2012:

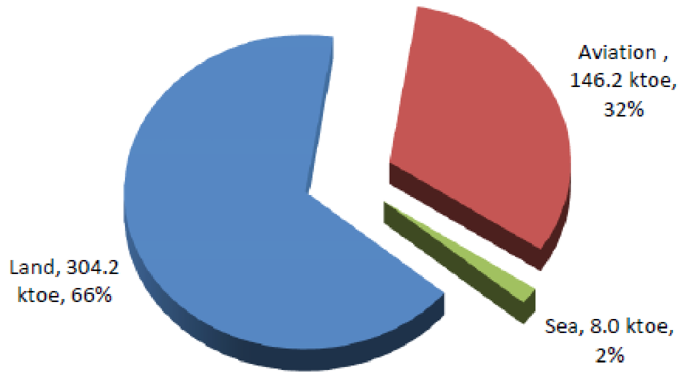

Figure 2.12: Fuel Consumption for the Transport Sector

(Source: Energy Observatory Report, 2012)

Furthermore, all the transport sub-sectors, that is, land, aviation and sea, are expanding globally due to population growth and the modes of transport that are expanding also happen to be the most polluting (Chapman, 2007). The bar chart in Figure 2.13 shows the carbon dioxide emission per passenger kilometre:

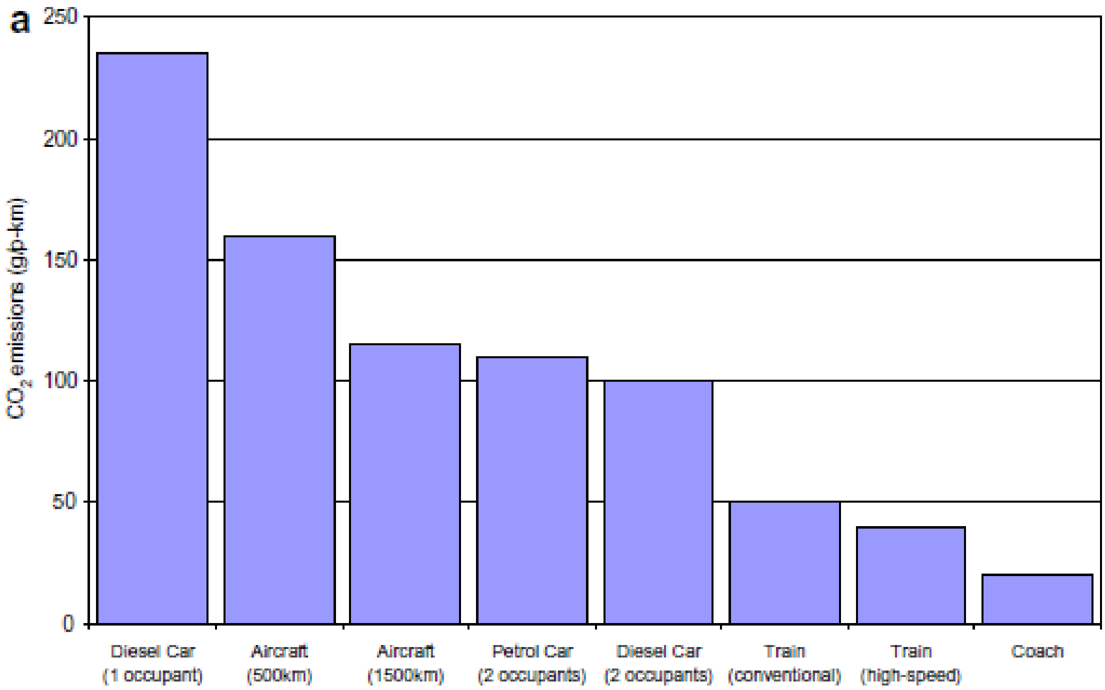

Figure 2.13: Carbon Emission for Long-distance Travel
(Source: Dings and Dijkstra, 1997 cited in Bonnafous and Raux, 2003)

From Figure 2.13, cars and aircrafts are the most common modes of transport, but are also the two major sources of carbon dioxide emission.

Figure 2.14: Travel Sub-Categories

Figure 2.14 shows the sub-categories for the travel category. The main travel category is broken down into local and foreign trips. Local trips include the types of private vehicles used, along with the annual mileage (in km). Any other public vehicles used and their distance travelled are also included. For foreign trips, the number of flights and annual destinations are required. As highlighted in Figure 2.12, aviation is the largest contributor to transport carbon emission, and thus the distances travelled by flight are needed to determine the amount of carbon released.

2.3.1.3 Diet

The dietary choice of consumers also affects GHG emissions, since production of livestock accounts for 18% of the total global greenhouse emission (Stehfest, et al., 2009). In broader terms, the consumption of meat results in clearing of lands, that is, deforestation, in order to be used as grazing land for the animals (Stehfest, et al., 2009). As discussed earlier in this chapter, deforestation contributes largely to carbon dioxide emission. In food production, the fossil fuel use on farms and the agricultural production processes, transport and packaging also contribute to the increasing GHG emissions, especially carbon dioxide (Berners-Lee, et al., 2012). Two studies in the UK and US (Druckman & Jackson, 2009; Weber & Matthews, 2008) confirmed the high emissions of GHG specifically from meat production and dairy products. The chart in figure 2.15 shows the emissions of GHGs, in terms of their CO_2e of different dietary data. This study is based on UK food production and consumption, and the result gives a global overview of the GHG emissions based on food types.

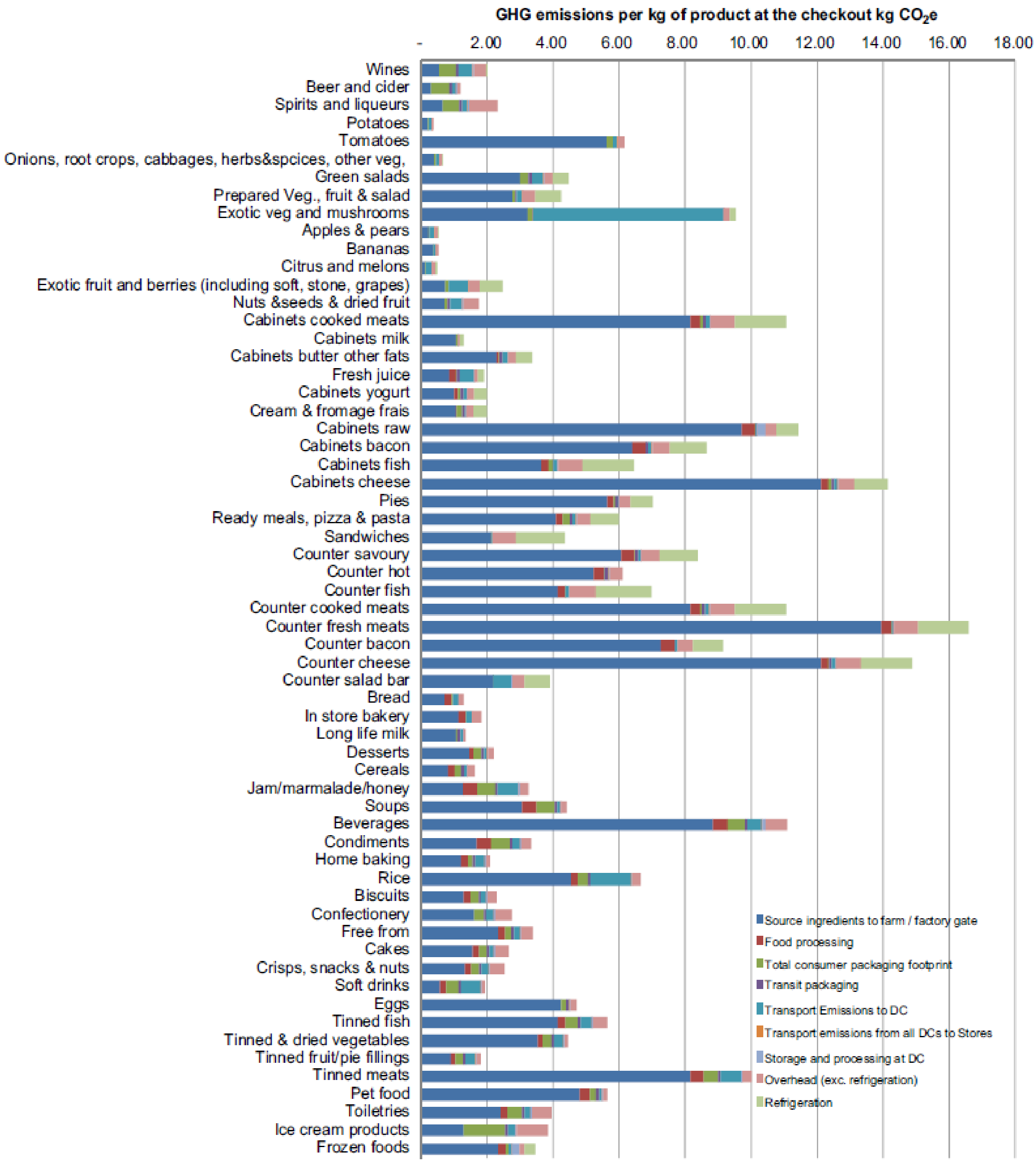

Figure 2.15: GHG emissions of different food categories
(Source: Berners-Lee, et al., 2012)

The chart in Figure 2.15 depicts that the largest emissions of GHG come from mainly meat and dairy products. Plant-based diets represent the lowest carbon dioxide emission, except the ones transported by airplanes. Consumption of seasonal fruits and vegetables contribute minimally to the emission of GHGs as well since their production during their seasonal periods would not require heating systems in greenhouses (Röös & Karlsson, 2013).

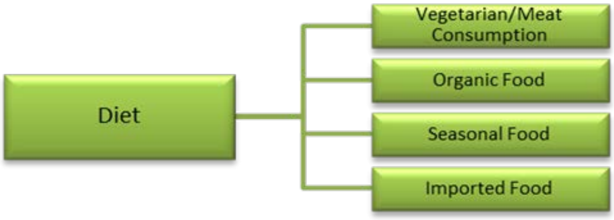

Figure 2.16: Diet Sub-Categories

As shown in figure 2.16, the diet category is related to the type of food the individual consumes, whether organic or not, locally produced or not and the amount of meat consumed in a particular period of time. These input are required to obtain an approximate amount of carbon released in food production due to the daily needs of an individual.

2.3.1.4 Lifestyle

Apart from household energy use, travel and diet, the last category to be considered is lifestyle. The lifestyle category comprises of the following components: recycling, finance, recreational activities, clothing, product packaging and furniture and electronics. These sub-categories form part of the general lifestyle choices which contribute to the energy and material demand of the individual. Recycling involves less emission of carbon in the atmosphere since less energy is needed as compared to producing new products from scratch (Carbon Footprint, 2014). The carbon emission associated with plastic packaging can be significantly reduced by the increasing use of recycled materials (Science for Environment Policy, 2013). The financial services used by individuals also contribute to carbon emission through the financial services industry, that is, the banks, insurance and pension policies (Carbon Footprint, 2014). Clothing adds to the individual carbon emission as well, since the different processes in the life cycles of clothes involve some forms of energy usage, and other pollutants. For example, the most widely used fibre in clothing, which is polyester, is made from petroleum, hence increasing the demand for energy (Claudio, 2007). Similarly, waste related to electronic products is expected to grow by 33% by 2017 in the world, hence increasing the fuel consumption for transportation and energy consumption needed for manufacturing new products (STEP, 2013). Lastly, some recreational activities, especially outdoor activities, contribute to individual carbon emission through fuel consumption during travelling or sport activities such as sky-diving.

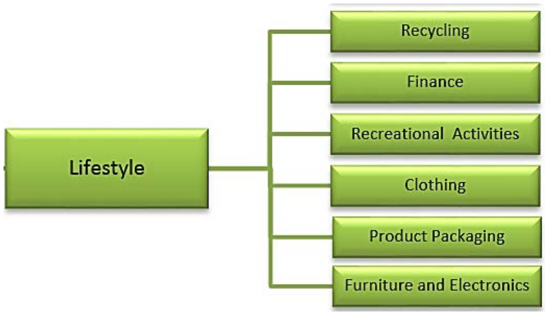

Figure 2.17: Lifestyle Sub-Categories

Figure 2.17 shows the different components of the lifestyle category. Lifestyle category mainly includes questions related to the lifestyle of the individual, for example, their waste management methods, use of recycled products, use of electronic devices and furniture renewals. The purchase of new products, whether electronics or furniture, requires more raw materials to be provided while at the same time, it increases the manufacturing process. These manufacturing processes result in an increase of carbon emission.

The whole taxonomy representation of the carbon footprint of the individual is shown in Figure 2.18. The diagram shows the main sources of carbon emission of an individual, along with a detailed representation of the different sub-categories which need to be considered while measuring and analysing the carbon footprint of an individual.

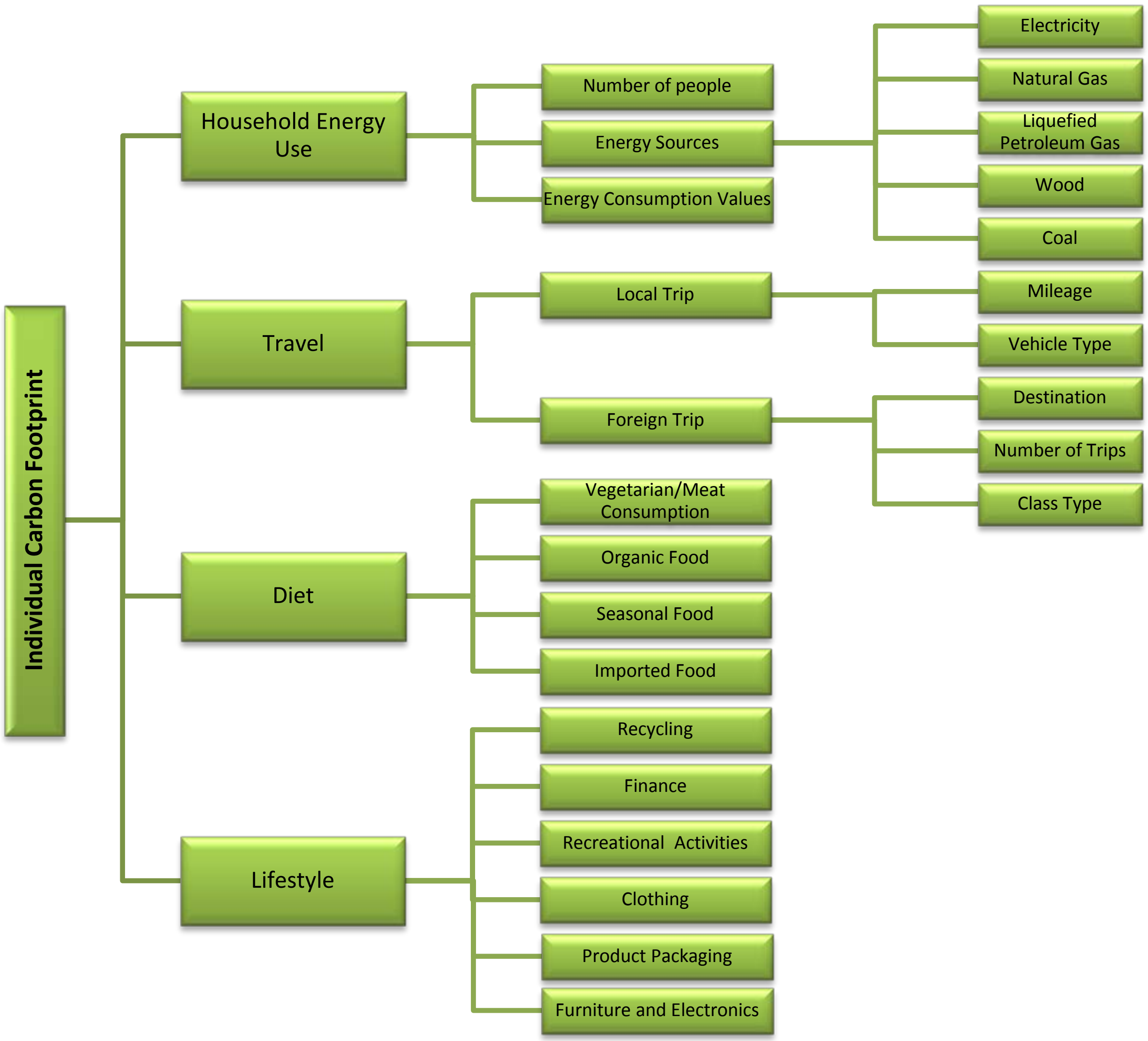

Figure 2.18: Diagrammatical Representation of Individual Carbon Footprint Dependencies

The different categories of the daily activities of an individual have been identified in the taxonomy to contribute to the daily personal carbon emissions. As discussed earlier in this chapter, the activities do not emit the same amount of carbon dioxide in the atmosphere, and thus the first research question investigated in the project is:

RQ 1: Which activities have the greatest contribution to the overall carbon footprint of an individual, based on the taxonomy being studied in Figure 2.18?

Chapter 3 - Managing Human Contribution to Carbon Emissions

In chapter 2, it was discussed that one of the major contributors to growing carbon emissions in the atmosphere was the human activities (IPCC, 2007). In the 2010 Cancun Climate conference, it was decided that global leaders would work towards restraining the global warming to 2^0C (UNFCCC, 2014). To stay within the 2^0C limit beyond the year 2020, it is crucial to pay attention to the global carbon emission budget, that is, the estimated maximum amount of carbon dioxide which could be emitted over time, and still remain within the temperature boundary (UNEP, 2014). According to the latest IPCC report (2014), in the late 19^{th} century, the rapid growth of carbon emission in the atmosphere has already reached aproximately 1900 Gt of CO_2, out of the estimated 3 670 Gt of CO_2 for the total carbon emission budget. The other substances released in the atmosphere due to human activities have reduced the carbon emission budget to around 2900 Gt of CO_2 (UNEP, 2014). This leaves around 1000 Gt of CO_2 which can be emitted in the future in order to maintain the temperature limit. Therefore, it is important for all stakeholders across the world to not only maintain, but also mitigate the carbon emission levels.

3.1 Mitigating Carbon Emissions – Key Stakeholders Involved

There are different stakeholders involved in reducing the amount of carbon emission in the atmosphere, from international organisations to individuals. The following sections provide an insight on how the different stakeholders are currently working on carbon emission reduction and adoption of effective carbon mitigation strategies.

3.1.1 International Organisations

An international campaign was initiated since the last half century with the aim of involving all countries towards the protection of the environment (Haas, 1992). Peter Haas (1992) has advocated the notion of an epistemic community, where diverse key players, such as inter-governmental organizations, green agreements, environmental and scientific professionals, and large numbers of international associations and non-governmental organizations come together to concede to the various ecological problems and the strategies to adopt (Gough & Shackley, 2001). These political and organizational structures can collaborate to utilize substantial powers with the policy actors, who can in turn disrupt the policy development and influence national agendas (Schofer & Hironaka, 2005). In order to maintain the commitment of the policy actors, scientific knowledge becomes a crucial asset (Gough & Shackley, 2001). This science-policy interconnection is represented by the IPCC, the UNFCCC and those nations who support the Kyoto Protocol.

The UNFCCC and its Kyoto Protocol are the principal institutional frameworks by which climate policy is developed. As stated in Article 2, one of the main purposes of the UNFCC is to:

"to achieve stabilisation of greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." (United Nations, 1992)

The UNFCC (2014) formalized an international process for countries to negotiate emission targets and international institutions have been developed. Thirty-four developed countries accepted the primary responsibility for addressing this problem. The group was divided into:

(a) the most developed countries, which agreed to endorse domestic policies and to support and fund developing countries to enhance their ability to tackle climate change and increasing carbon emission problems;

(b) the countries in transition were given more time to enact domestic policies. Developing countries were expected to report their GHG emissions after obtaining necessary financial resources (United Nations, 1992; IPCC, 2007)

Furthermore, regional co-operation could provide opportunities in both economic integration and in addressing the adverse effects of climate change (Denton, 2010). Initiatives such as the New Partnership for Africa's Development (NEPAD) and the African Ministerial Conference on the Environment conducted a number of reviewing processes in order to prepare an Environmental Action Plan for the Implementation of the Environment Initiative of NEPAD. One of the proposed projects is to evaluate synergistic effects of adaptation and mitigation activities, including on-farm and catchment management of carbon with sustainable livelihood benefits. Organisations such as the West African Monetary Union (WAMU) are actively engaged in energy development to address the persistent problem of energy poverty in the continent. The organizations focus on how to exploit the Clean Development Mechanism (CDM) and other mechanisms to mitigate present and future emissions, especially with the use of renewable energy. A special role can also be played by international funding agencies and climate change funds. For example, the World Bank BioCarbon Fund and Community Development Carbon Fund provide financing for reforestation projects to conserve and protect forest ecosystems, community afforestation activities, mini- and micro-hydro and biomass fuel projects. These projects are focused specifically on extending carbon finance to poorer countries and contribute not only to the mitigation of climate change but also to reducing rural poverty and improving sustainable management of local ecosystems, thereby enhancing adaptive capacity.

3.1.2 Governmental and Regulatory Organisations

Governments have a key role to play in climate change mitigation and carbon emissions reduction. Through the development of policies and schemes to encourage people and businesses towards the adoption of climate change mitigation measures, governments can considerably help meet the low-carbon targets set by the UN (Stern, 2006). In the UK, The Climate Change Act 2008 established a new approach to managing and responding to climate change in the UK. The Act created a legally binding target to reduce the emissions of greenhouse gases to at least 80% below 1990 levels by 2050 in the UK. This is one of the most challenging targets set by a national government.

At the local level, the Government of Mauritius has set up several long-term strategies in relation with sustainable development. To combat climate change and reduce carbon emission, the government has set up various sectorial strategies, which focus on areas like energy, coastal zone management, land, biodiversity, forests, waste water management and tourism. Those strategies also include the National Biodiversity Strategy & Action Plan (2006 – 2015), the National Forestry Policy (2006), the Long Term Energy Strategy (2009 – 2025), the Islets National Park Strategic Plan (2004) and the National Programme on Sustainable Consumption and Production (2008-2013) (UNDESA, UNDP, 2012).

In 2008, the government initiated the 'Maurice Ile Durable' with the objective to make the island a world model for sustainable development (Maurice Ile Durable, 2014). The government has targeted to achieve 35% of renewable energy production by the year 2025. Moreover, the recent years have witnessed the adoption of new legislation on energy efficient buildings. The Ministry of Environment and Sustainable Development is also working on a Low Carbon Development Strategy and Nationally Appropriate Mitigation Actions (NAMAs) in order to integrate carbon emission reduction in the institutional framework, development plans and policies for Mauritius. (Maurice Ile Durable, 2014; Mahomed, 2013).

Furthermore, a variety of incentives have been taken to enable the local population to use renewable energy sources. For example, a solar water scheme has been set up for at least 40, 000 families so as to reduce the electricity consumption and carbon emission simultaneously (Maurice Ile Durable, 2014). According to the Mauritius Environment Outlook Report (2011), incentives have been adopted to lessen atmospheric pollution through the introduction of unleaded petrol, and a reduction in the sulphur content of diesel (Ministry of Environment and Sustainable Development , 2011). The same report also mentions the implementation of a National Programme on Sustainable Consumption and Production to improve local water usage.

The Ministry of Environment in Mauritius has also adapted the 1990 National Environment Policy to encourage sustainable development and achieve national targets on sustainable production and consumption, such as the reduction of material and energy consumption by using eco-efficiency tools, adoption of Environmental Reporting by the business sector and the promotion of green consumerism (Procurement Policy Office, 2011).

3.1.3 Private Sector

The private sector has an important role to play in building a low-carbon, climate resilient future for the planet. The United Nations Framework Convention on Climate Change has a Private Sector Initiative to catalyse the role of the private sector in climate adaptation, and forms of climate finance, such as the Climate Investment Funds (United Nations Framework Convention on Climate Change, 2014).

Different reports have acknowledged that the correct incentives from private sectors can help enhance their involvement in carbon emission mitigation. For instance, according to the World Business Council for Sustainable Development (WBCSD) report (2009), businesses should emphasize on technology expansion and distribution, finance and carbon markets, and work on policy recommendations. Another report focuses on the different public finance mechanisms needed to encourage and develop solutions related to climate and carbon emission issues (UNEP, 2009).

At the local level, the private sector improved its commitment to associate with the local government on implementing the strategies from the Mauritius Strategy of Implementation (MSI) and Barbados Programme of Action (BPOA) (UNDESA, UNDP, 2104). The private sector has also begun working on an energy efficiency initiative to seek energy conservation in production. There are also projects where the carbon footprints of the main industries are monitored in order to reduce the industrial carbon emission (UNDESA, UNDP, 2014).

Moreover, private sectors in Mauritius are also collaborating with the government on several research works related to the development of sustainable buildings, and the identification of research themes and issues on sustainable and energy-efficient buildings in Mauritius (National Energy Research Group, 2012).

3.1.4 Tertiary Education Institutions as an Enabler of Research on Climate Change Adaptation

Tertiary education institutions hold a distinctive position in society and are critically important places of knowledge production, knowledge continuation, and knowledge propagation (Otara, 2014). Apart from being considered as knowledge hubs, tertiary education institutions have the unique ability to combine different types of knowledge to be integrated and applied for the betterment of society (Stephens, et al., 2008). For centuries, tertiary institutions have been key mediators of social change, and yet the majority remained reluctant to adapt to new frameworks developed (Lozano, 2010). During the last decade an increasing number of tertiary education institutions across the world have been engaged in integrating sustainable development into their curricula, research and operations. But despite their efforts, environmental sustainability is still an innovative idea and has not yet been adopted into all disciplines, scholars, and university managers, or throughout the curricula (Fien, 2002).

When working towards implementing environmental sustainability in a society, TEIs can be viewed upon in two different ways: the first one being as an institution that needs to be changed and the second one being that TEIs are the change agents themselves (Stephens, et al., 2008). There are four common types of perceptions on how institutions of higher education might contribute to the societal evolution towards sustainability. These are:

- Tertiary education institutions can model sustainable practices for society. This can be achieved by promoting sustainable practices in the campus environment, and this leads to learning how society can maximize sustainable behaviour.
- Tertiary education institutions can teach students the skills of integration, synthesis, and systems-thinking and how to cope with complex problems that are required to confront sustainability challenges.
- Tertiary education institutions can conduct real-world problem-based research that is targeted to addressing the urgent sustainability challenges facing society.
- Lastly higher education can promote and enhance engagement between individuals and institutions both within and outside higher education to resituate TEIs as trans- disciplinary

agents, highly integrated with and interwoven into other societal institutions (Stephens, et al., 2008).

The first and last categories are the main focus of this research, and justify the selection of tertiary institutions as the main agents towards a sustainable environment in Mauritius. Different research works on environmental sustainability, energy efficiency and green computing have been conducted across the different main tertiary education institutions of the island (IST Africa, 2014). However, there has been minimal focus on the human perspectives, that is, the behaviours and concerns of tertiary education institution employees or students towards the growing GHG emissions. Tertiary education institutions play a critical role in creating an environmentally sustainable future by raising awareness and influencing future professionals who can lead, develop and engage in sustainable living (Cortese, 2003). A survey conducted among students at the University of Technology in Mauritius indicated that majority of the students did not practise the necessary measures for reducing personal carbon emissions (Dookhitram, 2012). A similar work has not been conducted so far among employees in tertiary education institutions of Mauritius, and therefore it is not possible to determine whether employees are measuring and reducing their personal carbon emission. The next section reviews existing carbon management frameworks for tertiary education institutions, which emphasizes environmental sustainability across the campuses.

3.2 Review of Existing Carbon Management Framework

A framework outlines a process of assessing evidence that asks questions related to important aspects of interpreting research findings. It provides a sound methodology for reviewing practices to determine whether or not these practices can be considered “best practices” in the study. In the previous section, it was found that TEIs are among the key stakeholders in mitigating carbon emissions. However, tertiary education institutions as well are known to contribute to the growing carbon emissions. There have been many attempts in establishing such frameworks in various TEIs since the concept of environmental sustainability at the tertiary education level was proposed. Such existing frameworks are reviewed in the sections that follow.

3.2.1 Green Campus Initiative Model of Harvard University

The framework shown in figure 3.1 was developed by Harvard University and aims to address the real life challenges and obstacles of environmental sustainability at the institutional level. This model helps to engage the staff, students and faculties to develop sustainability within the university framework (Harvard University, 2009). The framework provides a broader overview of implementing different policies and engaging all departments for a greener campus initiative. It shows mainly how to fund the development of conservation projects in operational campus activities, such as transport, purchasing of university materials, buildings, operation and maintenance and then repaying the loans. This framework however restricts itself within the campus boundary, and provides an overview of funding and developing projects for a sustainable campus rather than focusing on the human perspective to carbon emissions reduction.

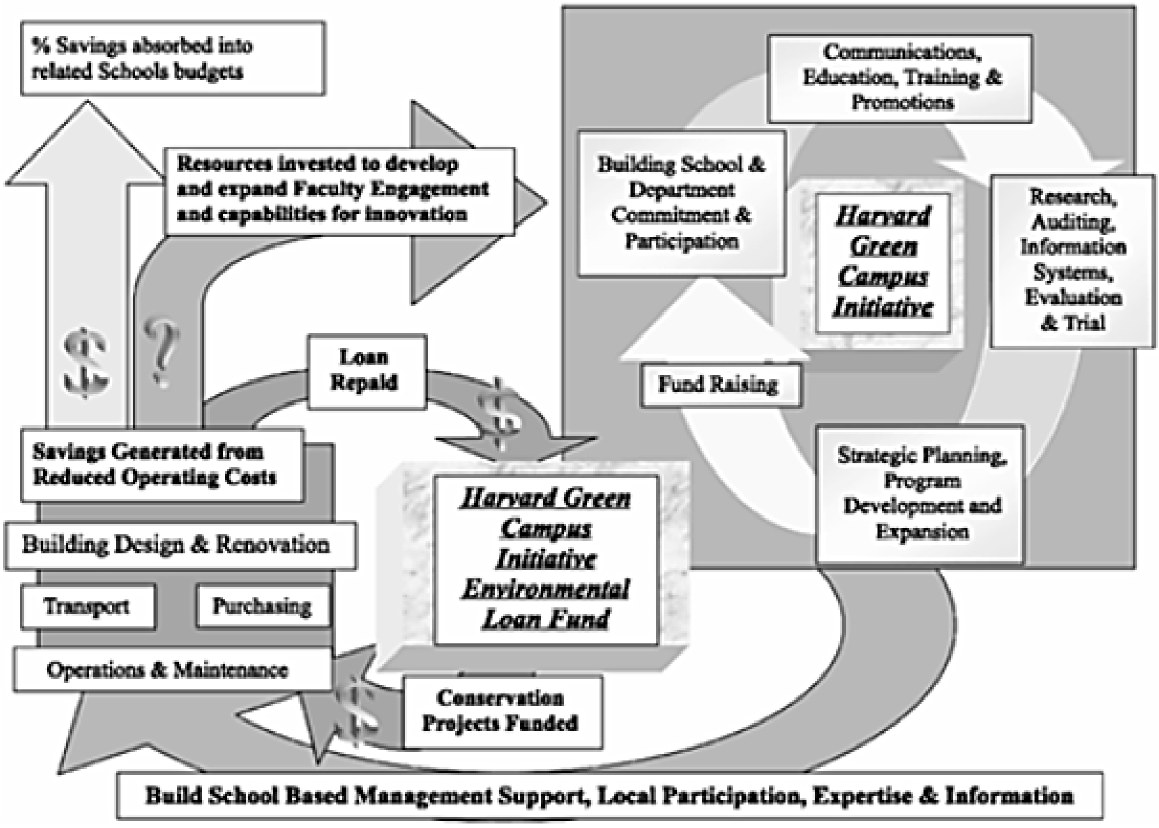

Figure 3.1: The Harvard Green Campus Framework
(Source: Sustainability at Harvard, 2009)

3.2.2 Green Campus Framework by University of West Sydney

This framework shown in figure 3.2 was proposed by the University of West Sydney and gives a general overview of the key components that should be addressed in order to adopt a Green Campus policy. The key components are: Buildings and grounds, Purchasing, Academic Departments, Admin Services, Classrooms, Dining Services, Labs and Research Facilities and Students Activities. It provides a conceptual overview of contributing to a greener campus through awareness and symbolic actions in the form of special projects. The framework also covers the management system of the university and the different policies to be adapted. A special management committee is set up to monitor and evaluate the environmental management plan of the university and the different procedures involved. This framework covers mainly the management aspect for a greener campus and the setting up a special environmental system and similar to the previous framework, the focus is not specific to human perspective to carbon emissions reduction.

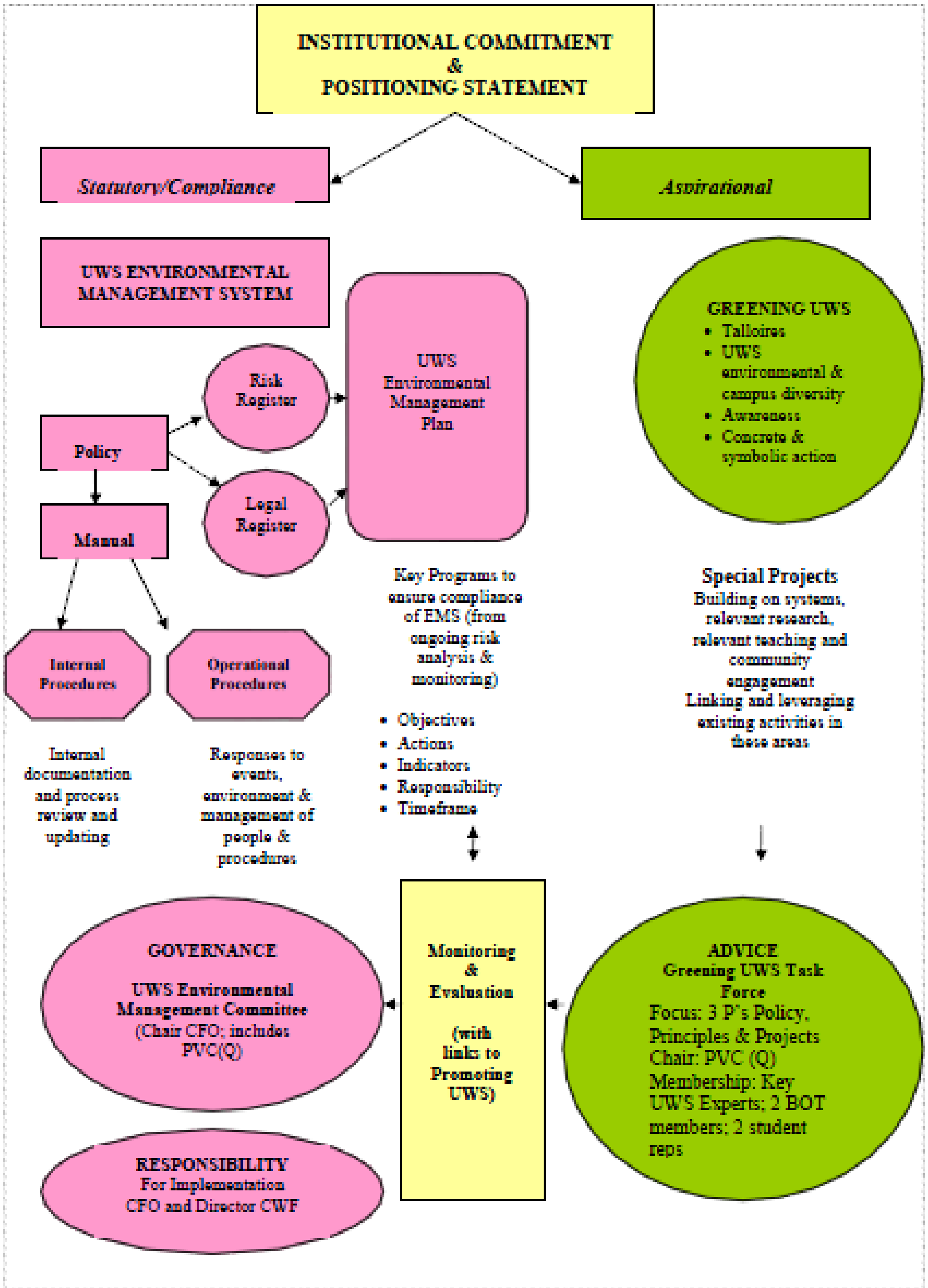

Figure 3.2: The University of West Sydney Green Campus Framework
(Source: University of West Sydney Sustainability Strategy)

The two frameworks discussed in the previous section shows on a broader level how to adopt best policies and setting up environmental projects for a greener campus by involving all departments and students. The frameworks are mainly based on developing green infrastructures and taking environmentally friendly incentives regarding the campus development rather than focusing on human perspectives. Furthermore, the frameworks reviewed do not provide a conceptual analysis of measuring the individual contribution to increasing carbon emission and developing sensitization measures carbon reduction in the daily activities of an individual. As such, the proposed frameworks are beyond the scope of this study. Thus, a new framework has to be proposed in this study that focuses on the human factor and seeks to improve the attitudes of the employees in tertiary education institutions towards a better consciousness of their lifestyles on the environment, especially, on the growing carbon emission. Moreover, for the tertiary education sector, Nicolaides (2006) has stated that any knowledge which does not result in personal behavioural changes concerning the protection and improve of the environment is a total waste. This leads to the following research question:

RQ 2: Are employees of tertiary education institutions aware of the growing carbon emissions problems?

In order to promote research and the implementation of the best practices for a greener environment, academic employees and scholars need to be aware of the measures needed in adopting eco-friendly lifestyles. There are a few obstacles which prevent such adaptation actions. Firstly, academics are unaware of the current environmental issues or regard them as irrelevant to their personal lifestyles (Velazquez, et al., 2005). This leads to the following research questions:

RQ3: Are employees measuring their carbon footprint and keeping track of it?

RQ 4: What is the baseline for employee carbon emission within the tertiary education sector?

Secondly, the lack of necessary resources to learn and apply sustainability measures for the environment results in the inability to apply any effective and concrete frameworks towards education in environmental sustainability (Nicolaides, 2006).

Chapter 4 - Personal Carbon Footprint Management

As highlighted in chapter 2, human beings contribute to the growing carbon emission through different activities, and as such there is a need to understand which of these activities contribute most to the personal carbon emission, and by what amount. This introduces the technique known as carbon footprint. Carbon footprint calculation allows individuals to calculate the amount of carbon emitted through their daily activities, and hence help in better managing the carbon emission at the individual level.

4.1 Carbon Footprint

'Carbon footprint' has become a widely used term and concept in the public debate on responsibility and abatement action against the threat of global climate change. But till date, no exact definition has been provided of what a carbon footprint is (Wiedmann & Minx, 2008). So far, only some well-known organizations have provided some explanations of what a carbon footprint means. Some of those definitions are listed below:

- *"A carbon footprint is the total greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organization, event or product, and is expressed as a carbon dioxide equivalent (CO_2e). A carbon footprint accounts for all six Kyoto GHG emissions."* (The Carbon Trust, 2012)
- *"The carbon footprint is the amount of carbon dioxide emitted due to your daily activities."* (BP, 2007)
- *"The carbon footprint (CF) is a measure of the exclusive total amount of carbon dioxide emission that is directly or indirectly caused by an activity or is accumulated over the life stages of a product."* (Wiedmann & Minx, 2008)
- *"A measure of the amount of carbon dioxide (CO2) emitted through the combustion of fossil fuels; in the case of an organisation or business, it is the CO2 emissions due to their everyday operations; in the case of an individual or household, it is the CO2 emissions due to their daily activities; for a product or service, it includes additional life-cycle CO2 emissions along the supply chain; for materials, it is a measure of the embodied CO2 emissions determined through life cycle assessment."* (CarboNZero, 2014)

For the research project, the definition provided by CarboNZero (2014) is taken into account since the project is based on measuring direct emission of carbon dioxide of human beings in the atmosphere due to their daily activities. According to the GHG Protocol (2014), direct emissions are from sources that are owned and can be controlled by the individual in question whereas indirect emissions are emissions that are a result of activities of the individual, but occur and controlled by other entities. Human activities such as using coal, natural gas for generating electricity and transportation (car, bus, plane etc.) all release carbon dioxide into the atmosphere. Much work related to carbon emissions reduction have emerged from various organizations in the past decade. This has given rise to ways of tracking and measuring activities, via which GHG is increased in the atmosphere. In this way, emphasis is laid on the breakdown of these activities to give a clear understanding of what to measure and the derived unit. For example, the amount of fuel consumed during the transport of products or activities related to energy consumption, travelling and so on. These breakdowns are used to measure the impact of individual components on the environment in terms of the total amount greenhouse gases emitted, which is measured in tons or kilograms of CO_2e. As such, regional bodies emphasized on the consensus for a carbon footprint for businesses, personal and enacting of legislation in reducing carbon (Chan & Boehmer, 2006). This has also brought the distinction of classifying the CF into two types- namely, business and personal carbon footprint (Weldma, 2008). For this study, personal CF calculation is focused upon.

The major reason for the widespread calculation of CF is the attention that climate change has received on the global environmental agenda, but CF also has several advantages. There is still no consensus on the measurement of GHG (Röös et al., 2011) and although the method used by the IPCC (2007) method for calculating GWP from GHG emissions is generally accepted, it has been questioned. However, in comparison with assessing the effects on e.g. biodiversity and expressing these in one score, the use of CO_2e as prescribed by IPCC (2007) to express GWP is more straight-forward. In addition, unlike the impact categories eutrophication, acidification and biodiversity, which have highly site-specific effects, GWP is the same regardless of where the GHG emissions take place. The ability to produce values that are globally applicable and comparable across a wide range of products makes CF easy to understand and communicate (Röösa, et al., 2013). The following research question also arises within the tertiary education sector in Mauritius:

RQ 5: What is the average carbon footprint of employees within the tertiary education sector in Mauritius and how is this value different from the per capita carbon footprint?

4.2 A Comparative Study of Carbon Footprint Calculators

Carbon Footprint calculators are vital technological tools in connecting individual actions and lifestyles to the rising emergency in reducing the impacts of climate change (Birnik, 2013). These tools remove the focus away from governmental responsibilities to mitigate the growth of GHG emission and put more emphasis on the responsibility of individuals (Paterson & Stripple, 2010). Despite its crucial role on raising awareness, till date there has been no consensus on how carbon footprints should be calculated, and hence most of the calculators vary in terms of their structures, input requirements and even their results can be different for the same data input (Kenny, 2009; Murray & Dey, 2009; Padgett, 2008; Pandey et al., 2011). As such, in order to determine the most appropriate calculators to be used for the research work, a set of criteria were first analysed and the most popular free online CF calculators were compared and reviewed against the list of criteria. Those criteria are based on literature-derived calculation principles (Birnik, 2013).

4.2.1 Criteria in CF calculator selection

The following principles, derived by Birnik (2013), were used to select the most appropriate CF calculators to be used in this study:

Number	Principles
1	A personal carbon footprint calculator should as a minimum requirement estimate emissions relating to carbon dioxide, methane and nitrous oxide.
2	A personal carbon footprint calculator should base conversions to carbon dioxide equivalents on 100-year GWP conversion factors
3	A personal carbon footprint calculator should estimate consumption based footprints as the purpose is to determine climate impact of an individual regardless of where goods and services consumed are produced
4	A personal carbon footprint calculator should allow users to adjust for income or consumption level instead of only using national averages
5	A personal carbon footprint calculator should adjust the relative distribution of consumption categories as a function of the income level
6	A personal carbon footprint calculator should adjust for the number of people living in a household.
7	A personal carbon footprint calculator should allow users to model their housing emissions in detail.
8	A personal carbon footprint calculator should capture emissions from household energy use as well as emissions from furnishings, appliances, building material, repair and maintenance of buildings
9	A personal carbon footprint calculator should allow users to model their food related emissions in detail.
10	A personal carbon footprint calculator should allow users to model their transportation related emissions in detail
11	A personal carbon footprint calculator should allow users to include radiative forcing of flights when modelling flight emissions
12	A personal carbon footprint calculator should provide a comprehensive footprint including allocating emissions for a variety of consumption categories
13	A personal carbon footprint calculator should base calculations on up-to-date and country/region specific emission factors whenever possible

Table 4.1: Carbon Footprint Calculator Principles

4.2.2 Selection of CF calculators

Numerous websites have been created to help to calculate the carbon footprint of an individual or an estimate of the carbon dioxide emissions that an individual is directly responsible for over a given period of time. These calculators are provided by government agencies, non-governmental organizations, and private companies. In terms of operations, the calculators typically divide the profile of an individual into household activities and transportation, and based on user input these calculators produce a quantified amount of carbon dioxide or carbon dioxide equivalents emitted, generally in units of mass of CO_2 per year. Apart from the basic categories (household and transportation), some calculators also include other categories, such as food consumption, lifestyle and waste management.

In order to select the most popular CF calculators which are best suited for the Mauritius context, a simple Google search on for the term “free carbon footprint calculator” revealed a list of 23 most commonly used CF calculators. These were individually reviewed and the CF calculators which were based on businesses and those which were focused mainly on ecology, that is, the calculation of water, land and GHG footprints altogether, were omitted. The list, as shown in table 4.2, was reduced to the top 10 most common CF calculators which focused only on individual carbon footprint calculations.

No	Carbon Footprint Calculators	Features						
		Region	Categories				Source Data	Additional Information
			Household Energy Use	Travel	Diet	Lifestyle		
1	WWF Footprint Calculator	United Kingdom	Measurement based on number of people living in house, heating system and energy saving systems used	Measurement based on type of vehicles used, hours travelled per day, use of public transport	Measurement based on amount of meat consumed per week, organic diet and locally produced or not	Measurement based on household items bought, pets, jewellery, DIY tools and personal hygiene products	WWF uses the ecological and carbon footprint of 123 production sectors, 76 different consumption categories, 54 socio-economic groups and over 400 local authorities in the UK. This data creates a baseline for the footprint calculator which enables the translation of the 20 simple lifestyle questions into a personalised ecological and carbon footprint.	This calculator is an ecological footprint calculator. Most calculators only measure carbon emitted per person. The calculator includes the production and use of raw materials as well, which gives a much more accurate idea of the impact an individual is having on the planet. Link: http://footprint.wwf.org.uk/
2	Carbon Footprint	Worldwide including Mauritius	Measures total household energy consumption, includes, electricity, gas, heating oil, coal, wood.	Measurement based on the number and type of flights taken in a year, car mileage and vehicle types.	Asks for food preferences, organic, seasonal food.	Food consumption, fashion, recycled products, recreation, finance details.	Calculations are based on conversion factors sourced from different departments in USA, UK, Australia	Time period option provided Link: http://www.carbonfootprint.com/
3	CarbonStory	Worldwide including Mauritius	Measurement based on household energy use and energy sourced involved in house furnishings and maintenance.	Measurement based on transport type, annual mileage and flight destinations.	Requires details of type of diet (vegan, vegetarian or red meat) and organic food.	Requires recreation, health and education details.	Not mentioned	Mathematic formulae provided. Link: https://www.carbonstory.org/calculator/calculate

No	Carbon Footprint Calculators	Features						
		Region	Categories				Source Data	Additional Information
			Household Energy Use	Travel	Diet	Lifestyle		
4	The Nature Conservancy	Not specified	Measurement based on type of house, any measures taken to reduce energy consumption.	Measurement based on type of vehicles used, whether air filters and tyre pressures are checked, and the number of short and long flights taken in the past year.	Measurement based on the amount of meat consumed and whether diet consists of organic food or not.	Includes recycling and waste category.	Not provided	None Link: http://www.nature.org/greenliving/carboncalculator/
5	Ecological Footprint	Worldwide including Mauritius	Measurement based on types of house, energy sources used.	Measurement based on distance travelled annually for different vehicle types.	Types of diet, whether organic or not, whether the individual has a garden or not for food production.	Includes type of regional climate, energy saving habits, water saving habits, spending habits and recycle waste management.	Starting with national per capita carbon emissions data taken from the World Bank's World Development Indicators, the quiz first segregates out the portion of carbon emissions attributable to home energy use and transportation. Then the quiz makes a series of additions or deductions to this footprint based on visitor choices.	The carbon footprint is outputted in global hectares by consumption category. Link: http://myfootprint.org
6	What's my Carbon Footprint?	United States	Number of people living in house, and type of heating system used. Electricity, gas, fuel bill.	Annual mileage of car distance traveller per week/year. Flight taken.	None	Recycled items	United States Energy Information Administration (EIA)	Mathematic Calculations used are provided. Link: http://www.whatsmycarbonfootprint.com/calculate.htm

No	Carbon Footprint Calculators	Features						
		Region	Categories				Source Data	Additional Information
			Household Energy Use	Travel	Diet	Lifestyle		
7	Earth Lab	Worldwide including Mauritius	number of people in house and type of house. average monthly electricity and gas bills (in US$) and renewable energy used.	type of car and public transports used. Travel questions on number of trip flights taken per year	organic food are consumed	Work questions on how computer systems are used, frequency of printing, use of recycle paper and whether public transports are used to travel to and back to work. use of appliances at home. whether the person is a recycler and use compost		Carbon footprint scores are compared to average scores for Mauritius and worldwide. Mathematics calculations and assumptions used provided. Link: https://www.earthlab.com/createprofile/home.aspx
8	Resurgence and Ecologist	United Kingdom	energy bills	type of cars and public transport used, the type of flights taken during the year.	diet and organic food consumption	any leisure activities which use fuels	The principal source of data for this calculator is the "Guidelines to DEFRA's Greenhouse Gas (GHG) Conversion Factors for Company Reporting.	Methodology notes provided. Link: http://www.resurgence.org/education/carbon-calculator.html

No	Carbon Footprint Calculators	Features						
			Categories					
		Region	Household Energy Use	Travel	Diet	Lifestyle	Source Data	Additional Information
9	Carbon Neutral Company	South Africa (nearest)	Measurement based on home energy use(electricity, fuel, gas, heating oil)	Measurement based on number of flights taken, types of vehicles used, and distance travelled annually.	None	Includes commute.	DEFRA 2013 UK Government conversion factors are used.	Data calculation methods are provided and conversion factors used are listed for the different categories. Link: http://www.carbonneutralcalculator.com/flightcalculator.aspx
10	PE International Carbon Footprint Calculator	South Africa (nearest)	Measures electricity, natural gas, and oil energy use.	Measurement based on distance travelled by car, flights and train.	None	None	Not provided	None Link: http://www.pe-international.com/services-solutions/carbon-footprint/carbon-footprint-calculator/

Table 4.2: Comparative Table of Free Online Carbon Footprint Calculators

The top ten calculators compared in table 4.2 were then thoroughly reviewed and compared against the list of principles highlighted in table 4.1. The mathematical calculations and source data were investigated to determine the emission factors used by the calculators. The structures were reviewed to see whether all the main categories derived in the taxonomic study performed in chapter 2, that is, household energy use, transport and lifestyle data like diet and lifestyle, were covered. Finally, Carbon Footprint, Ecological Footprint, Carbon Story and Earth Lab were selected because those calculators corresponded to all the criteria and most importantly, their mathematical calculations and emission factors were based on the Mauritius region, as compared to the others which used the United States, United Kingdom or South Africa source data only. Afterwards, the Ecological Footprint calculator was discarded since its structure and information requirement did not correspond to the other three calculators, and this would lead to some difficulty and bias results while calculating the average CF result of the employees of the tertiary education sector. Hence, 3 calculators were chosen and tested: Carbon Footprint, Carbon Story and Earth Lab.

For the purpose of comparing the outcome of the selected calculators, three different tertiary employee profiles were created and their annual (1st August 2013 – 31st July 2014) carbon footprints were calculated. The three profiles are described below, along with the results obtained on the 3 calculators for similar data.

Profile 1: John Harte

John Harte is a full-time lecturer at the School of Science and Engineering at Middlesex University Mauritius Branch Campus. He is a 50 year old married man, with two children and lives in a 3 bedroom family house in the eastern region of Mauritius. He travels around 70 km every day to his place of work, in his 2004 Honda Civic (IMA Executive 5MT) car and he owns no other vehicles. His monthly household energy use for electricity is 400kWh and Liquefied Petroleum Gas is around 90L. His family, including him, are vegetarians and consume organic food as much as possible. They mostly buy local food and try to opt for seasonal food. John prefers to buy clothing and home furniture only when they need them and do not buy new electrical products regularly. Their home consists of partial CFL lighting systems. As far as possible, they try to recycle their waste products. The whole family also uses the standard bank services. John takes his family for holiday at least once a year and they travel frequently to London in economy class.

The carbon footprint results of John Harte for the three CF calculators are shown in Table 4.3 below:

Categories	Carbon Footprint	Carbon Story	Earth Lab
Household energy use	1.28 metric tons of CO2e	1.24 tons	-
Travel	1.56 + 3.36 metric tons of CO2e	8.80 tons +0.01 tons	-
Diet	4.21 metric tons of CO2e	0.49 tons	-
Lifestyle		0.81 tons	-
Total	10.41 metric tons of CO2e	12.02 tonnes	8.2 tons

Table 4.3: Carbon Footprint Result of John Harte

There is a significant difference between the total result on Earth Lab calculator and the total results for Carbon Footprint and Carbon Story. Since there are no detailed results for each category on the Earth Lab calculator, it is not possible to find out for which specific categories there are larger differences in carbon footprint result as compared to the other two calculators. As observed in the result table, it is not possible to obtain a separate CF result for diet and lifestyle activities on Carbon Footprint calculator because the results for these two categories are added together on the CF calculator. The total CF results on Carbon Footprint and Carbon Story calculators are nearly the same, with no big variations. The only major difference in result is in the travel category. This is due to the fact that Carbon Footprint calculator allows for a detailed input of the mileage, type and efficiency of the vehicles, hence the calculator makes a difference between high fuel-efficiency vehicles and low-fuel efficiency vehicles. On the other hand, it is possible to only indicate the annual mileage for the Carbon Story calculator, which results in a higher travel CF result.

Profile 2: Emma McGill

Emma McGill is a Marketing Officer at the University of Mauritius since 2008. She is married with no children and lives in a 2-bedroom apartment building in the capital of Mauritius. Emma travels to work in her own car, which is a BMW X5 Series E70, and her daily mileage is around 50km. Her monthly household energy use for electricity is around 200 kWh and Liquefied Petroleum Gas is around 45L. At home, Emma consumes mainly a mix of white and red meat diet and tries to buy organic food as well. She does not notice where the products she buys come from and does not try to buy only seasonal food. She prefers to buy clothes only when needed and normally keeps her home furniture and electrical products for more than 5 years. She occasionally goes out to places like movies and restaurants. Some of her waste products are recycled. She and her husband use the stand bank services. They travelled at least once a year to Australia by economy class.

The carbon footprint results of Emma McGill for the three CF calculators are shown in Table 4.4 below:

<table>
<tr><th>Categories</th><th>Carbon Footprint</th><th>Carbon Story</th><th>Earth Lab</th></tr>
<tr><td>Household energy use</td><td>1.28 metric tons of CO_2e</td><td>1.30 tons</td><td>-</td></tr>
<tr><td>Travel</td><td>1.40 + 6.06 metric tons of CO_2e</td><td>7.54 tons + 1.11 tons</td><td>-</td></tr>
<tr><td>Diet</td><td rowspan="2">7.43 metric tons of CO_2e</td><td>1.15 tons</td><td>-</td></tr>
<tr><td>Lifestyle</td><td>2.03 tons</td><td>-</td></tr>
<tr><td>Total</td><td>16.15 metric tons of CO_2e</td><td>13.13 tonnes</td><td>9.0 tons</td></tr>
</table>

Table 4.4: Carbon Footprint Result of Emma McGill

Similar to the results of John Harte, the CF result for Earth Lab is much lower as compared to the CF results of the other two calculators. The CF result for household energy use is nearly the same for both Carbon Footprint and Carbon Story calculators, which indicates that nearly the same emission factors and energy data were being used on both CF calculators. For the travel category, the CF result for the flight section is higher on Carbon Footprint calculator than on Carbon Story calculator. This result could be influenced by different carbon emission factors for travel carbon footprint calculations. The lifestyle carbon footprint result is also higher on Carbon Footprint calculator than Carbon Story, and this may be due to the fact that more details are required on Carbon Footprint calculator concerning the lifestyle of individuals, hence affecting the CF result.

Profile 3: Tony Ross

Tony Ross is a laboratory assistant at the University of Technology since 2010. He is a non-married man and lives alone in a 2-bedroom house near his place of work. He travels around 150km daily to work on his motorbike (medium 125cc – 500cc). His monthly household energy use for electricity is about 150 kWh and Liquefied Petroleum Gas is around 45L. Tony consumes a mixture of white and red meat and prefers organic food at times. He does not try to buy seasonal food and doesn't notice where the products he buys come from. He regularly buys the latest fashion and likes to have the latest technologies at home. He does not recycle his waste products regularly. Tony uses the standard bank services and does not own any car. He also enjoys carbon intensive activities like hiking. He does not travel abroad during his holidays.

The carbon footprint results of Tony Ross for the three CF calculators are shown in Table 4.5 below:

Categories	Carbon Footprint	Carbon Story	Earth Lab
Household energy use	2.12 metric tons of CO2e	1.48 tons	-
Travel	6.60 metric tons of CO2e	8.59 tons	-
Diet	7.48 metric tons of CO2e	1.15 tons	-
Lifestyle		2.12 tons	-
Total	16.20 metric tons of CO2e	13.83 tonnes	1.4 tons

Table 4.5: Carbon Footprint Result of Tony Ross

Similar to the previous two profiles, the final CF result for Tony Ross on Earth lab calculator differ by a very large amount (approximately 10-15 metric tons of CO_2e) compared to the results of the other two calculators. This large difference could unfortunately not be further analysed since it was not possible to determine which emission factors or data were used by Earth Lab calculator during it CF calculation. For Carbon Footprint and Carbon Story calculators, the CF results were almost similar in the various categories, except for Lifestyle result which was higher on Carbon Footprint calculator than that of Carbon Story calculator. This could be explained by the lifestyle choices of the individual, which were responsible for a higher carbon emission.

4.3 Critical Analysis of the Selected Carbon Footprint Calculators

The results from the three different profiles created demonstrate that among the three calculators, final value from Earth Lab CF calculator for the total carbon emission of any one of the individuals differ by a large amount when compared to the other two. This large variation is possibly due to the type of input required for a few categories. For the household energy use category, Carbon Footprint and Carbon Story require the annual electricity use to be input in kWh, whereas for Earth Lab this value needs to be selected among a range of optional values given in $US. Hence, there is a discrepancy while trying to convert the electricity energy consumption. Another major disadvantage in the Earth Lab CF calculator is in the travel category, the type of transport details to be inserted is limited to car vehicles only. Contrary to the other two, no annual mileage can be inserted for other public transports like bus or taxi, and no options are provided for the selection of motorbike vehicles. This lack of options can render the final average CF results for an individual inaccurate. Thus, the final CF calculators chosen for this study are Carbon Footprint and Carbon Story. The little variations present in the final results can be accounted for the extra details provided by Carbon Footprint in vehicle type selection and the additional information it requires in its Lifestyle category. The two CF calculators were selected because the difference in the final results of both calculators was not too high, hence enabling the calculation of the average value of an employee's carbon emission.

As highlighted in section 4.1, the concept of carbon footprint plays a critical role in the implementation of carbon mitigation measures. Being a quantitative representation of carbon emissions released in the atmosphere due to a particular activity, carbon footprint aids towards a more effective assessment of carbon reduction measures (Pandey, et al., 2011). The notion of measuring individual carbon emissions helps to spread awareness among consumers by providing information on how change consumption behaviours for a more sustainable lifestyle (Peters, 2010). The next section thus emphasizes on the need of using carbon footprint to reduce individual carbon emission, and the different ways of leading a sustainable and eco-friendly lifestyle.

4.4 Reducing Carbon Footprint

The literature showed that human beings have an impact on the global carbon emission and therefore possess a key role in achieving an environmentally sustainable and low-carbon society. However, the current statistics, both from Mauritius and globally, show that energy demand, fuel consumption and private travels are on the rise, thereby indicating that there are limits and bottlenecks in engaging the public and implementation of measures towards a low-carbon lifestyle (Ministry of Energy and Public Utilities, 2013).

The first limitation is that despite having a global awareness of climate variability, there is still a lack of knowledge and engagement from individuals on the exact nature of climate change and the measures to take in order to reduce the negative effects (Adger, et al., 2009). When compared to other vital societal concerns such as health or finance, climate change is given less priority over the others and therefore there is a general perception that climate change poses a threat to future generations and countries, and not an immediate personal problem to be tackled (Whitmarsh, et al., 2010; Bord, et al., 2000). This lack of concern is mainly because public literacy about global climatic change and its consequences is fairly low (Henry, 2000). The more the population becomes aware of global warming, the more people will feel personally responsible for it and the more worried human beings will be about their impacts on climate change (Kellstedt, et al., 2008).

Secondly, the nature of the impacts of climate change and global warming, for example, rise in temperature, increase in storm frequency or rise in CO_2 emission, makes it complicated for the public to understand or feel the climatic changes . Those climate consequences are considered as 'weak signals' due to the long time intervals of the occurences (Bord, et al., 2000). A study showed that due to the nature of the climate effects, the public tends to underestimate the real risks posed by climate invariability, and expect the climate effects to manisfest in the form of extreme and dramatic natural disasters in the future (Henry, 2000).

Governance is also a crucial factor in bridging the gap between formal adaptation measures and local communities and individuals (Kuruppu & Willie, 2014). A study revealed that in least developed countries especially, there is poor communication and management among the different tiers of government, which in the end result in a lack of engagement between formal national adaption efforts and personal individual ones among the populace (Kuruppu & Willie, 2014). This study therefore also investigates the barriers and motivations of tertiary education employees towards personal carbon emission reduction through the following research question:

RQ 6: What are the motivations and barriers involved in the reduction of individual carbon emissions?

To overcome the barriers, there is a need to develop new methods for individuals to understand, adapt and reduce their personal carbon emissions (Whitmarsh, et al., 2010). The first step towards overcoming the barriers of climate change is to raise awareness among the population, that is, provide useful information on how to reduce the emission of carbon dioxide in the daily activities.

4.4.1 Best Practices in Reducing Individual Carbon Emission

To help reduce carbon emissions, a list of best practices was prepared based on the derived taxonomy in chapter 2. The list covers the main activities of an individual in his/her daily life, that is, their daily energy consumption, diet, travels and lifestyle choices. It is vital to enlighten the employees of the tertiary education sector on how to adapt their lifestyle choices and daily activities so as to emit the minimum amount of carbon dioxide in the atmosphere. All the best practices listed in the table have also been derived from literature and prior research concerning green living principles. For each category, the best practices to implement were established within the Mauritian context. The aim was to help the local population adopt an eco-friendly lifestyle, with the resources and products available on the island. The best practices are listed in Table 4.6.

Category	Best Practices	Description
Household Energy Use	Use compact fluorescent light bulbs.	Traditional incandescent bulbs use a lot of energy to produce light. 90% of the energy is wasted as heat. Newer energy-saving bulbs such as CFLs and LEDs can produce the same amount of light as a traditional incandescent bulb while using significantly less energy (Carbon Footprint, 2014).
	Unplug appliances when not in use and avoid using stand-by.	Standby power is electricity used by appliances and equipment while being switched off or not performing their primary function. That power is consumed by power supplies, the circuits and sensors needed to receive a remote signal or displays including miscellaneous LED status lights (Carbon Footprint, 2014).
	Look for energy labels (Energy Star) when buying new appliances.	The ENERGY STAR logo is on all qualified products that meet specific standards for energy efficiency (United States Environmental Protection Agency, 2014).
	Increase your use of renewable energy sources, such as solar and wind energy.	Renewable resources, such as wind, water, solar, and geothermal, come from sources that regenerate after consumption and are continuously available (Perry, et al., 2008).
	Use water efficiently.	It takes a considerable amount of energy to deliver and treat the water. For example, letting the faucet run for five minutes uses about as much energy as letting a 60-watt light bulb run for 22 hours. Heating water for bathing, shaving, cooking, and cleaning also requires a lot of energy (United States Environmental Protection Agency, 2014).
	In the kitchen, don’t open the fridge door unnecessarily. Use microwave to reheat or cook small portions of food.	Cooking in microwaves can save up to 80% of energy (CarbonFund, 2014).
Diet	Eat seasonal fruits and vegetables mostly.	The average distance our food travels is 1500 miles, mostly by air and truck, and this increase the dependence on petroleum (Röös & Karlsson, 2013).
	Eat local food whenever possible.	
	Drink tap water instead of bottled water.	Transporting the bottles and keeping them cold burns fossil fuels (CarbonFund, 2014).
	Go for healthier food instead of heavily-processed ones.	Pre-packaged foods, fast food, and soft drinks are fast and convenient, but the production of these highly processed foods uses large amounts of materials and energy (Röösa, et al., 2013).
	Cut down on meat and dairy products.	In 2006 the Food and Agriculture Organisation of the United Nations estimated the carbon emissions associated with the livestock industry to be 18% of global emissions. That’s partly because cows burp methane. It’s also because of the fossil fuels that are used to grow grain to feed to cattle, to make processed feed cake for cattle to eat, to pump water for cattle to drink, to refrigerate meat, to transport refrigerated meat, and to sell meat in supermarkets in open fridges and freezers (Röösa, et al., 2013).
	Grow your own garden to reduce pollution.	Farms use energy to run tractors, irrigation pumps, and other farm machinery. But many farms also use large amounts of petroleum-based fertilizers and pesticides that

		also require energy to produce and transport. Almost all of this energy comes from using fossil fuels (CarbonFund, 2014).
Category	**Best Practices**	**Description**
Travel	Reduce your car use for short journeys	A cold engine uses significantly more fuel than a warm engine (CarbonFund, 2014).
	Walk instead of using other modes of transport whenever possible.	Walking does not release any GHG and thus is the preferred mode of transport (Carbon Footprint, 2014).
	Use public transport instead of private ones more often.	CO2 emissions per passenger for train and coach are, on average, six to eight times lower than car travel (CarbonFund, 2014).
	When stationary, switch off the engine.	Turning off the engine when stationary reduces the amount of harmful pollutants being released and saves on fuel (CarbonFund, 2014).
	When buying a new vehicle, make sure it is fuel efficient and low polluting.	New vehicles are more energy efficient (Carbon Footprint, 2014).
	Learn about the impact of air travel and if possible, choose vacation destinations close to home country	Although aviation is a relatively small industry, it has a disproportionately large impact on the climate system. It accounts for four to nine per cent of the total climate change impact of human activity. Compared to other modes of transport, such as driving or taking the train, travelling by air has a greater climate impact per passenger kilometre, even over longer distances (Rothengatter, 2010).
Lifestyle	Always remember to reduce, reuse and recycle. Composting organic waste and recycling paper and bottle waste can reduce GHG emissions.	Reducing waste is good for the environment because it conserves natural resources. Recycling means transforming waste in order to create new products rather than using virgin material, hence again preserving natural resources (Carbon Footprint, 2014).
	Buy second-hand or vintage clothing whenever possible.	Clothing production has enormous environmental impacts – for example, cotton is the world's most polluting crop, responsible for 25% of all pesticide use in the world each year, hundreds of thousands of cases of chemical poisoning and massive damage to the environment (CarbonFund, 2014).
	Avoid over-packaged products.	It is important to get the packaging balance right. Using recycled glass, metal, paper, board and plastic to produce packaging also helps to increase demand for recyclable materials (Carbon Footprint, 2014).
	Buy in bulk for everyday items to reduce packaging resources.	Buying bulk foods and items with less packaging reduces waste (Carbon Footprint, 2014).
	Teleconferencing instead of flying.	Reduces carbon emissions due to aviation (CarbonFund, 2014).
	Reduce junk mail and get your bills and statements online.	Reduces the use of paper production and household waste (CarbonFund, 2014).

Table 4.6: Best Practices for Individual Carbon Emission Reduction

The best practices from table 4.6 highlight carbon mitigation measures to take at the individual personal level. Literature demonstrated that individuals are neither very knowledgeable of the real consequences of climate change and high carbon emission, nor of the effective carbon mitigation actions to take (Akerlof, et al., 2013). As such, in order to determine the extent to which the Mauritian population are conscious of effects of high carbon emission, there is a need to perform both a survey and a sensitization campaigns to inform people on how to main a green living. It is important to understand the major practices currently being adopted by the Mauritians, and the effect current sensitization campaigns have on the local lifestyle choices. The research question below is therefore explored during the survey:

RQ 7: Are the employees aware of the key practices of how to reduce their carbon footprint emissions?

4.5 The Need for Sensitisation and Data Collection

As discussed in Chapter 2, one of the main barriers to carbon mitigation is the lack of awareness on environmental issues, and the harmful consequences associated with climate change (Jan C. Semenza, 2008). One of the main objectives of this study is to create an awareness campaign among employees of the tertiary sector on the increasing carbon emission issues, and its negative impacts in Mauritius. The sensitization campaign was not restricted to the general climatic conditions in Mauritius, but there was emphasis on creating awareness on carbon footprint more specifically. The sensitization campaign provided an opportunity to inform the public on the importance of measuring personal carbon emission, and using the result to reduce household carbon emission. The sensitization campaign also provided tips on leading a more eco-friendly lifestyle, and the best practices to reduce carbon emission at home.

Apart from raising awareness on the climatic conditions in Mauritius and the importance of carbon footprint, the research study also includes an analysis on how much employees in the tertiary education sector are aware of how to lead an eco-friendly lifestyle and keeping track of their carbon emission. In order to perform this analysis, it is vital to obtain data from the employees on their current lifestyles, their knowledge on environmental issues and carbon footprint more specifically. Hence, one of the main phases of this study consisted of performing a survey among employees in tertiary institutions to obtain the required data.

Chapter 5 - Methodology

As discussed in Chapter 3, the tertiary education sector was selected to perform the research study and the targeted participants were the employees of the sector. Therefore, it was imperative to work on the list of tertiary institutions in Mauritius for conducting the survey and to also calculate the sampling size. Since one of the initial objectives of the project was to sensitize employees on carbon footprint, the approach to use also needs to be explored. This chapter discusses the methodology adopted for the data collection process.

5.1 Tertiary Education Sector in Mauritius

In Mauritius, the tertiary education sector is managed by the Tertiary Education Commission (TEC) which is responsible for promoting, planning, developing and coordinating post-secondary education in Mauritius, in addition to implementing and overarching regulatory framework for the achievement of high international quality. This sector consists of 65 tertiary education institutions out of which 10 are public institutions and the rest are private institutions. The tertiary education institutions offer around 778 programmes, out of which 44% were being offered on a full time basis (Tertiary Education Commission, 2015). According to the Tertiary Education Commission (2014), the sector employed around 2,700 persons on a full-time basis, of which approximately 400 employees were working in private tertiary education institutions. Overall, around 30% of the employees were academic staff, 35% working in the administrative section, 15% in the technical/paraprofessional and 15% as services/maintenance cadres. The number of employees in the publicly funded institutions stood around 2,200 persons.

5.2 Sampling Strategy Employed

Before determining the sample size for each institution to be investigated, a few factors about the target population and sample size were considered:

- Population Size: For this research project, the targeted population were employees of tertiary education institutions. As discussed in the previous section, 2,700 are working for the tertiary education institutions and the targeted participants for the survey were both academic and administrative staff working on a full-time basis. Hence, the population size considered for the sample size calculation was 2,700.
- Margin of error: The margin of error considered during the sample size calculation was 5%.

- Confidence Level: A confidence level of 95% was chosen.

The assumption made during the sample calculation is that there exist no demographic differences among participants from the targeted population.

The calculated desired total sample size is thus 337 based on the use of the following formula:

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+(\frac{z^2 \times p(1-p)}{e^2 N})}$$

Where N = Population Size

E = Margin of error

Z = z-score

e is percentage, put into decimal form (for example, 3% = 0.03) (SurveyMonkey, 2015).

The z-score is the number of standard deviations a given proportion is away from the mean.

To meet the calculated sample size, ten tertiary education institutions in Mauritius (including both private and public) were selected for the survey. The ten selected tertiary education institutions formed part of those tertiary institutions in Mauritius with the highest employee population, and were all well-established institutions. The only exception is the University of Mauritius, which did not participate in the survey. The total number of staff per institution, along with the individual calculated sample size, is given in the following table:

Tertiary Institution	Total Number of Staff	Targeted Number of Participants
Middlesex University	45	39
JSS Academy	24	24
University of Technology, Mauritius	160	71
Open University of Mauritius	140	62
Université des Mascareignes	120	54
The Mauritius Institute of Education	300	73
The Mahatma Gandhi Institute	80	44
Ecole Hôtelière Sir Gaëtan Duval	50	34
Fashion and Design Institute	30	24
Charles Telfair Institute	70	50
Total	**1019**	**475**

Table 5.1: Sample Size Calculation for the Selected Tertiary Education Institutions

Once the list of targeted tertiary education institutions was finalised, approval had to be sought from these institutions so as to perform the survey among their employees. An email was sent to the Directors of each targeted institution explaining the purpose of the research project, and seeking their approval at the same time. All the tertiary institutions selected in the sample size agreed to participate in the research project, except for the University of Mauritius. The list of targeted institutions was then adjusted so as to meet the sample size.

5.3 Sensitisation Approach

A key objective of this study is to sensitise employees of the tertiary education sector on carbon footprint calculation and tracking. The approach used for the sensitisation process involved the use of a flyer which details the current climatic conditions in Mauritius, in addition to the calculation and tracking of carbon footprint. Furthermore, a list of the best practices for carbon emission reduction was provided in the flyer (as highlighted in section 4.4) in order to inform the participants on how to lead an eco-friendly lifestyle and reduce their carbon emissions. A flyer was used because it is known to provide a combination of visual artistry along with a combination of strong texts, hence facilitating the understanding of the concepts in question. According to Anton and Aranaz (2011), flyers have also been one of the most used and powerful channels of propagation for advertising and sensitization. Since one of the main purposes of this project was to emphasize on the need to be more environmentally conscious, the flyers were not printed and distributed to employees. Alternatively, a more eco-friendly sensitization method was chosen so as to minimise printing in order to reduce paper, ink and electricity consumption. This is in the form of a blog, created specifically for this study, on which a copy of the flyer was made available for viewing and downloading. The blog also contained details on this study, along with more information on carbon footprint calculation and reduction.

Consequently, during the survey, the employees were shown a copy of the flyer, and were given an overview on the research project, the concept of carbon footprint and the best practices to reduce carbon emission in their daily activities. The employees were also given a small card containing the web link to the research blog as a reminder to view and obtain more information on carbon footprint. A face-to-face approach was used while sensitizing the employees on carbon footprint to be able to obtain individual feedbacks from the participants and also enabling them to express their own and ask questions in order to better understand the importance of carbon footprint calculation and tracking. A copy of the flyer and the card is given in Appendix A and B respectively.

5.4 Survey Instrument

The first step in the data collection process was to prepare and design the survey forms. The survey form and relevant questions were based on the taxonomy developed in section 2.3. Three sections of the survey forms included the participants household energy use, daily travel details and general diet and lifestyle choices. In order to obtain an accurate result, the questions and optional answers provided on the survey forms were similar to those of the calculators used in this study, namely from CarbonFootprint and CarbonStory as discussed in the previous chapter. Another section of the survey form included questions related to carbon footprint awareness and calculation and environmental concerns. These questions provided an insight on the level of awareness on 'carbon footprint' and how employees are keeping track and attempting to reduce their personal carbon emissions. The details provided by the participants for these queries also enabled RQ2 to be investigated, as stated in Chapter 3. The last section of the survey form was to collect the background information of the participants so as to get details related to their role in the tertiary education institution, income and address.

Then, a first draft of the survey form was prepared and a pilot test was conducted at Middlesex University among five participants to evaluate how the participants would respond to the questions. The five participants selected belonged to different departments and had different job positions at the tertiary education institution. The participants were academic and administrative staff. This type of selection allowed for a more detailed and reliable feedbacks since the targeted participants for the study were employees belonging to different job positions, both academic and administrative. Feedbacks obtained from the selected participants were used to improve the survey form. One of the main problems faced by participants was the necessity to give their monthly electricity and Liquefied Petroleum Gas consumption. Most of the participants did not know those values in the required units, that is, KWh and Kg respectively. Hence additional options were provided to write down the monthly electricity consumption in terms of cost and the LPG consumption in terms of number and type of cylinders used per month. Those details were later be converted into the required units before the carbon footprint calculation. In the Mauritian households, heating oil is not used for home heating systems. Some of the participants misunderstood the term heating oil as the types of oils used for cooking purposes. Those values were discarded during carbon footprint calculation and only electricity and LPG values were taken into consideration. In the Travel section, a few participants did not know their daily distance travelled, and thus, an additional option was added to precise the regions the participants travel to and from. These details would then be used so as to calculate the distance travelled. For this, a distance calculator (DistancesFrom.com, 2014) was used where the different regions indicated by the respondents were input on the calculator and the distance per trip was obtained. This value was then used to calculate the annual distance travelled. An assumption was also made during the transport carbon footprint calculation in cases where the participants did not list the model and year of manufacture of their private cars. An average model car option provided by the calculator was then used.

5.5 Survey Administration

After receiving the approval to conduct the survey in the premises of each targeted institution, a meeting was arranged between one of the members of the research project and a staff of the institution in order to further discuss the research project and how the survey would be conducted.

Via the adopted one-to-one sensitization approach, selected employees were briefed on the purpose of the research project and were explained about carbon footprint and how to reduce carbon dioxide emission in their daily activities, while making reference to the flyer. The employees were then given the survey forms and asked to fill in the required details accordingly. Employees who had difficulties completing the forms were helped to do so by the team member and their queries were also answered.

5.6 Reliability and Validity

After that an employee has filled-in the questionnaire, same was collected and verified so as to ensure the reliability and validity of collected data. This process involved checking whether the key information related to carbon footprint calculation were properly filled in within the questionnaire. Any odd or incoherent information detected was quickly clarified with the participant.

5.7 Data Analysis

Once survey has been completed within a tertiary education institution, the carbon footprint of each employee was calculated using the selected Carbon Footprint and Carbon Story online calculators and based on respective questionnaire. The collected data from the questionnaire, in addition to the results were then input on SPSS for statistical analysis and to answer the different research questions as part of the study. This process involved entering data from each section of the questionnaire and the related carbon footprint results from both calculators into the SPSS file followed. The data input were then thoroughly analysed via the use of different graphs and charts.

After the analysis process, the carbon footprint results were communicated to employees who requested details on their carbon emissions.

5.8 Key Challenges Faced

There were many difficulties faced during the survey, and immediate solutions had to be implemented in order to make the survey and the research project as a whole successful.

One major difficulty encountered during the study was getting access to the targeted tertiary education institutions. In many cases, the Directors or Head of Departments had to be contacted several times via email or telephonic conversations so as to gain access to their institution and also to get support of their staff to participate in the study. This caused delays in the data collection phase of this study.

The second difficulty encountered during the survey was meeting the participants during their free time. Since the survey was conducted during office hours, it was difficult to meet the participants and get them to participate. Many of the academic staff were busy in their lectures, and hence could not be contacted to participate in the survey. Some of the employees were also unwilling to participate in the survey due to privacy concerns or lack of time. A minimum of three to four days were spent in each institution in order to complete the survey successfully.

The third challenge encountered was related to the carbon footprint calculation process. As discussed earlier in this chapter, many employees did not know their monthly electricity consumption, neither in terms of kWh nor cost, and their LPG consumption as well. Since it was not possible to obtain an average value of monthly electricity consumption per household from the Central Electricity Board, an average value for the electricity consumption of all participants was calculated and assumed for cases where the employee did not state any monthly consumption. The same was done for the monthly LPG consumption.

Another difficulty related to the same electricity and LPG consumption questions was for those cases where the participants stated their monthly consumption in terms of cost for electricity and number of cylinders for LPG. For the electricity consumption, the values were converted to KWh using the latest tariffs provided by the Central Electricity Board's website[3]. The annual electricity consumption was then determined by multiplying the monthly consumption values by 12. For LPG,

[3] Central Electricity Board, 2015. *Domestic Tariff.* [Online] Available at: http://ceb.intnet.mu/ [Accessed 15 7 2014]

the monthly consumption values were determined in Kg by multiplying the number of cylinders used with either 12.2 kg or 5kg, depending on the cylinder types. The large cylinder contains 12.2 kg of LPG and the smaller one contains 5kg. The annual consumption was then calculated.

Chapter 6 - Results and Discussion

Based on the collected data, the individual carbon footprints of the employees were estimated on an annual basis using the two carbon footprint calculators selected in Chapter 4, and the final results were averaged. This chapter discusses the results obtained from the survey conducted, and provides an analysis of the research questions which were studied as part of this research project.

6.1 Participating Tertiary Education Institutions

The survey was conducted in ten tertiary institutions in Mauritius. Table 6.1 shows the list of institutions, along with the total number of staff, including both academics and non-academics, and the total number of employees who participated in the survey for each institution. A total number of 440 employees took part in the survey. As shown in table 6.1, for a few institutions, the number of participants does not correspond to the ideal number of participants calculated in the sampling. This is mainly because many staff in the tertiary education institutions, especially the academic staff, could not participate in the survey due to their busy time schedules, as discussed at the end of Chapter 5.

List of Institutions	Total number of staff	Total number of participants
Middlesex University	45	40
JSS Academy	24	24
University of Technology	160	83
Open University of Mauritius	140	62
Université des Mascareignes	120	47
The Mauritius Institute of Education	300	74
The Mahatma Gandhi Institute	80	47
Ecole Hôtelière Sir Gaëtan Duval	50	25
Fashion and Design Institute	30	18
Charles Telfair Institute	70	20
Total	**1019**	**440**

Table 6.1: List of Institutions which Participated in the Survey

6.2 Participants Profile

6.2.1 Gender Distribution

60.4% of the employees who participated in the survey were female and 39.6% were male.

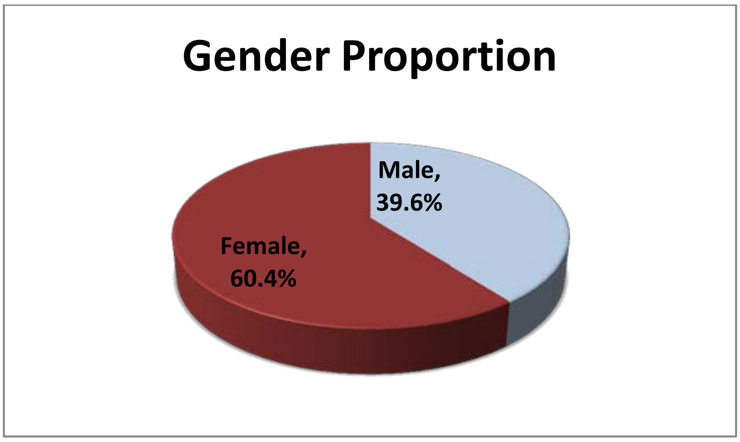

Figure 6.1: Gender Distribution of Participants

6.2.2 Age Distribution

The age groups to which the participants belonged to are shown in figure 6.2. One-third of the participants were between the age of 31 and 40 and the smallest percentages in the sample age distribution were participants above the age of 60.

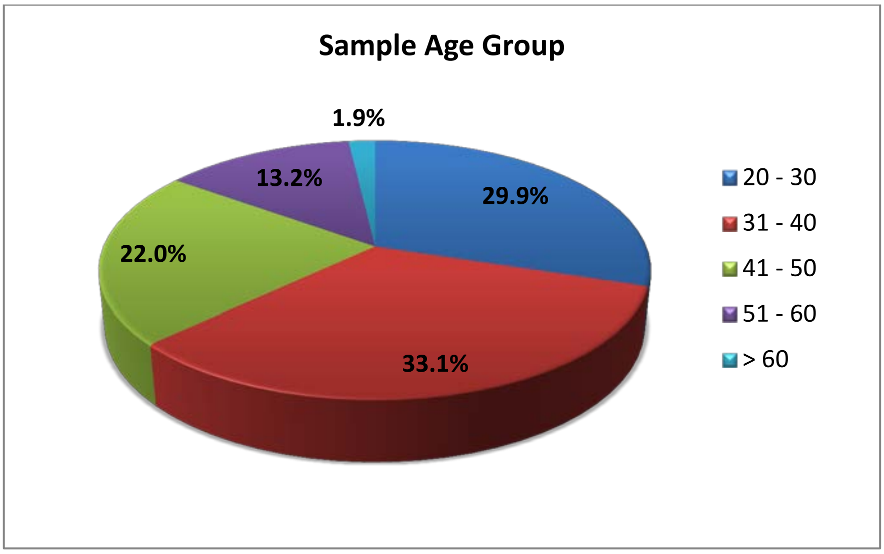

Figure 6.2: Sample Age Group of Participants

6.2.3 Job Profile Distribution

The pie chart in figure 6.3 shows the percentage of participants who were administrative staff and academic staff. According to the result, there were more participants who belonged to the administrative department than the academic department. This was mainly due to the fact that the administrative staffs were more available that the academic staffs to participate in the survey. 5% of the participants did not specify their job position out of privacy concerns.

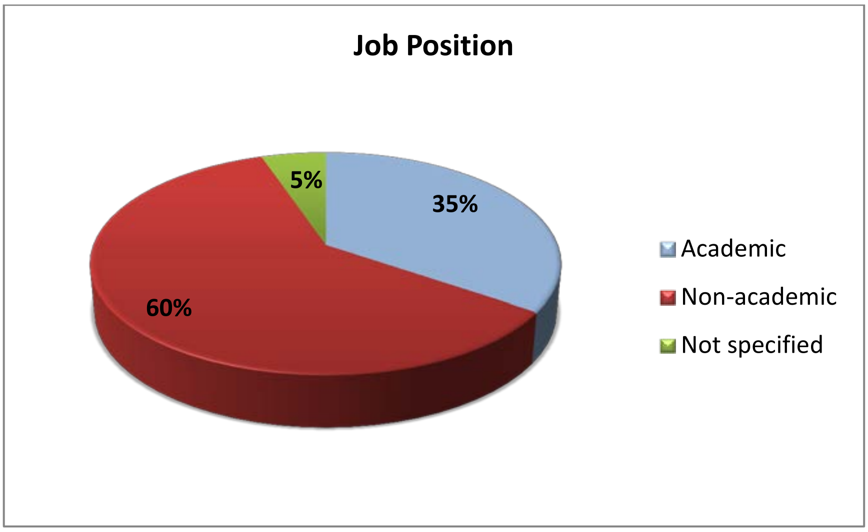

Figure 6.3: Job Position of Participants

6.2.4 Income Distribution

The monthly income range of the participants is illustrated in the bar chart in figure 6.4. 10% of the participants chose not to specify their income range due to privacy reasons.

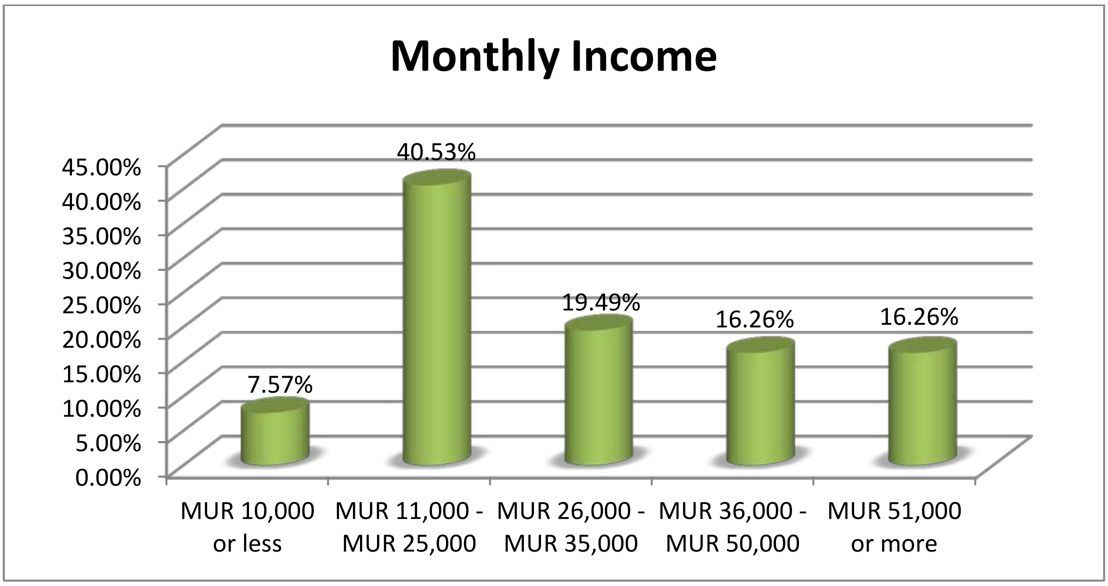

Figure 6.4: Monthly Income Range of Participants

The majority of the respondents stated an income range of MUR 11,000 – 25 000 and less than 10% of the participants stated a monthly earning of less than MUR 10, 000. From the observation made during the survey, the administrative staffs earned a lower income as compared to the academics and employees in high-level administrative job position. Table 6.2 shows a cross tabulation result of how the income range of the participants varies according to the job position stated and aids to better understand the income distribution. From the result, more than half of the academic staff (59.2%) earned more than MUR36, 000 whereas among the administrative staff, the percentage number is 13.2%. The lowest income range that is, MUR 10, 000 or less, consists of 2% of academic staff and 9% of administrative staff. These results demonstrate that academic staffs earned a higher income than most of the administrative staff, except those in directorial positions. Based on the positive correlation between economic growth, lifestyle and energy consumption discussed in Chapter 2, it is assumed that academic staffs have a higher carbon footprint than administrative staff, due to a higher income range and better lifestyle, and which eventually result in higher energy consumption. This is further analysed in section 6.5.16.

Job Position * Monthly income range in MUR Cross tabulation

			Monthly income range in MUR				
			MUR 10,000 or less	MUR 11,000 - MUR 25, 000	MUR 26,000 - MUR 35,000	MUR 36,000 - MUR 50,000	MUR 51,000 or more
Job Position	Academic Staff	Count	3	19	31	45	45
		% within Job Position	2.0%	12.5%	20.4%	29.6%	29.6%
		% within Monthly income range in MUR	11.1%	12.3%	40.8%	72.6%	71.4%
		% of Total	0.7%	4.6%	7.4%	10.8%	10.8%
	Administration Staff	Count	24	136	45	17	18
		% within Job Position	9.1%	51.3%	17.0%	6.4%	6.8%
		% within Monthly income range in MUR	88.9%	87.7%	59.2%	27.4%	28.6%
		% of Total	5.8%	32.6%	10.8%	4.1%	4.3%
		Total	6.5%	37.2%	18.2%	14.9%	15.1%

Table 6.2: Cross Tabulation of Job Position against Monthly Income Range

6.3 Carbon Footprint Awareness

6.3.1 Extent of 'Carbon Footprint' Calculation Awareness

From the responses of the participants, 50.8 % have heard of the term carbon footprint before, and 49.2% of the participants stated that the term "carbon footprint" was new to them. Among the participants who did not know about the term "carbon footprint", 25.7% of them were academic staff, and 74.3% of them were staff from the administration. This finding indicates that almost half of the employees in tertiary education sector were unaware of the carbon footprint concept and how to track and calculate their carbon footprint. This result may be deemed worrying, considering the effort made by the government in engaging in low-carbon activities and sensitization campaigns.

Only 4.8% of the participants were aware of the techniques and calculators used to calculate personal carbon emission. This figure is alarmingly low, especially in tertiary education institutions which are key players to help individuals develop better working and environmental ethics. Referring to table 6.3, only 9.2 % of the academic staff knew how to calculate their carbon footprint, which is a relatively very low figure. Academic staffs are the ones who are closer to students and key players in the field of research, and a lack of knowledge on carbon footprint calculation can result in a slower attempt in tracking and reducing the personal anthropogenic carbon emission in Mauritius. The cross tabulation for job position and carbon footprint calculation awareness is given in Table 6.3.

Job Position * Carbon Footprint Calculation Awareness Cross tabulation

			Carbon Footprint Calculation Awareness		Total
			No	Yes	
Job Position	Academic Staff	Count	138	14	152
		% within Job Position	90.8%	9.2%	100.0%
		% within Carbon Footprint Calculation Awareness	34.8%	70.0%	36.5%
		% of Total	33.1%	3.4%	36.5%
	Administration Staff	Count	259	6	265
		% within Job Position	97.7%	2.3%	100.0%
		% within Carbon Footprint Calculation Awareness	65.2%	30.0%	63.5%
		% of Total	62.1%	1.4%	63.5%
		Total:	95.2%	4.8%	100%

Table 6.3: Cross Tabulation for Job Position and Carbon Footprint Calculation Awareness

To investigate RQ 3, stated in Chapter 3, the participants were asked whether their carbon footprint have been calculated before. Only 2% of the total participants have calculated their carbon footprint at least once using one or several of the free online calculators, as illustrated in Figure 6.5. The percentage of employees who have calculated their carbon footprint was found to be extremely low and shows that there are not enough incentives in tertiary institutions of Mauritius to encourage employees to measure and reduce carbon emission. According to feedback received from the survey, many employees did not know that there exist tools to help in measuring and keeping track of personal carbon emission. This indicates the urgent need in sensitizing employees and the public in general on carbon footprint and how to reduce one's carbon emission through regular measurement.

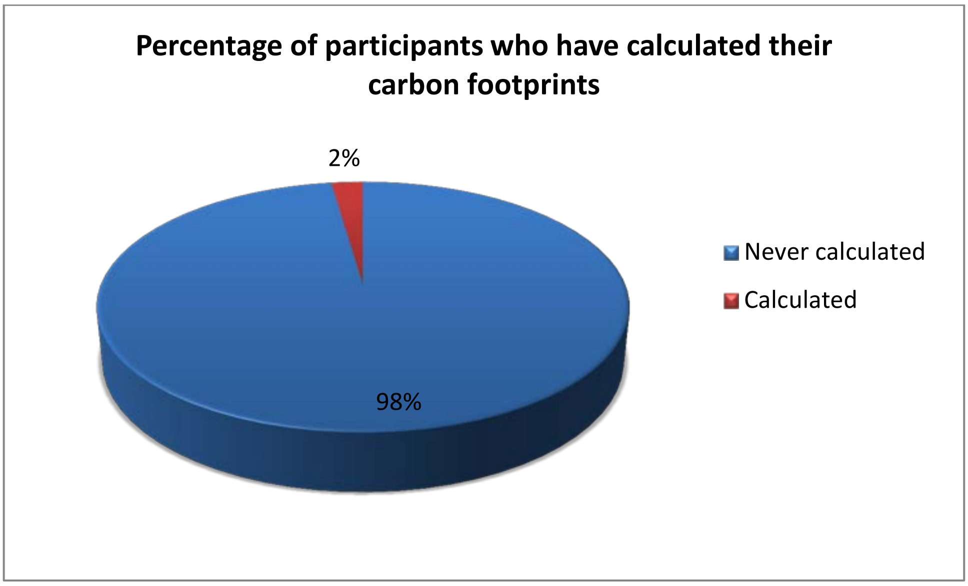

Figure 6.5: Percentage of Participants who calculated their Carbon Footprint

The different carbon footprint calculators used by the participants are shown in figure 6.6. The online calculator from carbonfootprint.org is the most common one used. One participant listed EPA[4], MyClimate[5] and Nature.org[6] as some of the other calculators used. The popularity of Carbonfootprint.org in the Mauritian context is due to the fact that it calculates the carbon emission of individuals based on the data and emission factors from Mauritius and hence making it more reliable. Furthermore, the website name as well refers directly to carbon footprint calculation and the tool is well indexed on search engines.

[4] United States Environmental Protection Agency, 2015. *Carbon Footprint Calculator*. [Online] (1) Available at: http://www3.epa.gov/carbon-footprint-calculator/ [Accessed 18 June 2014]
[5] myclimate, 2015. *Calculate your CO2 footprint and see how you can offset it.* [Online] (1) Available at: http://www.myclimate.org/ [Accessed 16 June 2014]
[6] The Nature Conservancy, 2015. *Carbon Footprint Calculator*. [Online] (1) Available at: http://www.nature.org/greenliving/carboncalculator/ [Accessed 16 June 2014]

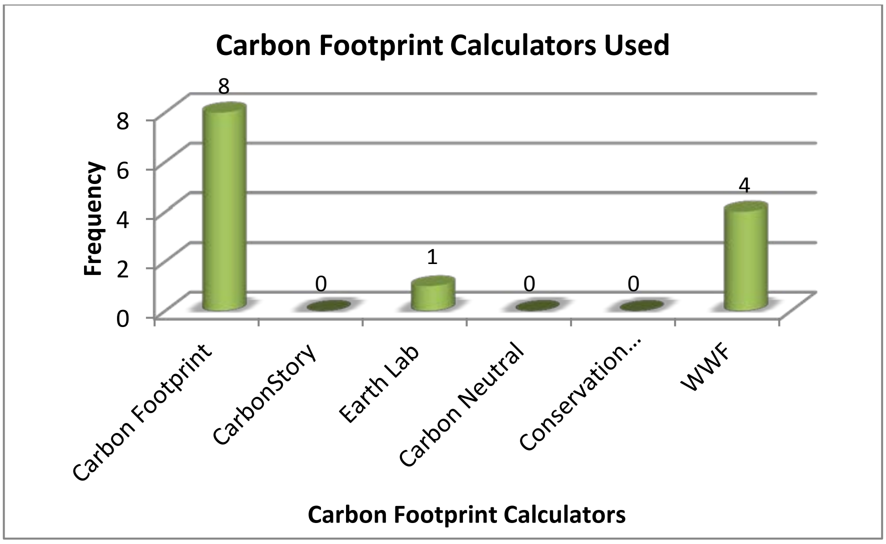

Figure 6.6: The Most Common Carbon Footprint Calculators used by the Participants

6.3.2 Carbon Footprint Results of Participants based on Carbon Footprint Awareness

The variation on the average carbon footprint result depending on whether employees were aware of the carbon footprint concept or not is illustrated in figure 6.7. The average carbon footprint of the employees who were aware of the concept of carbon footprint was higher than for those employees who have not heard the term before. According to Table 6.4, the percentage of participants who were aware of the concept of carbon footprint and who belonged to the academic staff (65.6%) is higher than for those participants who belonged to the administration staff (43.4%). These results mean that academic staffs had a higher carbon footprint than administration staff, despite being more conscious of the term carbon footprint. As shown in Table 6.2, the academic staff had a higher salary income range compared to the administrative staff. This result indicates that the income range, and hence the lifestyle choices of the participants have an impact on their carbon footprint result. Despite being more aware of the concept of carbon footprint, academic staff, with higher income range, had a higher carbon footprint than administrative staff. This result shows that apart from creating awareness on the importance of carbon footprint, there is a need to provide effective solutions on how to use carbon footprint calculation as a means to measure and reduce personal carbon emission of the individuals.

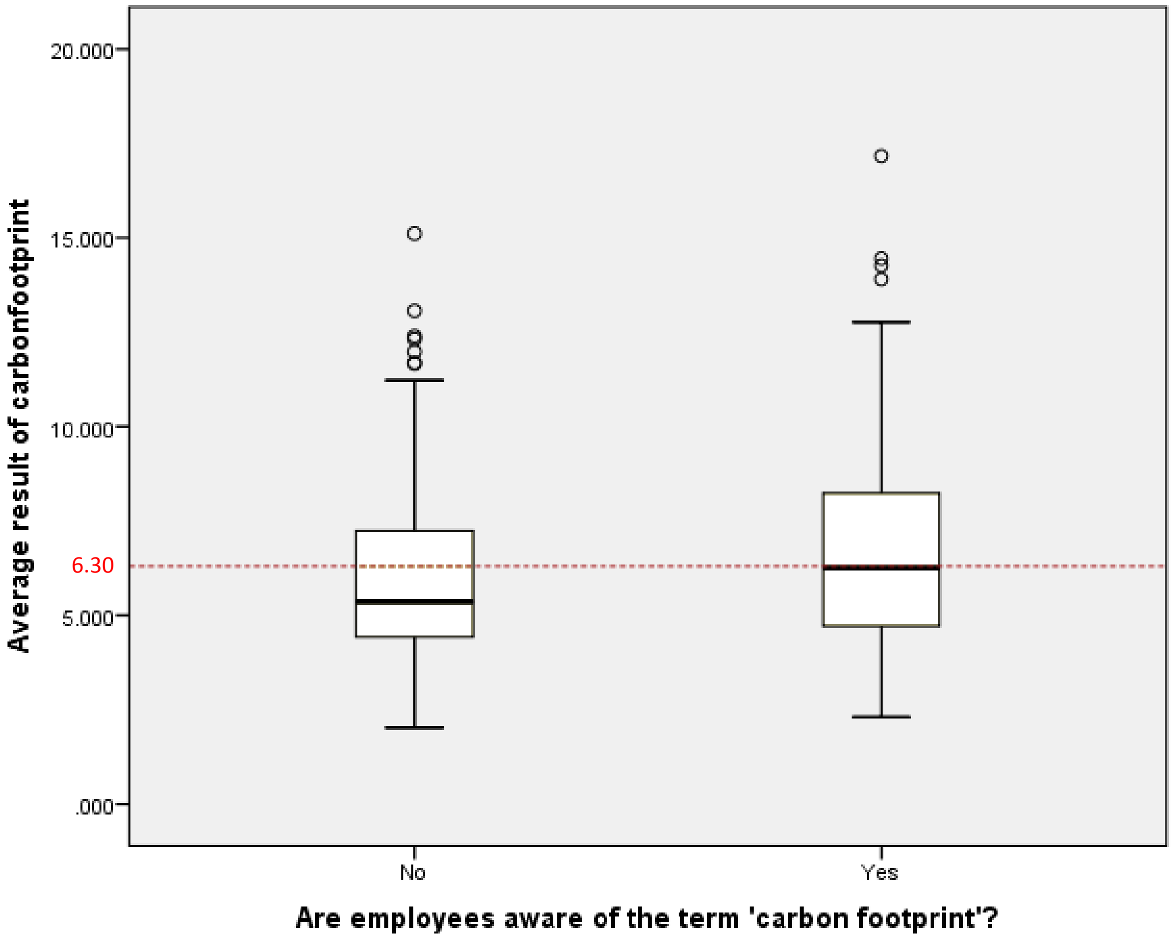

Figure 6.7: Comparison of carbon footprint result of employees based on their awareness of the carbon footprint concept

Job Position * Are employees aware of the term 'carbon footprint'? Crosstabulation					
			Are employees aware of the term 'carbon footprint'?		Total
			No	Yes	
Job Position	Academic Staff	Count	52	99	151
		% within Job Position	34.4%	65.6%	100.0%
	Administration Staff	Count	150	115	265
		% within Job Position	56.6%	43.4%	100.0%
Total		Count	202	214	416
		% within Job Position	48.6%	51.4%	100.0%

Table 6.4: Carbon Footprint Awareness against Participant Job Position Cross-Tabulation

After calculating their carbon footprints, individuals are expected to keep track and reduce their carbon emissions. In order to analyse the carbon footprint results of those participants who have calculated their carbon footprint at least once, a box-and-whisker diagram was created as shown in figure 6.8. According to the result, those participants who have calculated their carbon footprints have a lower carbon footprint range than those who have never calculated their carbon footprints.

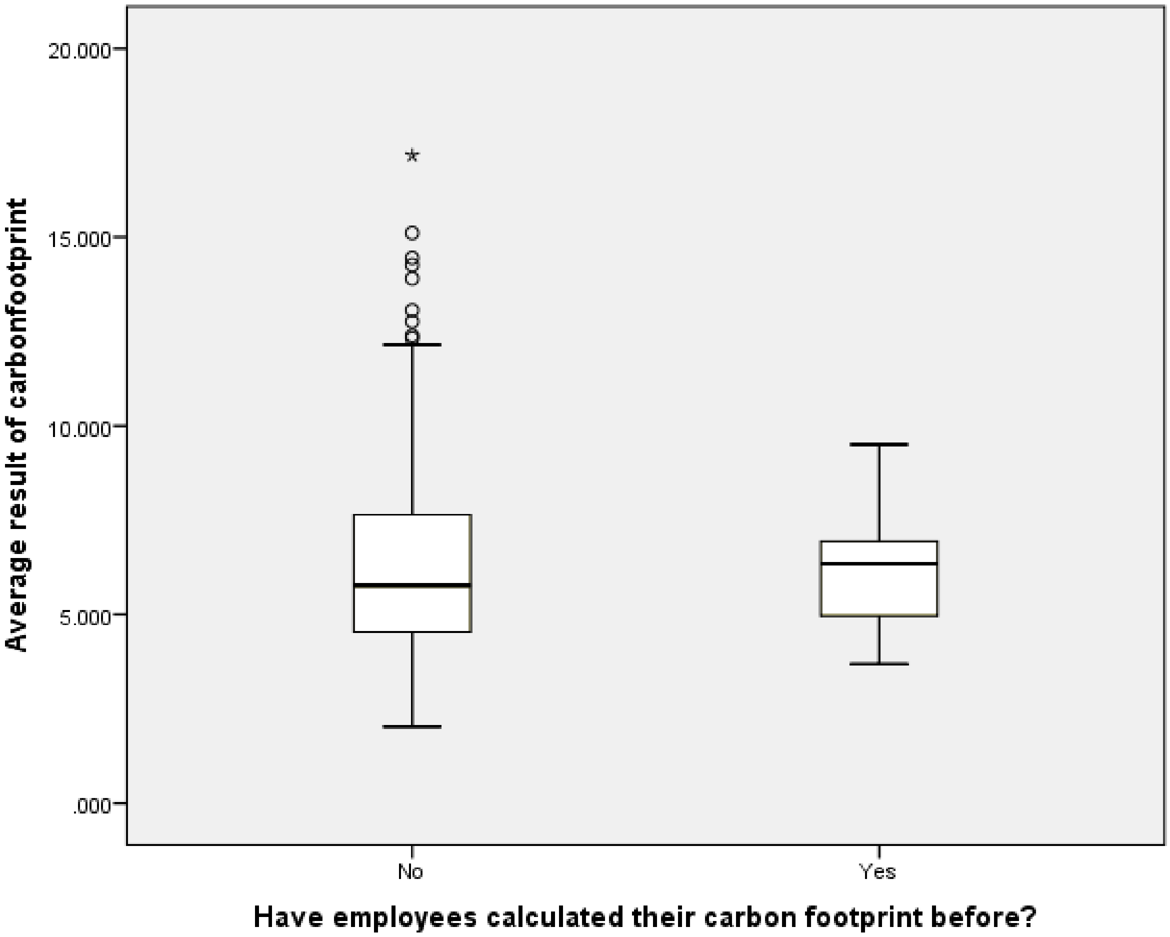

Figure 6.8: Comparison of carbon footprint result based on whether or not employees have calculated their carbon footprint before

6.4 Opinions on current carbon mitigation measures in Mauritius

The participants were asked on current personal carbon emission reduction practices being adopted and the barriers preventing them from adoption any eco-friendly measures in Mauritius. This section analyses the results obtained on the carbon mitigation practices of the participants.

6.4.1 Motivating Factors for Carbon Footprint Calculation

The major reasons motivating the participants to determine their personal contribution to the rising carbon dioxide emission and to learn more about carbon footprint calculation are illustrated in figure 6.9. This chart is also related towards answering RQ 6 (stated in Chapter 4). The majority of participants listed their personal desire to adopt a more eco-friendly lifestyle as the main reason to calculate their carbon footprint. The willingness of the participants to adopt eco-friendly attitudes could be influenced by the level of education and awareness received through different mediums on protecting the environment and also due to personal beliefs on the fragility of Nature and the need to avoid destroying natural resources (Dietz, et al., 1998). In the context of this study, the fact that employees are willing to learn and adopt eco-friendly actions can facilitate the implementation of a carbon management framework in the tertiary education sector and the tracking and reduction of employee carbon emission.

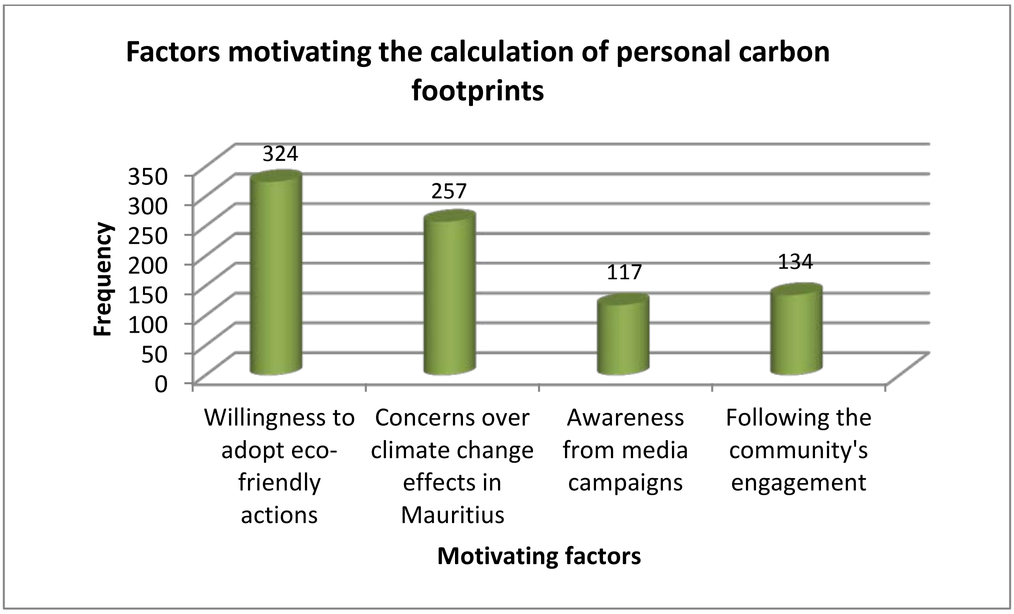

Figure 6.9: Reasons which would encourage the participants to calculate their carbon footprints

6.4.2 Barriers to Carbon Emission Reduction

This section also analyses the research question related to the barriers involved in the reduction of personal carbon emission. The participants were asked to identify the main reasons preventing them to change their current lifestyle for a more environment-friendly one. As shown in figure 6.10, more than half of the participants specified that an insufficient knowledge of effective and viable eco-friendly actions were the main reason for an inability to lead a green lifestyle. This shows that even though the measures taken by different stakeholders do aid to raise awareness on environmental issues, there is not enough resources provided to help the employees in understanding the causes of climate change and carbon emission, and what measures could be taken in reducing carbon emission at the personal household level. This result answers the last research question (RQ 7) of the study; on whether employees are aware of the key practices of how to reduce their carbon footprint emissions. This result also supports the barriers of carbon emission reduction stated by Kuruppu & Willie (2014) and shows that in Mauritius, the sensitization campaigns are not effective enough to help people reduce their carbon emission. Moreover, nearly half of the participants also mentioned the lack of renewable energy alternatives and more eco-friendly alternatives to activities like driving to work or household energy use. This shows that there is still a lot to be done in Mauritius to cater to the non-renewable energy usage.

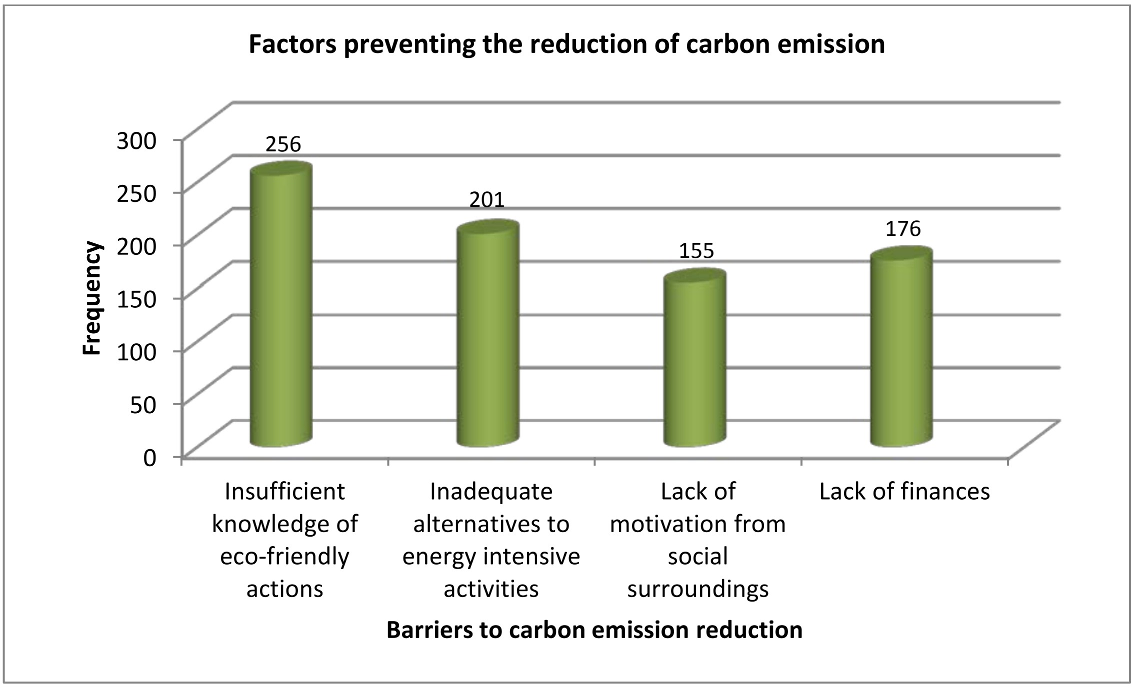

Figure 6.10: Factors preventing the participants from calculating their carbon footprints

6.4.3 Carbon Reduction Initiatives

Out of the total 440 participants, 8.9% of the participants agreed that enough was being done in Mauritius by the different related stakeholders to help individuals reduce their personal carbon dioxide emission. However, 89.1% disagreed and this indicates that majority of the participants feel that not enough is being done to support individuals in adopting a greener living and that the actual sensitization campaigns and actions undertaken by the government have not been helpful and efficient so far. According to the respondents, the government is the main player in aiding the implementation of proper policies and eco-friendly schemes in different sectors, including the tertiary one, and at present, the measures taken to reduce carbon emission are not as well-organized and successful. Furthermore, there are different factors which prevent individuals from taking the initiatives to reduce their personal carbon emission, such as lack of information. This result points out the emergency in reviewing the current sensitization and mitigation measures for carbon emission in Mauritius and the need to implement a better carbon management strategy. According to the participants, the main opinions on how to reduce carbon emissions are given in Figure 6.12.

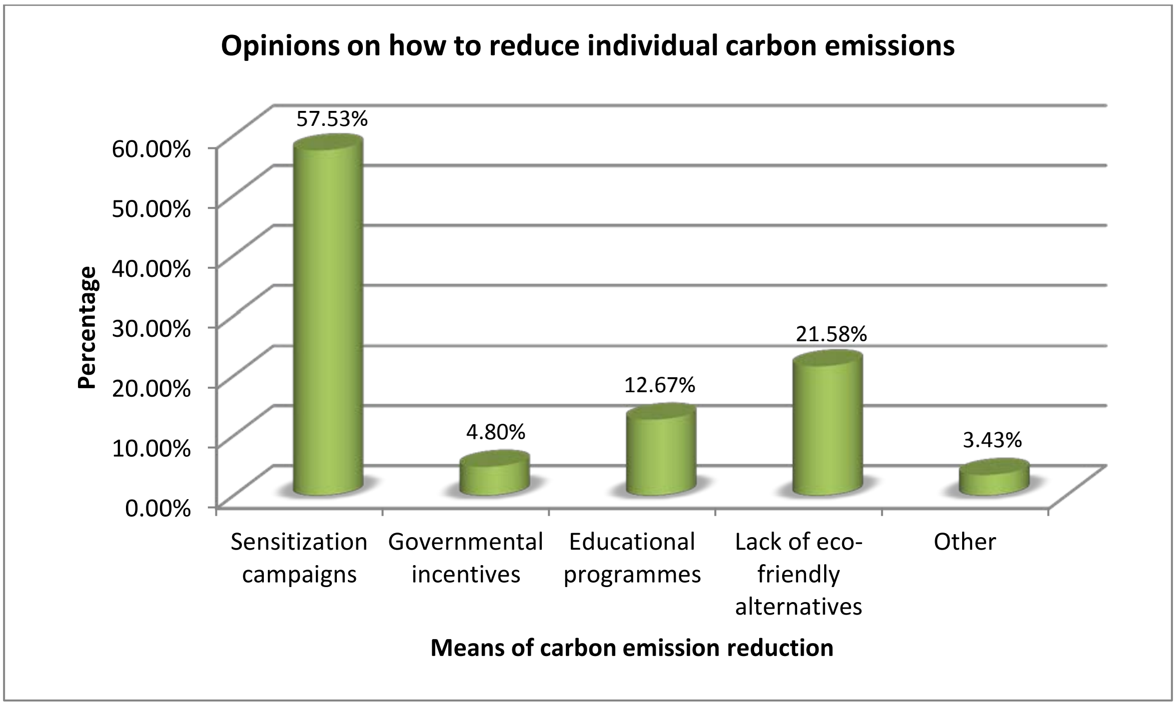

Figure 6.11: Methods of reducing carbon dioxide emission at the individual level

More than half of the participants stated that there is a need to be educated on effective eco-friendly measures to adopt for a greener lifestyle through sensitization campaigns on television, newspapers and other media. During the survey, the participants were informed on the importance of reducing their personal carbon emissions and on the different ways of achieving this in their daily routine activities. In order to ensure that employees from the tertiary education institutions keep track of their carbon footprint and that the best practices on carbon emission reduction are being implemented at home, there is a need to develop some monitoring strategies at the tertiary education institutions level. 21.58% said there is a serious lack of renewable energy alternatives and eco-friendly products in Mauritius. The 3.43% of participants mentioned other measures like there should be more strict laws related to protecting the environment as an incentive for individuals to adopt an eco-friendly lifestyle. As observed during the survey, the participants did not know which of their daily activities contribute most to carbon emission and what eco-friendly alternatives exist in Mauritius.

6.4.4 Current Incentives on Adoption of Eco-friendly practices

The participants were queried on how they applied some carbon emission reduction practices at home. The result is displayed in Table 6.4.

	Rarely	Often	Always
Reduce consumption of heavily-processed food.	33.6%	50.7%	12.7%
Use water efficiently.	3.9%	34.1%	60.%
Avoid eating meat.	41.1%	39.8%	16.1%
Eat organic food as much as possible.	38.2%	44.3%	13.6%
Recycle majority of waste products.	50.5%	34.5%	11.8%
Use e-services instead of paper-based systems.	20.5%	51.8%	24.3%
Replace energy sources with renewable ones.	43.4%	40.7%	11.4%
Turn off lights when not using.	3.4%	21.8%	72.3%
Reduce personal transport vehicles for short journeys.	28.2%	39.1%	28.9%
Use public transport instead of private ones whenever possible.	41.1%	32.7%	23.6%

Table 6.4: Adoption of eco-friendly measures by the Participants

The above categories in Table 6.4 are further discussed as follows:

Reduce consumption of heavily-processed food: Half of the participants tried their best to avoid the consumption of canned food, and the availability of fresh fruits and vegetables in Mauritius help them in avoiding imported or heavily-processed food. Nearly 34% of the respondents rarely adopt this particular measure since according to them, it is not possible to avoid the consumption of some particular foods which are not available in Mauritius or which are not available in any other forms except in cans. Some participants also did not know what heavily-processed foods are or how these are responsible for carbon emission.

Use water efficiently: Most of the participants apply this measure since avoid water wastage is the most common eco-friendly measure mentioned in sensitization campaigns. This indicates that the aggressive campaigns undertaken by different stakeholders on efficient water management did positively impact the lifestyle of the population. These sensitization campaigns were also due to the water shortage situations faced by Mauritians, which forced individuals to make diligent use of water resources. Hence, it can be deduced that similar campaigns on the other effective carbon reduction measures would have a similar effect on the public and would enable the better understanding of the contributing factors of human carbon emission.

Avoid eating meat: The result indicated a mixed feeling among respondents. Majority of the participants were non-vegetarians, and find it difficult to reduce their meat consumption. During the survey, it was observed that some of the participants did not know that the reduction of meat consumption could result in a decrease in personal carbon emission reduction through less manufacturing processes and carbon emission due to transportation vehicles.

Eat organic food as much as possible: According to the result, 44.3% of the participants try and buy organic food, while being aware that organic food consumption involves a reduction in carbon emission through less carbon generated in the production of synthetic pesticides and fertilisers.

Recycle majority of waste products: Results showed that 50% of the participants rarely recycle their waste products. From the observations made during the survey, the participants could not recycle their waste products due to a lack of awareness of recycling systems available in Mauritius. Among the 12% of participants who mentioned practising waste recycling, majority of them referred to composting of their organic wastes only, and not plastic or paper garbage. This finding indicates the need for an efficient waste recycling system in Mauritius by the concerned governmental bodies.

Use e-services instead of paper-based systems: Most of the participants do use online services and other digital services, hence indicating that current sensitization campaigns on reducing use of paper and protecting natural forests have a positive impact on the public. But the use of online and digital services also results in energy consumption through electricity usage mainly, and therefore there is a need to also sensitize individuals on reducing the power consumption associated with digital services as well.

Replace energy sources with renewable ones: Nearly half of the participants rarely use renewable energy sources, and around 40% of the participants try to replace non-renewable energy sources with renewable ones. As per observations made during the survey, the participants could not adopt this eco-friendly measure due to the unavailability of renewable energy sources. According to some of the participants, there exist no alternatives to household energy use, except for solar energy which is used solely for heating purposes. This confirms the lack of awareness among participants on other household renewable energy sources.

Turn off lights when not using: Almost three-quarter of the participants agreed on turning off lights in rooms when not in use. This result is probably due to aggressive campaigns made on saving energy. It should nevertheless be noted that such awareness campaigns often target household electricity usage, and not electricity consumed at the workplaces.

Reduce personal transport vehicles for short journeys: According to the result, the majority of the participants try to apply this measure whenever possible. 28.2% of the participants do not apply this carbon emission reduction measure. This figure could be influenced by the lack of alternative transport vehicles to be used by the participants, or a refusal to use public transport due to the perceived lack of comfort (Mackett, 2003).

Use public transport instead of private ones whenever possible: Almost 40% of the participants rarely choose to travel in public transports. From the feedbacks obtained during the survey, the participants mentioned that the poor quality of public transports in Mauritius prevents them from travelling in those transports. This indicates the need for the government to invest in energy-efficient, comfortable and quality-based public transport vehicles.

6.5 Carbon Footprint of Participants

The following pie chart in figure 6.13 shows the percentage number of people in the homes of the participants.

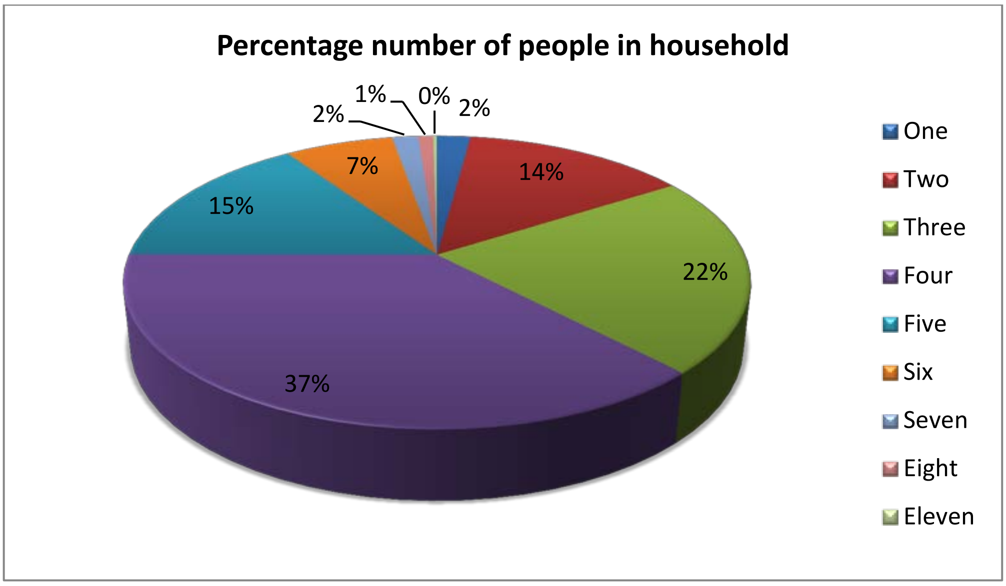

Figure 6.12: Number of people in households

37% of the participants have four people in their households. It is important to precise the number of people in order to divide the amount of energy consumption by the number of people to obtain the individual carbon footprint of the participants, instead of the whole household carbon footprint. It is also assumed that the energy consumption path for each member in each household is similar.

6.5.1 Household Energy Use

The list of energy sources used by the participants is shown in figure 6.14. In Mauritius, the main household energy consumption sources are electricity and liquefied petroleum gas (LPG). All the participants use electrical energy. Some of the participants did not specify LPG as one of the energy sources used due to not owning any personal kitchen for cooking purposes. Some people also use wood for cooking purposes.

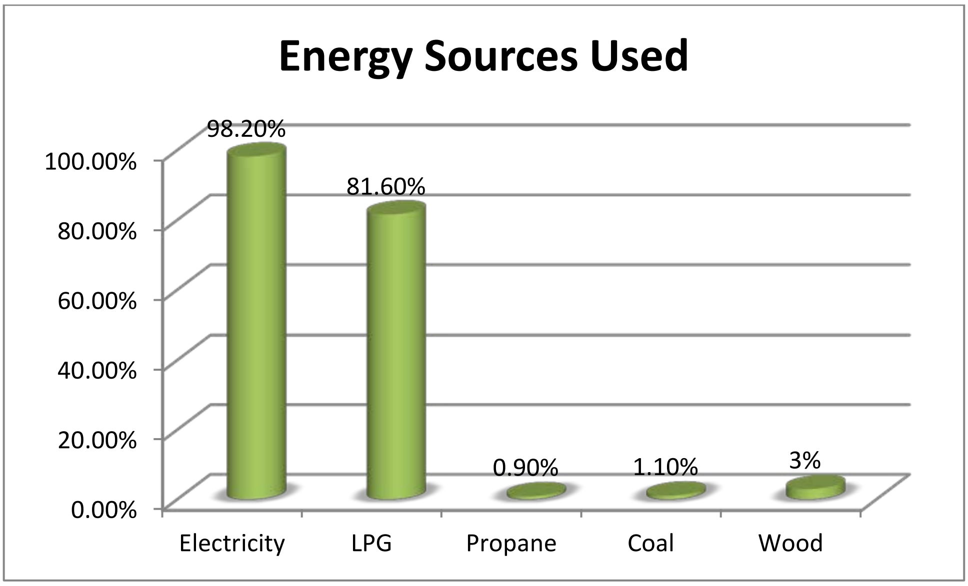

Figure 6.13: Energy sources Used by the Participants

6.5.1.1 Annual Electricity Consumption of Participants

The participants were queried on the annual electricity consumption in order to determine their carbon footprint related to personal energy consumption. The range of annual electricity consumption in kWh of the participants is shown in figure 6.14. The mean electricity consumption is 2492.39 kWh. A comparison was made between the electricity consumption of academic and administrative staff, in order to analyse the relationship between salary income and energy consumption. As shown in figure 6.15, the mean electricity consumption for academic staff is higher than that of administrative staff, and also higher than the average electricity consumption of all staff. The result confirms the positive association between energy consumption and lifestyle discussed in Chapter 2. With a higher income range, academic staffs consume a higher amount of electricity than administrative staff.

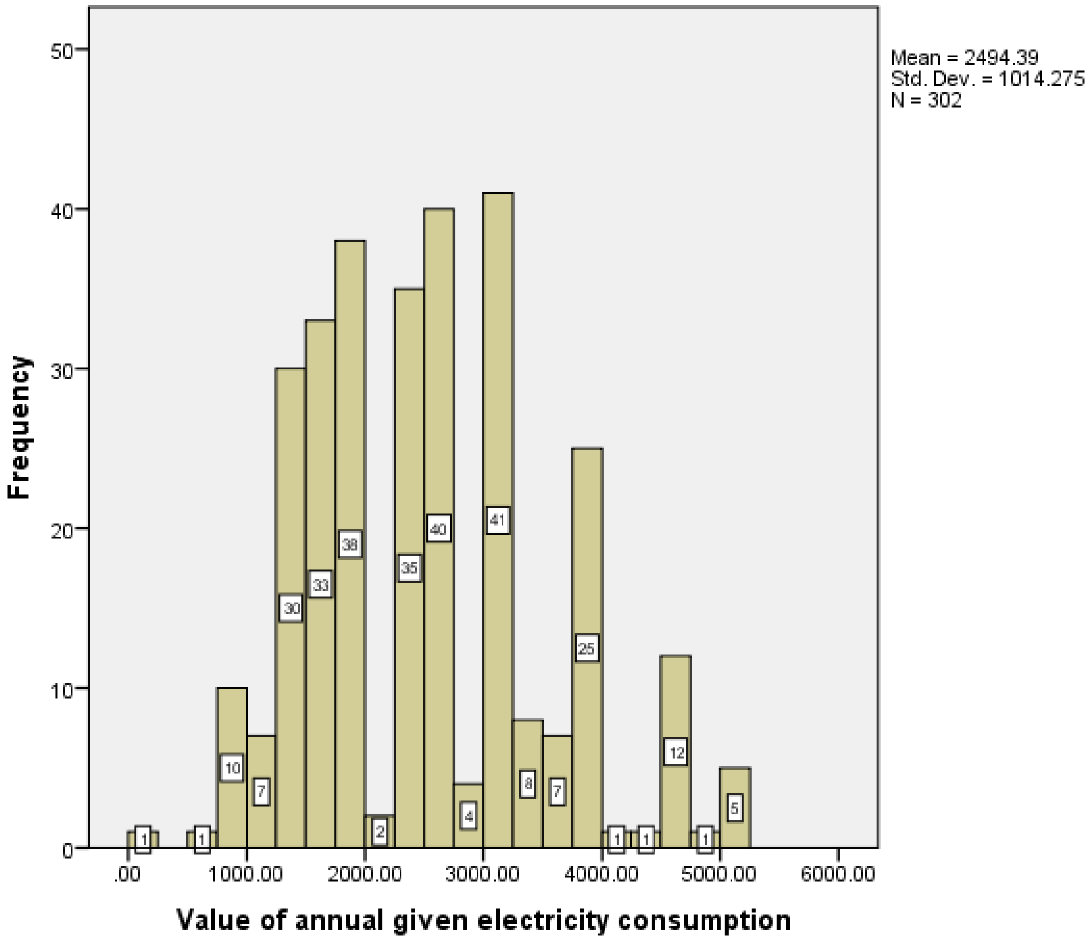

Figure 6.14: The range of annual electricity consumption of all the participants

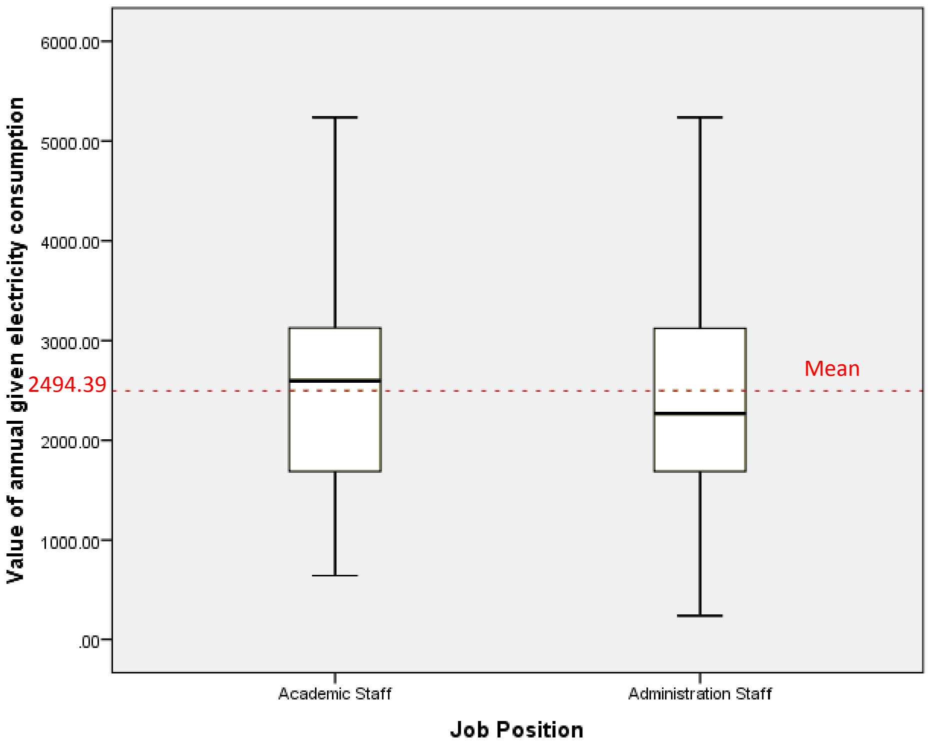

Figure 6.15: Comparison of annual given electricity consumption of academic and administration staff

6.5.1.2 Annual LPG Consumption of Participants

The participants were queried for their annual LPG consumption and the result is shown in figure 6.16. 288 participants are aware of how much LPG are consumed per month in their household. The mean LPG consumption for the participants is 160.16kg. The majority of participants (151) have an annual LPG consumption in the range of 140-160 kg.

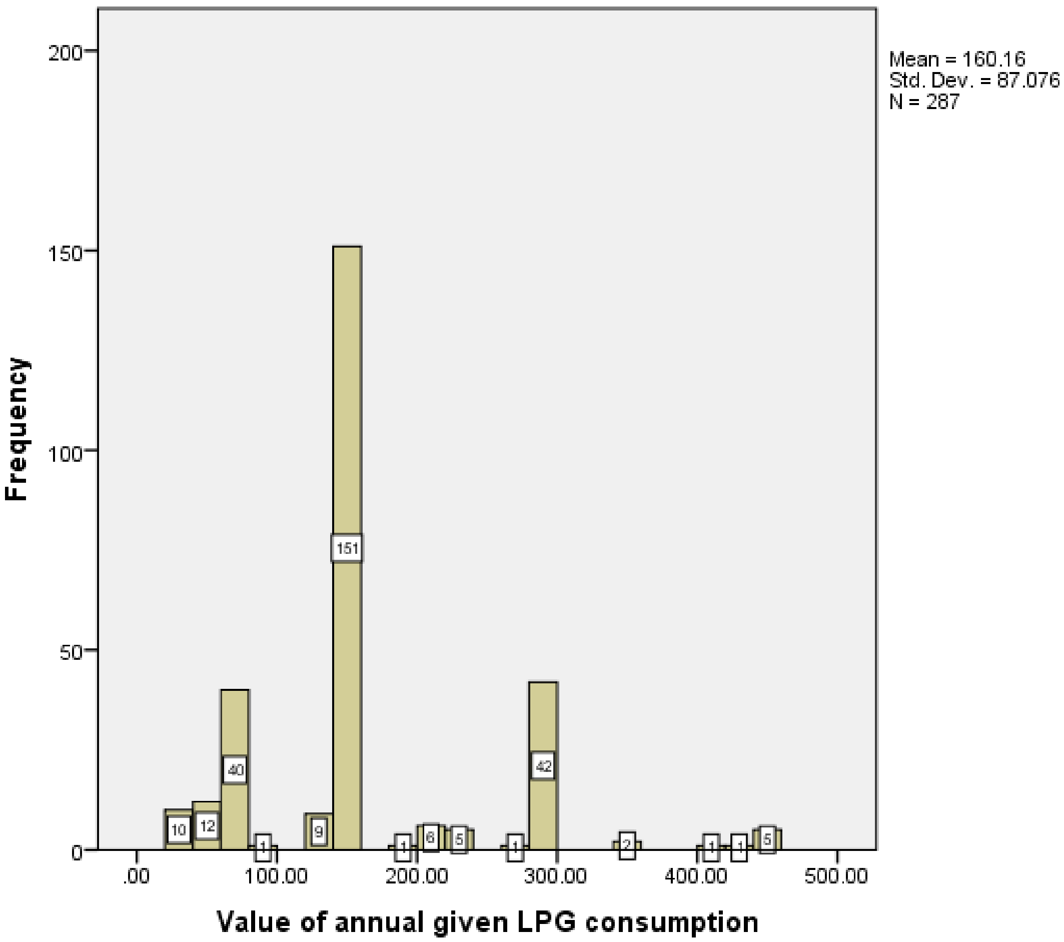

Figure 6.16: The range of annual LPG consumption of all the participants

6.5.2 Modes of Transport of Participants

The following chart in figure 6.17 indicates the most common modes of transport used daily by the participants. More than half of the participants use their personal cars or vans to travel to their workplaces and 9 of the participants opted to walk to and back from their workplaces instead of using any means of transport due to the short distances between their homes and workplaces.

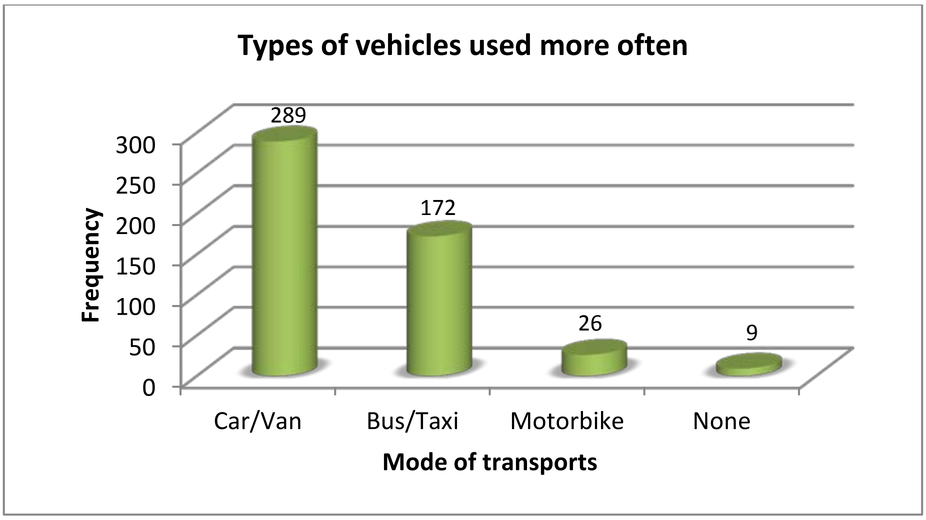

Figure 6.17: Mode of transport used daily by the participants

6.5.3 Food Preferences of Participants

The food preferences of the participants is indicated in figure 6.18. Majority of the participants consume a mix of white and red meat and only 26% of the participants are vegetarians and vegans. This finding indicates the high need of meat production and import in Mauritius, which results in higher carbon emission per individual. As discussed in Chapter 2, higher meat production and consumption results in higher GHG emissions (Röös, et al.,2013). The high percentage of non-vegetarian also has an effect on the overall carbon footprint results. 45.2% of the academic staff and 47.7% of the administrative staff consume both white and red meat.

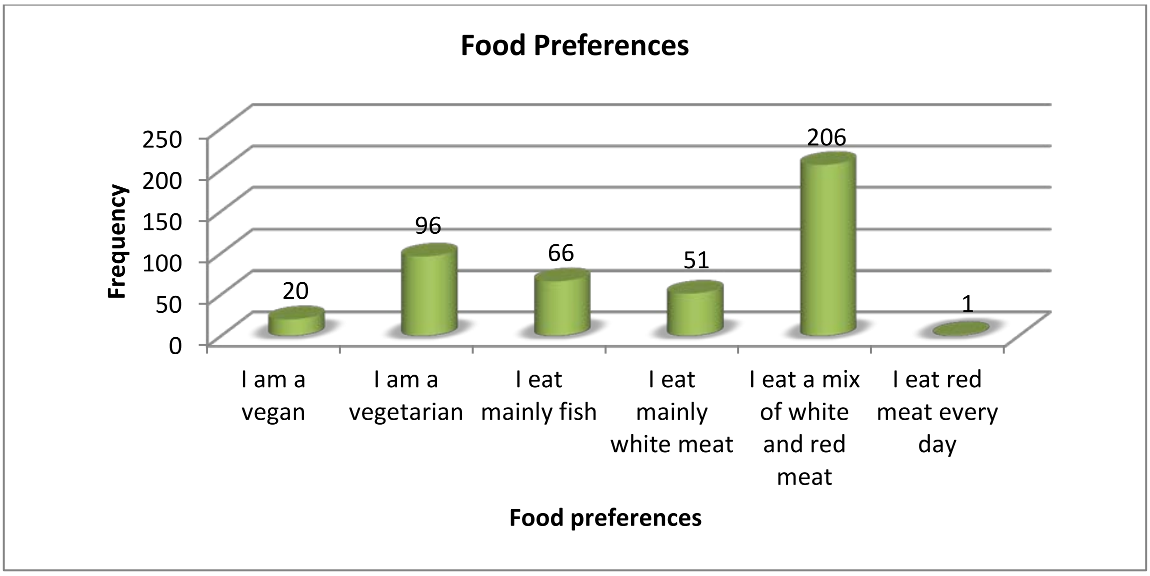

Figure 6.18: Food preferences of the participants

6.5.4 Organic Food Preferences of Participants

The participants were asked on how much organic food they consumed, and the result is displayed in figure 6.19. Almost 63% of the participants try to consume organic food and during the survey, most of the participants mentioned the ease in obtaining or growing their own organic vegetables or fruits. It should also be noted that among the participants who do not buy or grow organic products, some of them observed the unavailability and high cost of a variety of organic food in Mauritius. Based on the results obtained from the survey, 67.1% participants among the academic staff and 60.7% participants among the administrative staff try to buy or grow some organic food.

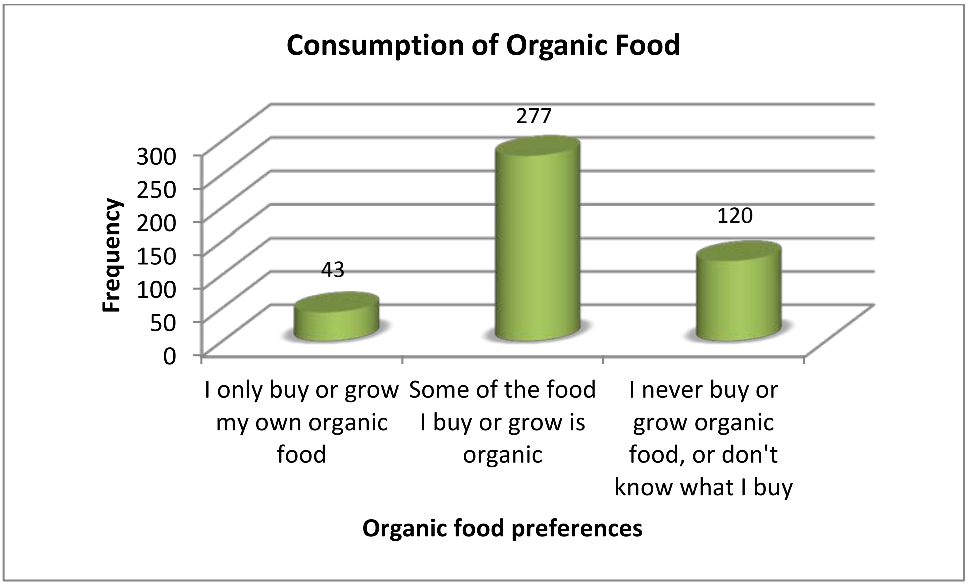

Figure 6.19: Organic food consumption

6.5.5 Seasonal Food Preferences

The preference to seasonal food of the participants is shown in figure 6.20. As discussed in Chapter 2, the purchase of fruits and vegetables during their seasonal period results to a decrease in personal carbon emission due to less transportation fuel consumed during import and export and less energy s needed for heating in greenhouses (Röös & Karlsson, 2013). More than half of the participants prefer to buy foods which are in season instead of buying imported foods which are not in season. This means that the carbon footprint associated with the consumption of locally produced and seasonal food contributes a small amount to the overall carbon footprint of the participants. 26.5% of the academic staff and 17.5% of the administrative staff only buy or grow seasonal food.

Figure 6.20 Seasonal food preferences

6.5.6 Purchase of Imported Food and Goods Preferences

The preferences of the participants to buying imported foods and goods are shown in figure 6.21. Most of the participants prefer to buy local products and 129 of the participants do not pay consideration to where their products come from. The fact that almost 30% of the participants do not know where the products come from shows that there needs to be more sensitization in that direction about the importance of reducing carbon emission through reduction of buying imported products. It is also essential to put proper labels on products so as to inform consumers of products with high carbon footprint values.

Figure 6.21: Preferences of Participants to Imported Food and Goods

6.5.7 Clothing Preferences

The chart in figure 6.22 shows the shopping preferences of the participants. This indicates that the majority of the participants do not buy clothes unnecessarily or excessively, hence indirectly prevent an increase in their carbon emission through manufacturing processes and transportation of the clothes. 17.4% of the academic staff and 16.8% of the administrative staff regularly shop to have the latest fashionable clothing.

Figure 6.22: Shopping Preferences of Participants

6.5.8 Product Packaging Preferences

The preferences of the participants to the type of product packaging are demonstrated in figure 6.23. Nearly half of the participants try to buy products with little packaging as possible. According to the result, more than half of the participants prefer to avoid too much packaging while purchasing goods. 21.9% of the academic staff and 31.2% of the administrative staff only buy things which are nicely packages.

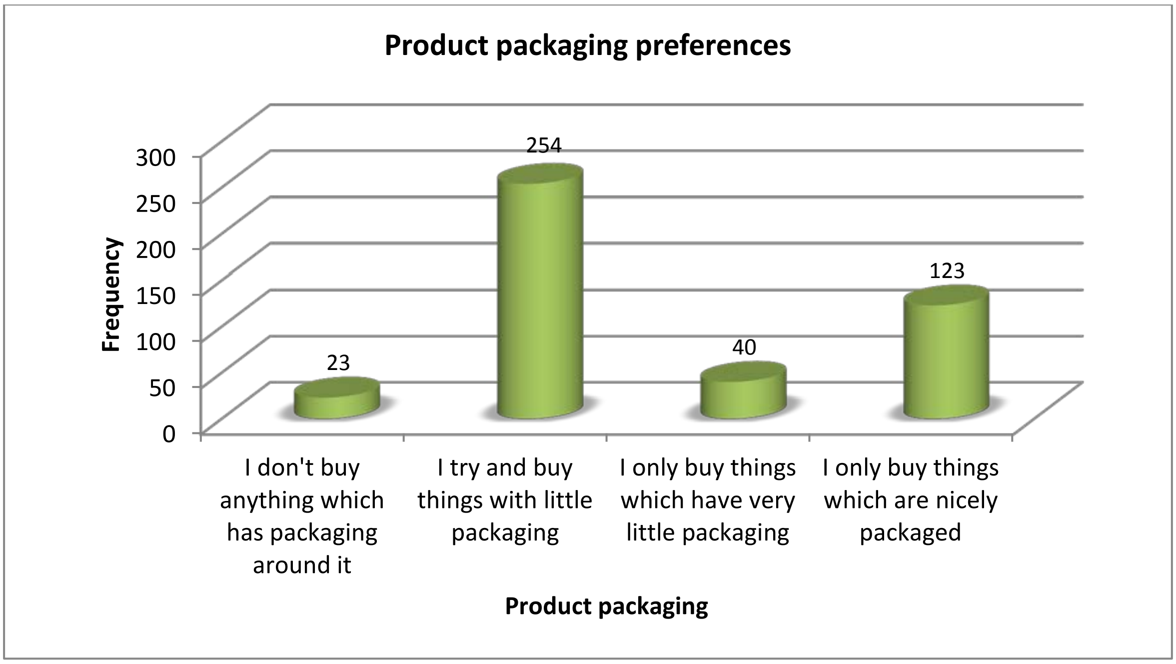

Figure 6.23: Product Packaging Preferences of Participants

6.5.9 Furniture and Electronic Products Preferences

The bar chart in figure 6.24 shows the participants' preference to the purchase of furniture and electronic products. More than half of the participants prefer to wait till their furniture and electronic products become unusable before purchasing new ones. This finding is very positive since it shows that the employees choose to reduce the manufacture of new furniture and electronic products as much as possible, hence contributing less to the carbon dioxide emitted during the manufacturing processes. Only 12.3% of academic staff and 13.7% of administrative staff stated their preference for getting the latest technological devices and home fashions.

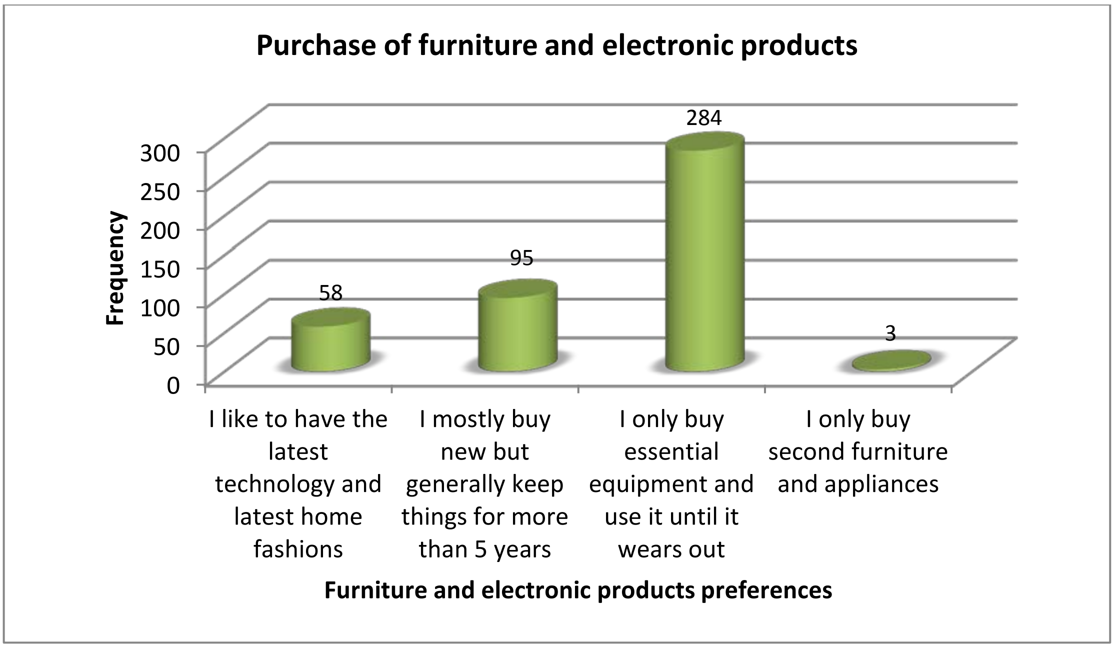

Figure 6.24: Preferences of Participants to buying new furniture and electronic products

6.5.10 Waste Products Recycling

The participants were queried for their waste recycling habits. The result is shown in figure 6.25. Most of them do not recycle at all or do only some composting of their waste products. 44% of the participants mentioned that some of their wastes are recycled. According to observations made during the survey, majority of these participants referred to recycling their organic wastes as their only means of adopting a waste recycling initiative. Almost half of the participants do not recycle their waste products at all (36.1% among academic staff and 51.2% among administrative staff). The main reason for not adopting any recycling measures was due to a lack of any proper recycling system in Mauritius. The participants did not know how or where to leave their waste products to be recycled, although there exists recycling bins in various areas in Mauritius. This finding indicates the need for governmental bodies to take actions to implement effective recycling systems around the island.

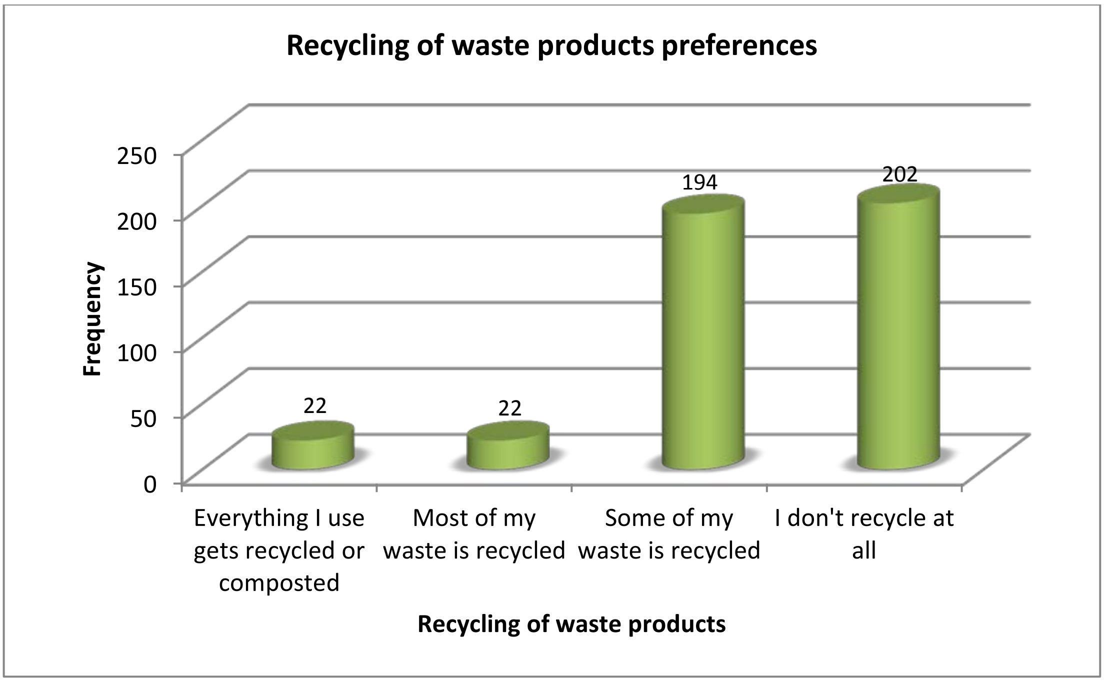

Figure 6.25: Waste products recycling

6.5.11 Recreational Activities Preferences

The types of recreational activities preferred by the participants are shown in figure 6.26. 198 participants occasionally go out to movies or restaurants and other places. 162 participants prefer activities which involve less carbon emission, out of which 39.4% are academic staff and 35.4% are administrative staff. Among those participants who enjoy and participate in sport activities, the majority of them (7.8%) are between the ages of 20 and 30.

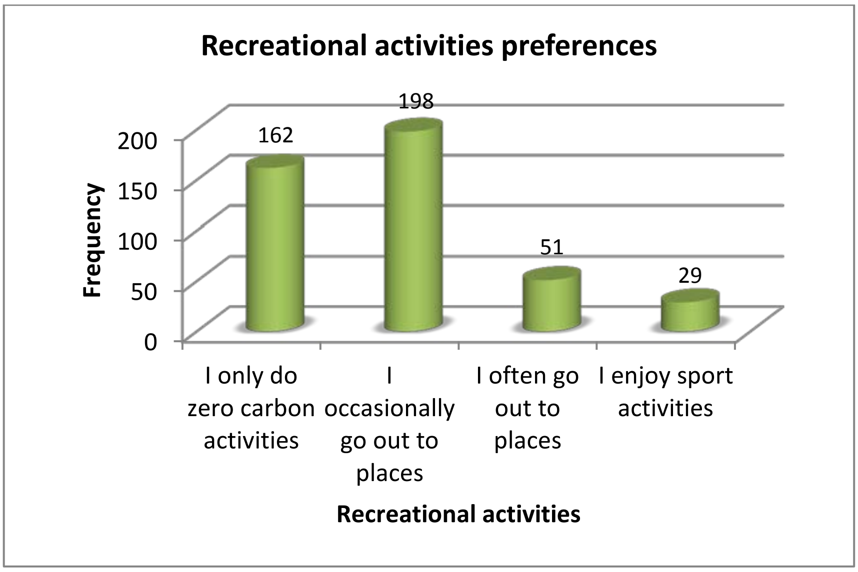

Figure 6.26: Choice of recreational activities

6.5.12 Mean Carbon Footprint of Employees in Tertiary Education Sector

Based on the analysis from the previous section, the carbon footprint of the employees in the tertiary education sector was determined so as to obtain a comparison of the average CF result among the participating tertiary education institutions.

The box-and-whisker diagram in figure 6.27 allows for a detailed comparison on how the carbon footprints of employees vary in the different tertiary education institutions. The chart shows that Middlesex University has the largest range of carbon footprint results among its employees, and the highest value obtained was approximately 15 metric tons of CO_2e. From the survey, it was observed that majority of the staff from Middlesex University took more foreign trips throughout the year, hence explaining the high carbon footprint result. The dotted red line drawn, known as the "baseline", represents the average carbon footprint value of all 440 participants in the ten tertiary education institutions. This mean value is equal to 6.29 metric tons of CO_2e. The calculation of this value is fundamental in the study since it allows for a quantitative comparison with the average carbon emission per capita within Mauritius. The mean average value obtained for the 440 participants in the study is almost twice the average per capita carbon footprint emission measured in 2010, which is 3.2 metric tons of CO_2e (The World Bank Group, 2015). This also answers the fifth research question of the study, RQ 5. The high difference in the average national per capita value and the calculated value from the survey data indicates a lower than average environmentally-conscious lifestyle among employees in the tertiary education sector. This means for the employees from the tertiary education sector, the average result obtained can be used as a baseline for measuring and keeping track of employee carbon footprint in the tertiary education sector. This result obtained from the graph also provided a detailed analysis RQ 4.

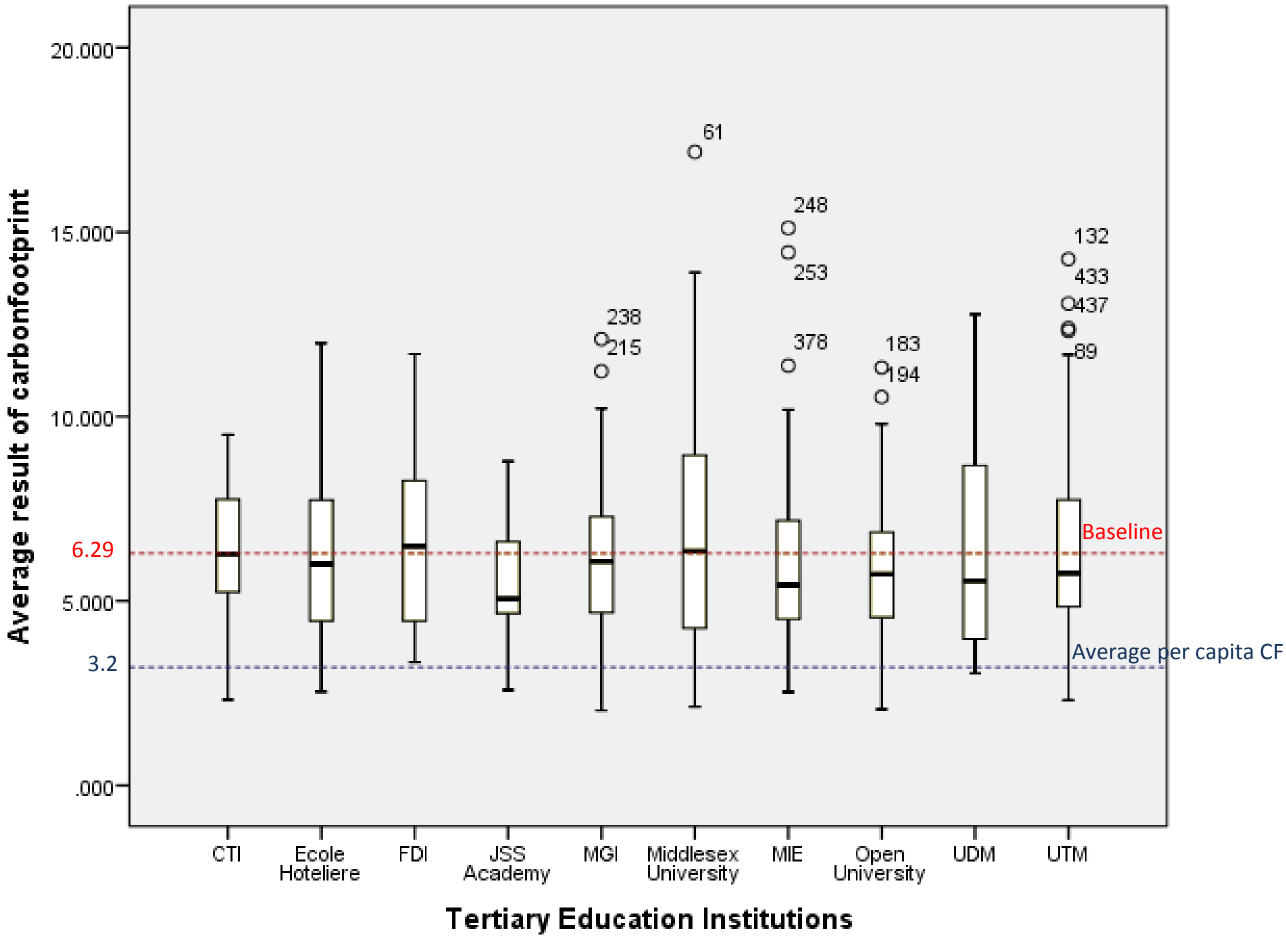

Figure 6.27: Average carbon footprint results per institution

6.5.13 Income-Carbon Footprint Relationship in Tertiary Education Sector

In Chapter 2, it was demonstrated that various factors are responsible for the amount of carbon a person emits through daily activities. One of the factors discussed was that the financial situation of an employee has a direct impact on his/her consumerism habits (Roy & Pal, 2009). It was shown in Chapter 2 that the higher the income of a person, the more the person tends to indulge in carbon-intensive activities and higher energy consumption. For example, a high-income employee may consume more electricity due to possessing a larger house or more electrical appliances. Likewise, the high-income person might be more tempted to drive his private car to work than walking. Hence, there was a need to investigate the correlation between the employee's income range and the resulting carbon footprint. Figure 6.27 demonstrates the result of how the income range varies with the carbon footprint result. The graph confirms the hypothesis that the carbon footprint of a person increases when the income range is higher. For those participants with an income of more than MUR 51, 000, their average carbon footprint is approximately 7.5 metric tons of CO_2e whereas the participants whose income were MUR 10,000 or less has a smaller carbon footprint, the average value being approximately 5 metric tons of CO_2e. As discussed in Chapter 2, there is a positive association between better standard of living and higher energy consumption for both household and individuals. This is demonstrated in figure 6.27, where the average carbon footprint of the participants increases when the income range increases.

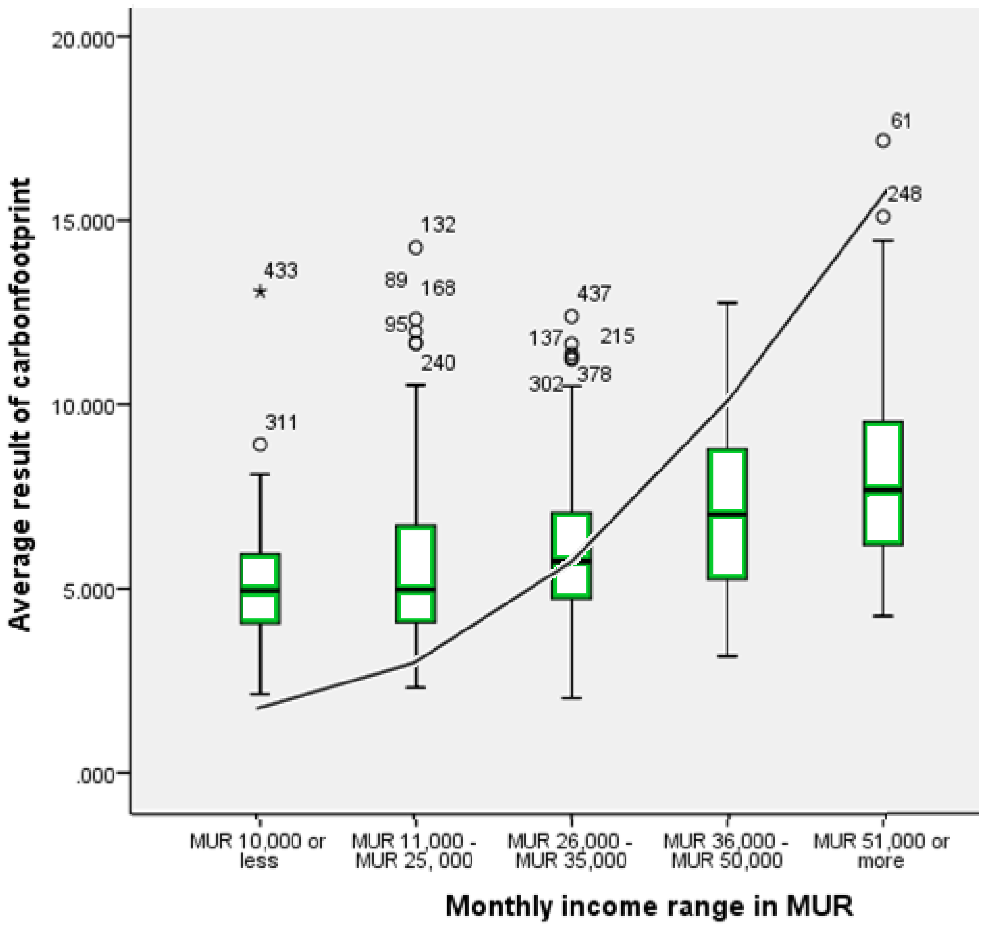

Figure 6.28: Average carbon footprint results based on employee income range

6.5.14 Food Preferences – Carbon Footprint Relationship among Participants

The variation in the carbon footprint result according to the food preferences of the participants is shown in figure 6.29. As stated previously in literature, the consumption of meat products result in a higher carbon emission, and the graph below shows that for white and red meat consumption, the mean carbon footprint result is higher than that for vegan and vegetarian consumption. As seen in the previous results, most of the employees consume white and red meat, hence explaining the higher than average carbon footprint per capita result.

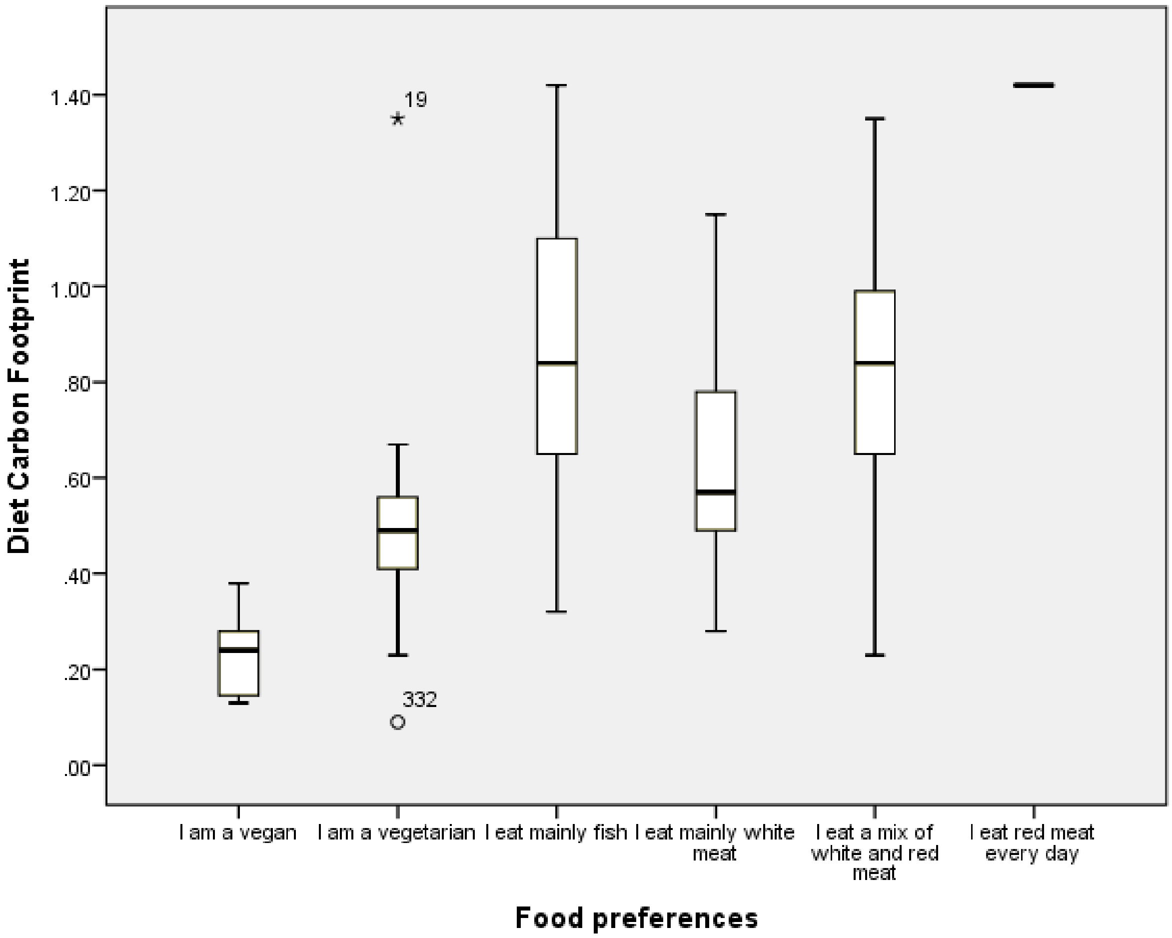

Figure 6.29: Food Preferences Carbon Footprint Relationship

6.5.15 Gender-Carbon Footprint Relationship among Participants

The disparity of carbon footprint results according to the gender of the participants is demonstrated in figure 6.30. The graph demonstrates that the mean carbon footprint of female employees is lower than that of male employees. The average carbon footprint of male employees is 6.74 metric tons of CO_2e and that of the female employees is 6.02 metric tons of CO_2e. This result could be influenced by several factors, such as income differences between male and female employees, modes of transports used, lifestyle choices and environmental consciousness.

Table 6.5 indicates how the job position of employees is related to the carbon footprint results of employees. According to the table, there are more female employees (190) than male employees (74) who belong to the administration staff. As seen in section 6.2.4, administrative personnel earn a lower income than academic staff on average, and the results in section 6.5.13 indicates that the lower the income range of an employee, the lower is the respective carbon footprint result. These findings thus explain the fact that incomes and job positions of female employees are two of the factors responsible for a lower carbon footprint result compared to their male counterparts.

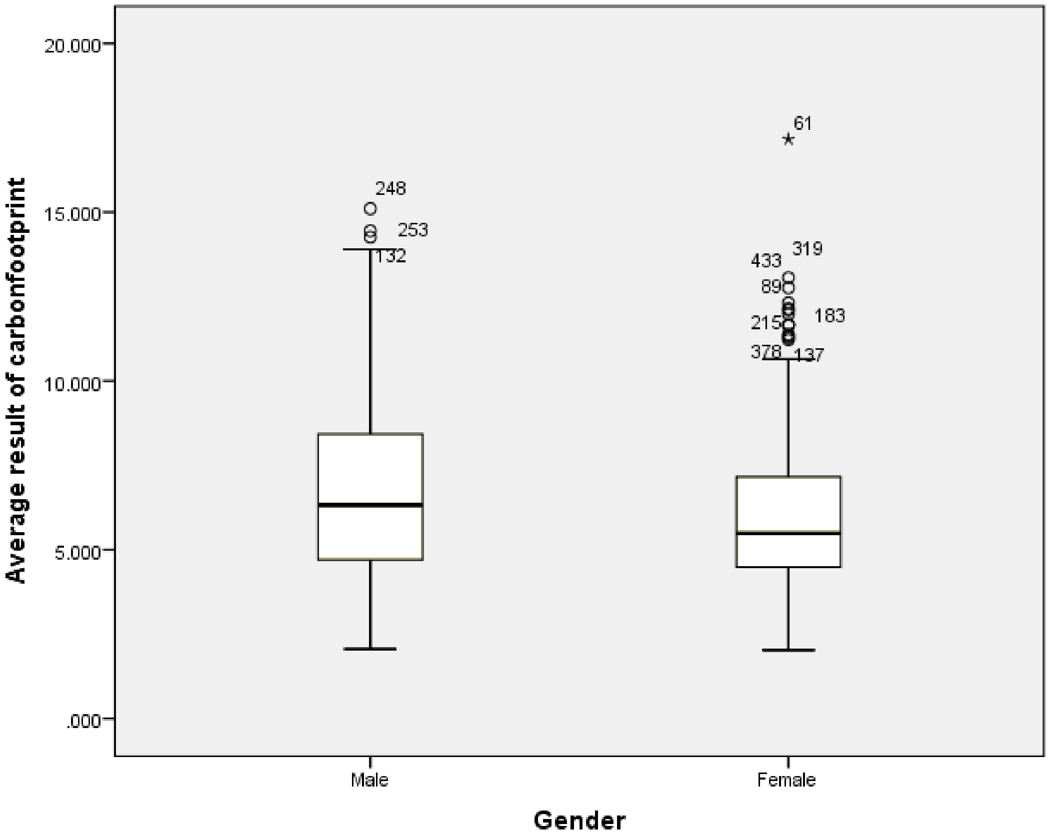

Figure 6.30: Gender-Carbon Footprint Relationship among Employees

Job Position * Gender Cross tabulation

Count

		Gender		Total
		Male	Female	
Job Position	Academic Staff	94	58	152
	Administration Staff	74	190	264
Total		168	248	416

Table 6.5: Job Position - Gender Relationship of Employees

6.5.16 Job Position – Carbon Footprint Relationship of Employees

Figure 6.31 shows the relationship between the job positions of employees and the respective carbon footprint results. The finding shows that employees belonging to the administrative department have on average a lower carbon footprint than employees belonging to the academic department. As seen in section 6.2.4 and 6.5.13, the income range is one factor influencing the carbon footprints of administrative staff. This is because earning a lower income indicates lower expenses on household energy usage, transports, food consumption and general lifestyle choices. The less the individual spend on those factors, the lower is the carbon footprint result.

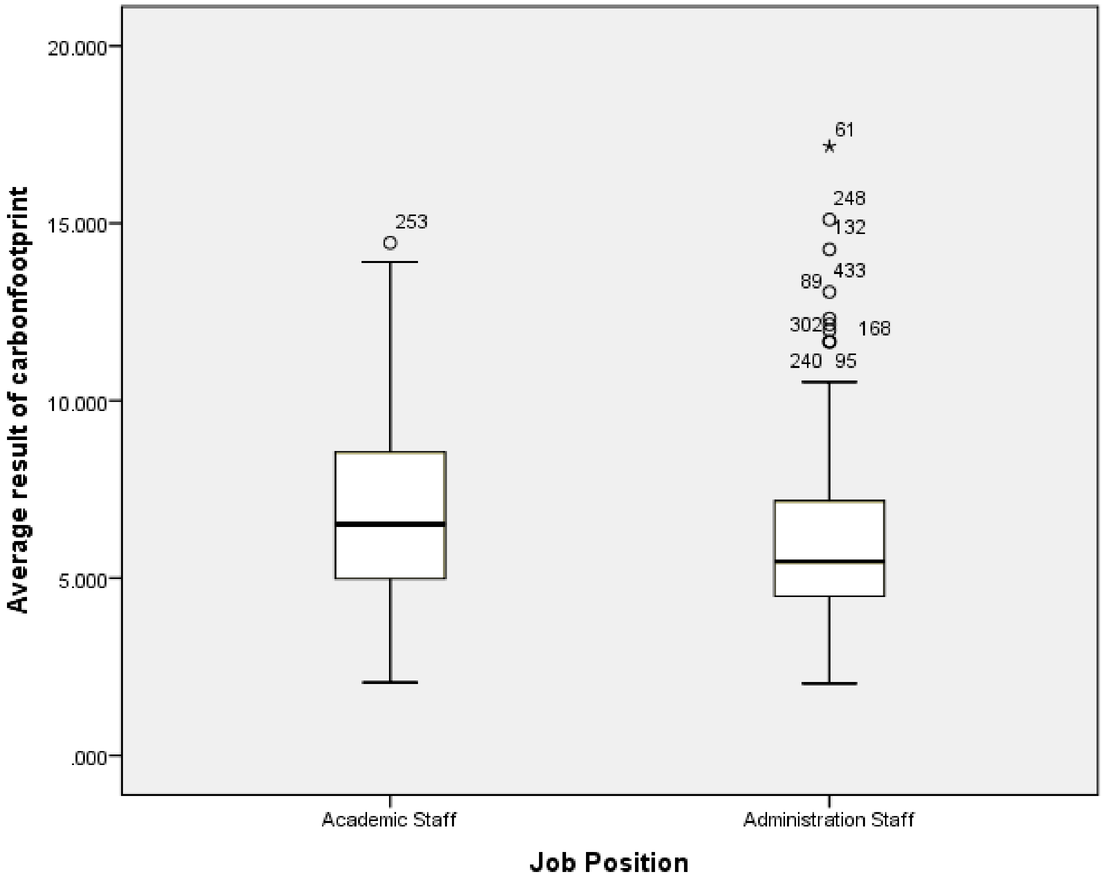

Figure 6.31: Job Position - Carbon Footprint Relationship of Participants

6.5.17 Age – Carbon Footprint Relationship among Participants

The variation of the carbon footprint results according to the age groups of the participants is shown in figure 6.32. From the graph, employees of the age 31 to 50 years old have higher carbon footprint results than those who are less than 30 and between the ages of 51 and 60. This result confirms the findings from prior research that the age distribution (35 to 49 years old) contributes to carbon emissions of individuals (Jensen, et al., 2013).

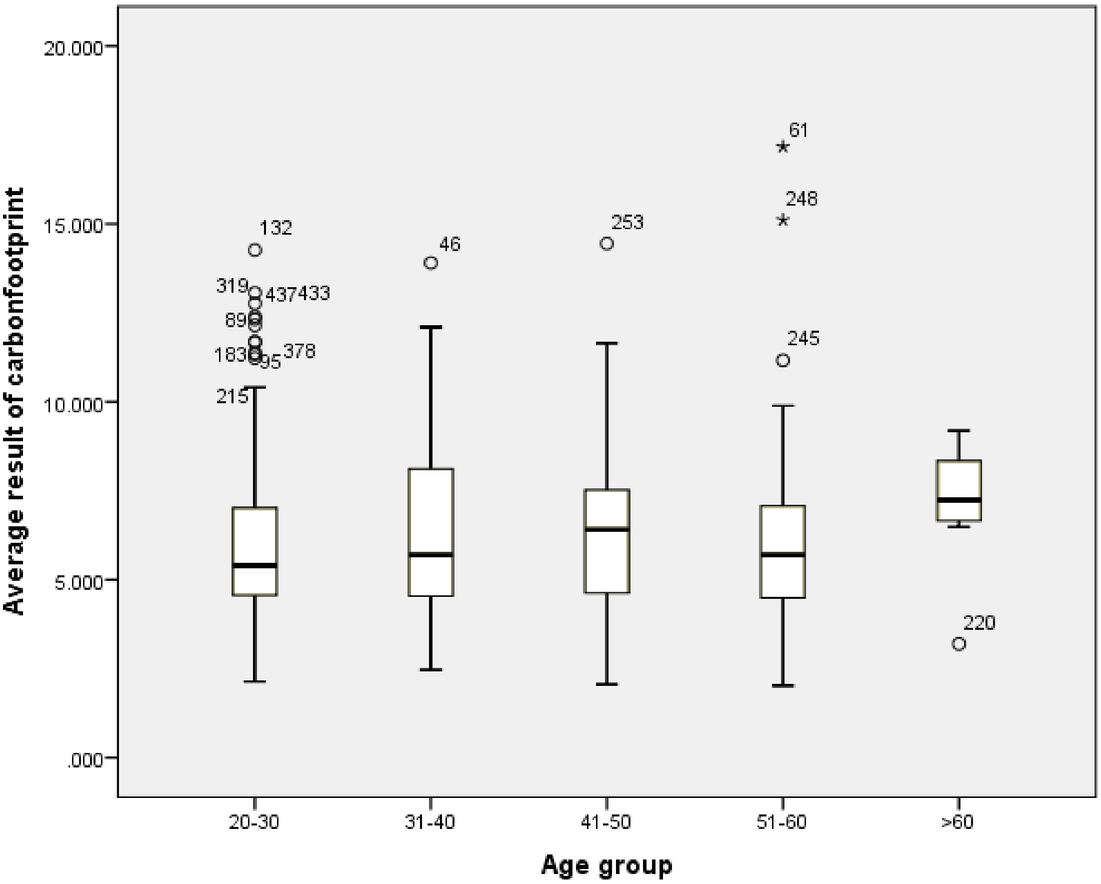

Figure 6.32: Age - Carbon Footprint Relationship of Employees

6.6 Critical Analysis of Carbon Footprint Results

In Chapter 2, it was emphasized that one of the objectives of the study was to determine which activities in the daily life of an individual contribute more to the total personal carbon emission. The two CF calculators used, carbonfootprint.org and CarbonStory, enabled the determination of approximate amount of carbon dioxide emitted in the different categories and sub-categories of daily activities outlined in the taxonomy (section 2.3.1). Quantitative values for household energy use, travel, diet and lifestyle were obtained and the results on both CF calculators were compared in a path analysis diagram, to also answer RQ 1. A path analysis diagram is an extension of the regression model and is used to test the correlation matrix against two or more causal models, consisting of dependent and independent model, which are being compared (Garson, 2008). For this research study, the diagrams are used to compare the CF results for both CR calculators used, and how the results vary for the different categories and sub-categories. This path analysis is shown in Figure 6.28 and is based on the same taxonomy developed in Chapter 2. Based on the same taxonomy, a quantitative analysis could be made on how much each element contributes to the overall individual carbon footprint after analysing the data of the participants from the survey.

From Figure 6.28, it could be seen that 63% of the overall average carbon footprint result of an individual belonged to the “Lifestyle” category. Since this significant result could not be further broken down into based on its different sub-categories, another path analysis had to be conducted based on the second calculator used in this study, namely from CarbonStory. Furthermore, as indicated in the literature (Chpater 3), the online carbon footprint calculators do not produce the same exact results so far (T. Kenny, 2009; Murray & Dey, 2009; Padgett, 2008; Pandey et al., 2011). Hence the need to develop two path diagrams for a better analysis. Figure 6.28 shows the path diagram for the carbonfootprint.org calculator and figure 6.29 shows the path diagram for the CarbonStory calculator. The path diagram for the carbon footprint results from the CarbonStory calculator is depicted in Figure 6.29.

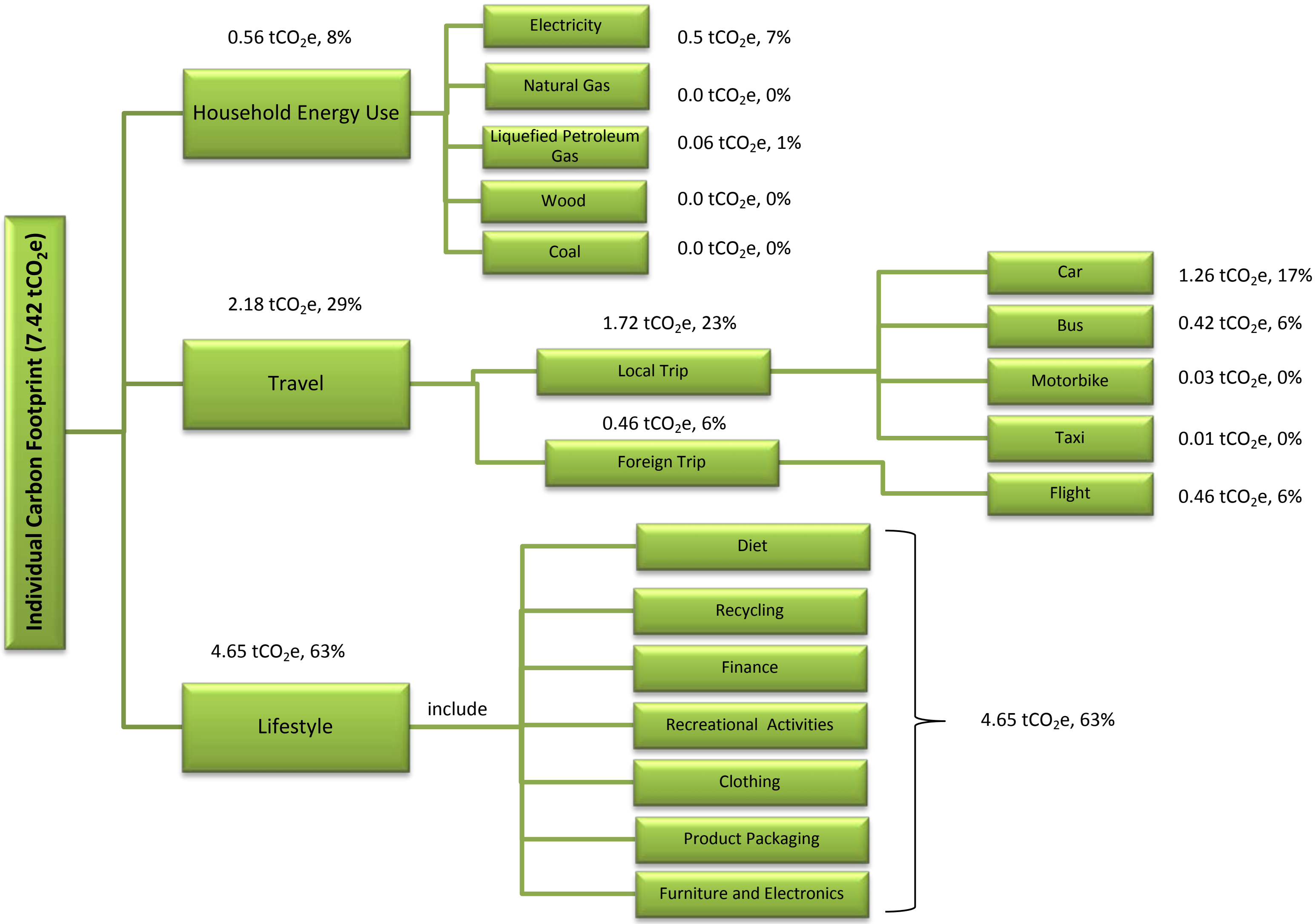

Figure 6.28: Path Analysis for Carbonfootprint Calculator

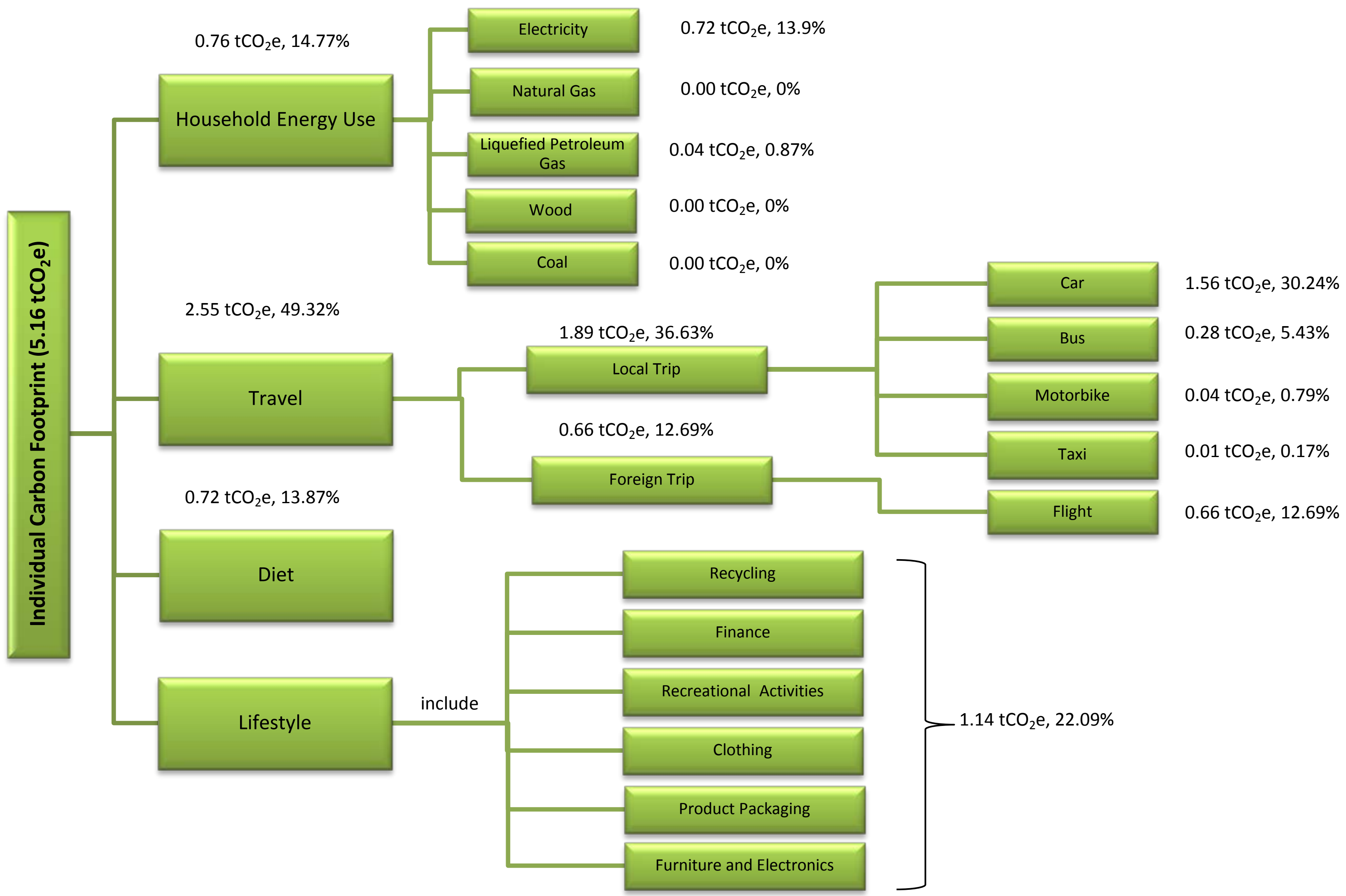

Figure 6.29: Path Analysis for CarbonStory Calculator

As discussed earlier, it could be seen from figure 6.28 that 63% of the overall average carbon footprint result of the participating employees belonged to the “Lifestyle” category. That is, the general lifestyle choices, including diet, contributed to more than half of an employee’s carbon emission. When this value is compared to the Lifestyle and Diet result in the CarbonStory path diagram, it could be seen that both the diet and lifestyle results contribute to approximate 35% of the overall average carbon footprint result. This value is almost half of the value obtained for the carbonfootprint.org calculator result. This huge difference could be a result of different estimation values used by the calculators. Moreover, the lifestyle questions required on the carbonfootprint.org calculator were not all similar to the ones asked on the CarbonStory calculator. This difference could also have increased the lifestyle results for carbonfootprint.org calculator.

The “travel” carbon footprint result was also considerably higher for CarbonStory calculator. On carbonfootprint.org, the CF associated with travel contributed to 29% of the result, whereas for CarbonStory the travel CF result contributed to 49% of the total carbon footprint result. This discrepancy could mainly be the result that the carbonfootprint.org calculator required more detailed information on the types of vehicles and their efficiency, whereas on CarbonStory it was only required to indicate the total distances travelled. The importance of inputting the makes and models of the vehicles is mainly to differentiate the more fuel-efficient vehicles from older models which consumed more fuels. This explains the lower carbon footprint result for the carbonfootprint.org calculator. Both diagrams demonstrate that the carbon footprint results for travel are higher than the household energy use or diet. The results for local trips are also higher than foreign trips. This shows that travelling, with its higher fuel consumption, contributes a major part in the daily carbon emission of an individual.

The difference in household energy use CF results on both calculators could also be the result of different emission factors used. There is no large difference in the average household energy use CF results for both calculators, as was observed in the analysis of CF calculators in section 4.2.2. The carbon footprints for both electricity and LPG were almost similar on both calculators, hence explaining the use of same emission factors and calculation data. For both calculators, the CF of household energy use constituted of less than 15% of the total carbon emission of an individual, hence indicating that household energy use is not one of the major sources of carbon emission in the daily lifestyle of the participants.

The diet category constituted of 18% of the total carbon emission for an individual as per the CarbonStory calculator result. This shows the food consumption of the participants contributed to almost one-fifth of the total carbon emission, through the food manufacturing processes and transports. It was not possible to determine the estimated value for the diet category on carbonfootprint.org since the CF result for the diet data were merged with those of the lifestyle CF results.

The total average carbon footprint result for an individual on carbonfootprint.org calculator is 7.42 metric tons of CO_2e, and for CarbonStory calculator, the result is 5.16 metric tons of CO_2e. Both results are much greater than the per capita CF value of an individual, which is 3.22 metric tons of CO_2e, and therefore showing the need to develop more effective strategies and a framework to be used to aid employees of the tertiary education sector to decrease their personal carbon emissions. The overall difference between the two results corresponds to the expected result indicated in literature in section 4.2.2, which examined the difference in results on the selected CF calculators. The difference in the survey average CF results from the two CF calculators did not exceed more than 4 metric tons of CO_2e, as was predicted in the simulation made in section 4.2.2. The results found also answers RQ 1.

Chapter 7 - The Carbon Management Framework

The results discussed in the previous chapter gave insightful information on awareness and calculation of carbon footprint related to employees within the tertiary education sector. This chapter uses these insightful information in order to formulate the carbon management framework meant for employees within the same sector.

7.1 Key Findings

The survey conducted within the different tertiary education institutions involving 440 participants helped to answer the 7 research questions of this study. The key findings from these answered research questions are as follows:

- A comparative analysis of the existing online carbon footprint calculators showed that a limited number of such calculators could be used for Mauritius. This is because not all of the calculators used data and emission factors for the Mauritian context and hence, these calculators cannot be used by the local population. Moreover, most existing calculators do not provide clear indication of data used to calculate carbon footprint within Mauritian context.
- Currently, the concept of carbon footprint was found to be new in Mauritius and among the population of TEI staff. Summary of results from the survey indicate that employees of the tertiary education sector have little to no knowledge on the notion of carbon footprint and the tools used to measure the personal carbon emission. Less than 5% of the participants have ever calculated their carbon footprints or used the technique as a tool to reduce their carbon emissions. It was also found that the employees do not know which of their daily activities contribute more to their carbon emission and what measures to adopt to reduce their carbon footprints.
- An analysis of the carbon footprints of all employees of the tertiary education sector who participated in the survey showed that the average carbon footprint was nearly twice of that of the average per capita carbon footprint of an individual in Mauritius. The average carbon footprint of the employees, which was 6.29 metric tons of CO_2e, can be used as a baseline for the employees in the tertiary education sector to measure, compare and reduce their carbon footprints to be similar or less than the per capita CF value.

- The income of the employees was found to have an impact on their carbon footprint. Employees earning more than MUR 51,000 had an average carbon footprint of approximately 7.5 metric tons of CO_2e whereas the participants whose income were MUR 10,000 or less had a smaller carbon footprint, the average value being approximately 5 metric tons of CO_2e. Earning a lower income indicates lower expenses on household energy usage, transports, food consumption and general lifestyle choices. The lesser the individual spend on those factors, the lower is the carbon footprint result.
- The survey results also showed that the food preferences of participants affected their carbon footprints. Those participants consuming red and white meat frequently had a higher carbon footprint as compared to those consuming a vegetarian diet. This also shows that food production in farms and food transportation are responsible for higher carbon emission.
- The mean carbon footprint of the female participants was lower than that of male participants. The average carbon footprint of male employees was 6.74 metric tons of CO_2e and that of the female employees was 6.02 metric tons of CO_2e. This result was influenced by the difference in income and subsequently, lifestyle as well.
- Employees of the age 31 to 50 years old have higher carbon footprint results than those who are less than 30 and between the ages of 51 and 60. This result confirms the findings from prior research that the age distribution (35 to 49 years old) contributes to higher carbon emissions of individuals (Jensen, et al., 2013).
- According to many employees, there have been no effective sensitization campaigns, especially in the tertiary education sector, on the importance of carbon footprint and how to measure and reduce carbon emission associated with daily individual activities.
- From the survey results, it was also observed that the current lifestyle of most of the participants does not constitute of the necessary measures to adopt for a greener living. This led to a high average carbon footprint result and it therefore became necessary to put in place a framework to assist the individuals in measuring, learning, reducing and monitoring their personal carbon footprints.

The key findings of this study highlight the minimal implementation of eco-friendly measures for reducing personal carbon emissions. Therefore, there is a need to develop an effective and reliable carbon management framework for the tertiary education sector so as to enable employees to measure, keep track and hence reduce their carbon footprint. This carbon management framework is further developed in the next section.

7.2 Carbon Management Framework for Employees in the Tertiary Education Sector

On the basis of literature and the analysis made from the results of the survey, a new framework is being proposed for personal carbon footprint management and reduction among the employees of the tertiary education sector. This carbon footprint management framework has been specifically created to encourage employees of the tertiary education sector to engage personally into the carbon emission reduction incentives, and not only through broader on-campus carbon emission mitigation measures, but also from a personal way of living. This framework is conceptualised so as to ensure that carbon mitigation measures are applied with optimal effect from all relevant stakeholders, that is, the employees and tertiary education institutions management, in order to achieve better environmental sustainability from employees. The proposed Carbon Management Framework has been specifically designed to meet the following objectives:

- To bridge the gap of communication and understanding of the need to reduce carbon emissions among staff members;
- To advocate more efficient carbon mitigation measures in the tertiary education sector by making environmental sustainability more pertinent in the lifestyle of employees;
- To compare employee carbon emission and environmental sustainability across individual tertiary education institutions of Mauritius by using the calculated baseline;
- To engage individuals in using carbon footprint as a tool for carbon emission reduction;

The framework is initially intended to be used by employees, both administrative and academic, of the tertiary education sector in Mauritius. The literature in Chapter 3 highlighted the critical role played by the tertiary education sector in knowledge dissemination in the society, and therefore the carbon management framework is to be used initially by employees of this sector.

The proposed Carbon Management Framework was developed based on the on literature review conducted in this study and results obtained from the survey. It has been conceptualised based on the taxonomy for carbon footprint management defined in Chapter 2, by making reference to the different factors that contribute to the carbon emission of an individual, namely household energy use, diet, travel and lifestyle activities. Figure 7.1 depicts the proposed Carbon Management Framework.

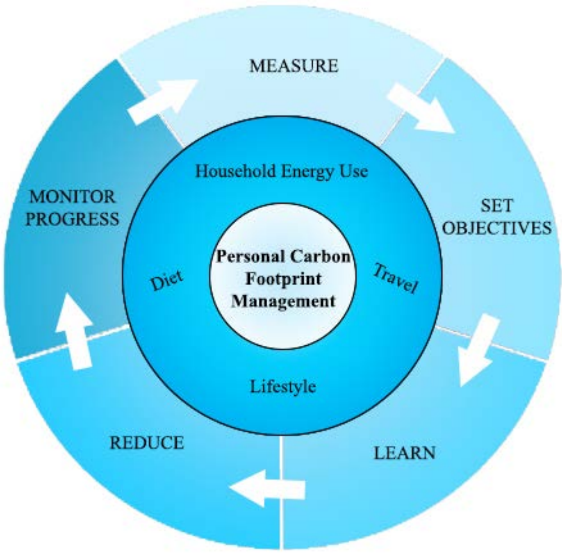

Figure 7.1: Carbon Management Framework for Employees within the Tertiary Education Sector

The framework includes a cycle which demonstrates the continuous carbon mitigation process to be followed by an employee in the tertiary education sector for carbon emission reduction. The framework is composed of three key stages, as shown below:

<u>Inner Ring:</u>

Personal Carbon Footprint Management: The central focus of the framework is to provide an insight on the best principles to maintain so as to reduce the individual carbon dioxide emission. The objective is for the employee of the tertiary education sector to be able to develop and maintain an easy routine in managing the amount of carbon emitted as a result to the daily activities performed.

<u>Middle Ring:</u>

The middle ring in the framework is based on the taxonomy developed in Chapter 2. It consists of the four main categories which represent the main sources of carbon dioxide emission, namely, household energy use, travel, diet and lifestyle. The middle ring represents a categorisation of the activities which need to be assessed and measured in order for the employee to manage his personal carbon emission.

Household Energy Use, Travel, Diet and Lifestyle: As per the taxonomy developed in Chapter 2, the four main categories through which a person contributes to the emission of carbon dioxide are the amount and type of energy used in the house, travel, the type of diet and lifestyle and choices. Therefore, these four factors need to be always considered while measuring and keeping track of the carbon footprint so as to be able to efficiently reduce individual carbon emission. As illustrated in the framework, the categories are the linking components for personal carbon footprint management and the processes involved to achieve the latter. An individual cannot properly apply the best practices in managing carbon emission without taking into consideration the main drivers to be controlled for achieving carbon dioxide reduction. These drivers are listed below:

- Household Energy Use: This category consists of the personal energy usage, such as the amount of electricity and liquefied petroleum gas consumed annually. By measuring and keeping track of the amount of carbon emitted due to the energy consumption, the employee can contribute to a global decrease in carbon dioxide emitted due to fuel consumption at his individual level.
- Travel: This category measures the amount of fuel consumed by the vehicles used by the employee to travel. The amount of carbon dioxide emitted depends on the type of vehicles and the distance travelled by the employee. The technique of measuring travel carbon footprint can help the employee to consider using fuel-efficient vehicles or other alternatives to using personal vehicles for travelling.
- Diet: The diet category involves a measure of the amount of carbon dioxide emitted indirectly due to the type of food consumed by the employee. By measuring their diet carbon footprint, the employee can become aware of how much carbon is emitted through their diet, and thus can adopt organic diet alternatives.
- Lifestyle: Lifestyle category involves a general estimate of how much carbon is emitted based on the lifestyle choices of the employee. This is an incentive for the employee to understand the importance of their lifestyle choices, such as choice of clothing and purchase of electronic products, have on their overall personal carbon emission. The employee can considerably reduce their carbon emission by measuring their lifestyle carbon footprint and then adopt proper low-carbon alternatives.

Outer Ring:

The outer ring consists of a series of steps required in order for the employee to manage and reduce his/her personal carbon footprint. These steps are described as follows:

- ***Measure*****:** The first step in managing personal carbon footprint is to measure the amount of carbon dioxide emitted through the daily activities of an employee. As discussed in this study, the amount of carbon emitted for any period of time can be calculated using an appropriate carbon footprint calculator. An employee can thus initiate a carbon management plan by measuring and obtaining the quantitative value of emitted carbon dioxide due to energy use and other daily activities. For Mauritius, the CF calculator from Carbonfootprint.org and CarbonStory could be used to measure personal carbon emission of employees.
- ***Set objectives*****:** After obtaining the carbon footprint result from the online calculators, the employee would become aware of how much carbon dioxide is emitted due to personal activities and the need to cut his/her carbon emission. The employee would not be able to immediately reduce his carbon footprint since this would involve major changes in his lifestyle. Therefore, the employee should set different objectives based on the areas from the taxonomy which demand a more urgent need to carbon emission reduction.
- ***Learn*****:** The next step after setting the objectives of which categories required immediate adoption of low-carbon practices, the employee needs to learn what the low-carbon activities and alternatives are and how to implement them accordingly. The employee can make use of the flyer created in this study to learn and research more on how to reduce their carbon emission for any particular activity or category. Furthermore, the employee could use the carbon emission reduction tips provided on the different carbon footprint calculator websites and decrease their carbon footprint. There are other online resources, notably websites and blogs related to protecting the environment, and books and magazines which can be used by employees to learn about the various methods to reduce carbon emission.
- ***Reduce*****:** After learning the different alternatives and techniques which exist to help people on reducing their personal carbon emission, the employee should then implement those best practices in order to achieve their initial objectives. The employee can focus on those activities which contribute more to their personal carbon emission, and then adopt the respective low-carbon alternatives to start decreasing

their carbon footprint. The employee should then continue to work on decreasing the amount of carbon dioxide emitted through other sources of activities.

- ***Monitor Progress*:** The ability to maintain an eco-friendly and low-carbon lifestyle does not involve a one-time procedure only. The key to a proper personal carbon footprint management strategy is to be able to keep track of the progress made and take appropriate measures to sustain the aims set. The employee should regularly check the best practices for carbon reduction are being sustained and there is improvement in their carbon emission amount.

This cycle as indicated in the framework is a continuous process, which the employee can do on an annual basis or several times throughout the year to properly manage their personal carbon emission. The framework developed is applicable to any individual employee in the different tertiary institutions and can be used as a guide for personal carbon footprint management. As such, by using the framework to measure and reduce personal carbon emission, each individual can work towards significantly reducing the global carbon emission and create a greener world.

Chapter 8 - Conclusions & Future Works

8.1 Conclusions

One of the growing concerns to the world today is climate change which does not only adversely impacts the environment, but also negatively affects the society. Climate change is primarily attributed to global warming, which is caused by emissions of carbon in the atmosphere. Since the industrial times, the amount of global carbon emissions has escalated by 70% where an important contribution was attributed to human activities through increasing energy demand, transport, deforestation and more development in residential and commercial buildings. Furthermore, through their daily activities, human beings emit carbon via different direct and indirect sources. A taxonomy created in this study classified the individual sources of carbon emission into four main categories, namely: household energy use, travel, diet and lifestyle. Household energy use referred to carbon emissions from energy consumed at the household level of an individual and the travel category involved carbon emissions from the vehicles used for travelling on a daily basis. The diet category deals with carbon emissions from common food consumption habits of individuals and the lifestyle category is about carbon emissions from general lifestyle choices of the person, e.g. recycling habits and recreational activities, among others. The proposed taxonomy helped to break down the carbon emission sources of the individual so as to facilitate management of carbon emissions at individual level and to simplify mitigation practices.

Different key stakeholders are involved in studies related to carbon emissions management and these include international organisations, the private sector, government and the tertiary education sector. These key stakeholders contribute towards reducing global and local carbon emission, through international and national carbon mitigation projects and via promotion of environmentally sustainable practices. Among these key stakeholders, the tertiary education sector is considered as an effective changing agent while being an ideal analyst to comprehend local population behaviours towards environmental sustainability and carbon emissions reduction. However, in Mauritius, there has been minimal focus on the human perspectives to carbon emissions within the sector even though human activities are being considered as a key contributor to carbon emissions. Furthermore, there is no indication on whether employees within this sector are managing their carbon emissions and are aware of carbon mitigation practices. Moreover, there exists no carbon management framework focusing on the human factor to carbon emissions which is being adopted within the tertiary education sector so as to manage carbon emissions of employees. Therefore, the aim of this study was to develop a carbon management framework to assess, reduce and sensitize employees within tertiary education institutions in Mauritius, after measuring their carbon emissions.

In order to fulfil this aim, the method known as carbon footprint analysis was adopted for measuring carbon emissions of employees. Several online carbon footprint calculators are presently available for calculation of the carbon footprint of individuals and in this report, the major personal online carbon footprint calculators were critically reviewed and analysed in order to identify the most suitable ones to be used. For this research project, two carbon footprint calculators, namely Carbonfootprint.org and CarbonStory were selected because the data utilised for carbon footprint calculation were suitable for the Mauritian context. These selected calculators also considered measurement aspects related to the four categories of the proposed taxonomy.

In order to develop the framework, a survey was conducted in the major tertiary education institutions of the island to measure the carbon footprint of employees while simultaneously performing a sensitization campaign on carbon emission reduction. While using a face-to-face approach during the campaign, 440 employees within major TEIs in Mauritius were sensitized on calculation of carbon emissions and carbon mitigation practices via the use of flyers. Furthermore, this project also helped employees within the tertiary education sector in Mauritius to determine their personal carbon footprint.

Analysis of the data collected during the survey showed that the concept of carbon footprint was new in Mauritius among employees of TEIs where more than 95% of the participants have never calculated their carbon footprint prior to this study. Moreover, it was also found that employees within the sector do not know which of their daily activities contribute more to their carbon emission and what measures were available so as to reduce their personal emissions. Carbon footprint analysis also showed that different demographic parameters were related to carbon emissions of employees within the sector and these include income, age and sex. Employees with higher average income were found to have a significantly higher carbon footprint than employees with lower average income. Likewise, employees aged between 31 to 50 years were found to have higher carbon footprint results than those who are less than 30 and those between the ages of 51 and 60. Similarly, the mean carbon footprint of the female participants was lower than that of male participants. Overall, carbon footprint analysis showed that the average carbon footprint of employees within the tertiary education sector was nearly twice of that of the average per capita carbon footprint of an individual in Mauritius. This result is alarming as it indicates a low environmentally-conscious lifestyle among employees in the tertiary education sector.

Based on the results of the study, a carbon management framework was proposed so as to help employees within the tertiary education sector self-assess and reduce their carbon emissions. It contains 3 rings where the inner ring highlights the focus of the framework and the middle ring emphasises on the key sources of carbon emissions, based on the proposed taxonomy. The outer-most ring relates to 5 key activities that employees should engage into so as to better manage their carbon emissions. Overall, this research project has met its aim and objectives while at the same time being beneficial to employees, campuses and the natural environment.

8.2 Future Works

During the course of this study, different avenues for future work were identified and these include:

Firstly, this research study was conducted among employees of the tertiary education sector and the framework developed is applicable for the personal carbon footprint management of an individual. Future work would involve performing the same carbon footprint measurement and sensitization among students of the tertiary institutions and applying the same proposed framework for the students. This would allow for a broader population to be reached, and at the same time the sensitization campaign would instil eco-friendly practices in students, who are future employees of other sectors.

Although this framework was developed for employees within the tertiary education sector, there is a possibility for its use within different other sectors in Mauritius. The personal carbon management processes can be used by any employee or individuals belonging to other sectors in Mauritius. As seen in the literature, the concept of carbon footprint is still fairly new among employees, and hence this indicates that there is much work to be done in that area to inform and sensitize the Mauritian population on the importance of carbon footprint. The personal carbon footprint management framework can thus be further improved and implemented to adapt to other sectors of the island.

Since limited carbon footprint calculators were found to be available for Mauritian context, there is also the possibility to work on and develop a carbon footprint calculator which corresponds to the Mauritian context and can be used by the local population.

Finally, further research on carbon footprint management would help towards building an environmentally sustainable Mauritius and contribute towards the global carbon emission reduction.

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Appendix A – Flyer Design

Front page:

Tips on leading a more eco-friendly lifestyle

Travel

- Reduce your car use for short journeys.
- Walk instead of using other modes of transport whenever possible.
- Use public transport instead of private ones more often.
- Buy the smallest type of vehicle which fits your needs.
- When stationary, switch off the engine.
- When buying a new vehicle, make sure it is fuel efficient and low polluting.
- Learn about the impact of air travel and if possible, choose vacation destinations close to the home country.

(Source: Carbon Footprint, EPA, Carbon Fund)

Lifestyle

- Always remember to reduce, reuse and recycle. Composting organic waste and recycling paper and bottle waste can reduce GHG emissions.
- Try to wear clothing for longer time whenever possible.
- Avoid over-packaged products.
- Try to buy items in bulk in order to reduce packaging.
- Use teleconferencing instead of flying.
- Reduce junk mail and get your bills and statements online.

(Source: Carbon Footprint, EPA, Carbon Fund)

This campaign is being conducted by Middlesex University (Mauritius Branch Campus) in collaboration with the University of Technology and funded by the Mauritius Research Council.

Middlesex University Mauritius Branch Campus

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Reduce Your Carbon Footprint

and contribute towards a greener Mauritius!

Middlesex University Mauritius Branch Campus

UNIVERSITY TECHNOLOGY, MAURITIUS

Back Page:

Change to a greener environment

Climate Change and Mauritius

Climate change is one of the most important challenges of our time. Various regions across the globe have experienced the detrimental effects of climate invariability, such as extreme weather events and disappearance of the flora and fauna. The impacts of climate change are also being felt on the natural and ecological systems of Mauritius and its surrounding islands(Mauritius Meteorological Services).

Observed impacts of climate change in Mauritius

- Rise in sea level (local mean sea level rose by 2.1mm/year).
- Rise in average temperature by 0.74ºC.
- Decrease of annual rainfall of around 8% since the 1950s.
- Increase in the number of hot days and warm nights.
- Regular torrential rains in summer.
- Frequent droughts. Mauritius experienced its worst droughts in 1999 and 2011.

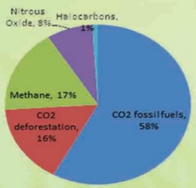
(Source: Ministry of Environment and Sustainable Development)

Apart from weather patterns, climate change is also affecting the socio-economic development of our island, namely the tourism, agriculture and health sectors.

Did you know?
It is projected that by 2050, utilizable water resources will decrease by up to 13%.
(Source: Ministry of Environment and Sustainable Development)

Causes of climate change

Climate change is the result of a global warming that occurs when the atmosphere traps heat radiating from Earth to outer space.This warming up is known as the greenhouse effect. The greenhouse effect constitutes of various greenhouses gases.



Greenhouse Gases Composition (Source: IPCC)

Those gases keep the planet around 30º warmer than it would be otherwise. But through the use of fossil fuels, deforestation and industrial processes, human beings are causing the greenhouse gases to rise and hence trapping more heat, which finally result in global warming.

Human Sources of CO_2 emissions

87%	9%	4%
Fossil Fuel Use	Deforestation	Industrial Processes

(Source: Global Carbon Budget)

Did you know?
There has been 43% increase in the concentration of carbon dioxide recorded in 2013

How do you contribute personally to the increasing carbon emissions?

As an individual, you contribute to the increasing carbon emissions through your daily activities. When you consume energy derived from fossil fuels, for example, lighting your home with electricity or using gasoline to drive your car, you produce greenhouse gases, mainly carbon dioxide.

Did you know?
The CO_2 emissions per capita in Mauritius is
3.22 metric tons
(Source:World Bank)

Carbon dioxide is the engine that drives climate change. Therefore, it is vital to know your carbon footprint, which is your impact on the environment, and determine the amount of carbon you release in the atmosphere.

Household (building and furnishings) 9%	Recreation and Leisure 14%	Gas, Oil and Coal 15%	Share of public services 12%	Private Transport 10%
Clothes and personal effects 4%				Public Transport 3%
Financial Services 3%	Carbon in car manufacture 7%	Electricity 10%	Food and Drinks 5%	Holiday Flights 6%

Carbon footprint of a typical individual

(Source: Carbon Footprint)

To calculate your carbon footprint, a carbon footprint calculator is used. The calculator determines an estimated amount of CO_2 emitted in the atmosphere, based on your daily household energy use, travels, diet and other activities. Free online calculators include:
1. Carbon Footprint: http://www.carbonfootprint.com/
2. CarbonStory: https://www.carbonstory.org/
You can also compare your result with the average national emission per capita, and if needed, reduce your carbon footprint by applying the following tips.

Tips on leading a more eco-friendly lifestyle

Home

- Use compact fluorescent light bulbs. They consume 75% less energy than a regular bulb.
- Unplug appliances when not in use and put them on stand-by mode.
- Look for energy labels (e.g. Energy Star) when buying new appliances.
- Increase your use of renewable energy sources, such as solar and wind energy.
- Use water efficiently.
- In the kitchen, do not open the fridge door unnecessarily. Also, use microwave to reheat or cook small portions of food. Cooking in microwaves can save up to 80% of energy.

(Source: Carbon Footprint, EPA, Carbon Fund)

Diet

- Eat seasonal fruits and vegetables mostly.
- Eat local food whenever possible.
- Drink tap water instead of bottled water.
- Go for healthier food instead of heavily-processed ones.
- Cut down on meat and dairy products.
- Grow your own garden to reduce pollution.

(Source: Carbon Footprint, EPA, Carbon Fund)

Appendix B: Blog Address Card


Do you wish to save money
while being eco-friendly?
Then visit us at
www.greentechnologiesmauritius.wordpress.com
for more information

Appendix C: Survey Form

Development of a Carbon Management Framework for the Tertiary Education Sector in Mauritius:

Carbon Footprint Measurement and Employee Sensitization

This research study involves the development of a carbon management framework to assess, reduce and sensitize employees within tertiary education institutions in Mauritius, after measuring their individual carbon emissions. This innovative framework can be a potential solution to alleviate climate change impacts and also helping towards a greener Mauritius.

This project is being conducted by Middlesex University (Mauritius Branch Campus) in collaboration with the University of Technology, and is being funded by Mauritius Research Council.

OATH OF CONFIDENTIALITY

This is to certify that any information (written, verbal or other form) obtained during the performance of this survey will remain confidential. This includes all the information about the participants, the institutions and any other confidential information being asked in this survey.

We understand that any unauthorized release or carelessness in the handling of this survey questionnaire is considered a breach of the duty to maintain confidentiality. Any breach of duty in maintaining confidentiality is liable to any legal action arising from such breach.

PLEASE NOTE

- You are not required to identify yourself and your responses shall not reveal your identification.
- Feel free to seek any clarification and ask any question(s) regarding the research project from the investigator.
- All responses will be treated in strict confidentiality and will be used solely for academic research purposes.
- Your individual response is highly valued, thus it would be appreciated if you do not confer with others while filling in this survey questionnaire.
- Please note there are no right or wrong answers for the survey questions.
- Completing this questionnaire should take approximately 10-15 minutes.

Kindly respond to the questions by ticking (✓) in the boxes wherever required and PLEASE ANSWER ALL QUESTIONS.

SECTION 1: CARBON FOOTPRINT AWARENESS

Human beings contribute personally to the increasing emission of carbon dioxide in the atmosphere through their daily activities, such as household energy use, travelling and lifestyle choices. The amount of carbon dioxide emitted as a result of those daily activities is known as *carbon footprint*.

1.1 Have you heard of the term “carbon footprint” before?

Yes ☐ No ☐

1.2 Do you know how to calculate your carbon footprint?

Yes ☐ (go to question 1.3) No ☐ (go to question 1.4)

1.3(a) Did you ever calculate your personal individual or household carbon footprint?

Yes ☐ No ☐ (go to question 1.4)

1.3(b) If yes, how often do you calculate your carbon footprint? ________

1.3(c) Did you use any of these online calculators to calculate your carbon footprint? Please tick all that apply.

Carbon Footprint ☐	CarbonStory ☐	Earth Lab ☐
Carbon Neutral ☐	Conservation International ☐	WWF Footprint Calculator ☐

Other: ________________________________

1.4 What would motivate you to calculate your carbon footprint? Please tick all that apply.

- Personal willingness to adopt eco-friendly actions ☐
- Concerns over the effects of climate change on Mauritius ☐
- Awareness from campaigns on television, newspaper and other media ☐
- Following my community’s engagement towards a low-carbon lifestyle ☐

Others: ________________________________

1.5 Which factors would prevent you from reducing your personal carbon emission? Please tick all that apply.

- Insufficient knowledge about effective eco-friendly actions ☐
- Inadequate alternatives to energy intensive activities such as driving ☐
- Lack of motivation from social surroundings ☐
- Lack of finances for adopting eco-friendly measures and products ☐

Others: ________________________________

1.6 How useful do you think carbon footprint calculation is as an initiative to reduce individual carbon emission?

Not useful ☐ Quite useful ☐ Very useful ☐

1.7 Do you think enough is being done to help individuals in Mauritius reduce their emission of carbon dioxide?

Yes ☐ No ☐

1.8 What more do you think could be done to help individuals in Mauritius reduce their carbon dioxide emission?

____

____

1.9 Please indicate how often you apply the following actions towards carbon footprint reduction by ticking in the most appropriate boxes.

	Rarely	***Often***	***Always***
Reduce consumption of heavily-processed food (food packaged in boxes, cans or bags)	☐	☐	☐
Use water efficiently	☐	☐	☐
Avoid eating meat	☐	☐	☐
Eat organic food as much as possible	☐	☐	☐
Recycle majority of waste products	☐	☐	☐
Use e-services instead of paper-based systems	☐	☐	☐
Replace energy sources with renewable ones	☐	☐	☐
Turn off lights when not using	☐	☐	☐
Reduce personal transport vehicles for short journeys	☐	☐	☐
Use public transport instead of private ones whenever possible	☐	☐	☐

The following sections are based on your personal lifestyle, and your answers will help in calculating an estimated amount of carbon dioxide emitted in the atmosphere due to your daily activities.

SECTION 2: HOUSEHOLD ENERGY USE

2.1 How many people are there in your household? _______

2.2 Which energy sources do you use in your house? Please tick all that apply

Electricity ☐ Coal ☐

Heating oil ☐ Propane ☐

Wood ☐ Liquefied Petroleum Gas (LPG)* ☐

**LP Gas cylinders are used mainly for cooking and heating purposes.*

2.3 Please enter your monthly consumption for each type of energy sources:

Electricity: _____ kWh or Rs._____ (cost) LPG: _____ litres (no. of cylinders: large ☐ small ☐)

Propane: _____ litres Coal: _____ metric tons

Heating oil: _____ litres Wood: _____ metric tons

2.4 If your house uses electricity, is some of the energy generated from renewable sources?

Yes ☐ No ☐

2.5 If yes, which energy renewable source(s) do you use and approximately what overall percentage of energy is generated from it?

Solar ☐ Wind ☐ Hydropower ☐ Other: ______________________

Approximate overall percentage: _____

SECTION 3: TRAVEL

3.1 What type of vehicle(s) do you use more often? Please tick all that apply.

Car/Van ☐ (go to question 3.2(a)) Bus/Taxi ☐ (go to question 3.2(c))

Motorbike ☐ (go to question 3.2(b)) None ☐

3.2(a) Please enter details of your daily car use:

Distance:________ km (from ____________ to ____________)

Year of manufacture: ________ Manufacturer: ________________________

Model: ________________________ Efficiency: ________ g/km

3.2(b) Please enter details of your daily motorbike use:

Distance: ________ km (from ____________ to ____________)

Model: Small motorbike/moped/scooter up to 125cc ☐

Medium motorbike over 125cc and up to 500cc ☐

Large motorbike over 500cc ☐

3.2(c) Please enter your daily distance covered for each public transport type you use:

Bus: ________ km (from ____________ to ____________)

Taxi: ________ km (from ____________ to ____________)

3.3(a) What is the number of flights you have taken in the last year? ________

3.3(b) Please enter details of at least 3 of your flight itineraries:

From: ________________________

To: ________________________

Via (optional): ________________

Class: Economy ☐

Premium Economy ☐

Business ☐

First ☐

From: ________________________

To: ________________________

Via (optional): ________________

Class: Economy ☐

Premium Economy ☐

Business ☐

First ☐

From: ________________________

To: ________________________

Via (optional): ________________

Class: Economy ☐

Premium Economy ☐

Business ☐

First ☐

SECTION 4: DIET & OTHERS

Please tick the most appropriate option.

4.1 What are your food preferences?

I am a vegan ☐ I am a vegetarian ☐ I eat mainly fish ☐

I eat mainly white meat ☐ I eat a mix of white and red meat ☐ I eat red meat every day ☐

4.2 Do you consume organic food?

I only buy or grow my own organic food ☐ Some of the food I buy or grow is organic ☐

I never buy or grow organic food, or don’t know what I buy ☐

4.3 Do you buy seasonal food only?

I only buy or grow seasonal food ☐ I try to buy or grow some seasonal food ☐

I don’t try to buy or grow seasonal food ☐

4.4 Do you buy imported food and goods?

I grow all my own food, and don’t buy any produce ☐ I only buy locally produced food and goods ☐

I prefer to buy goods produced closer to home ☐ I mostly buy local produce ☐

I don’t notice where goods come from ☐

4.5 Do you buy clothes according to the latest fashion?

I regularly shop to have the latest fashions ☐ I buy new clothes only when I need them ☐

I only buy second hand clothes ☐

4.6 What kind of product packaging do you prefer?

I don’t buy anything which has packaging around it ☐ I try and buy things with little packaging ☐

I only buy things which have very little packaging ☐ I only buy things which are nicely packaged ☐

4.7 What kind of furniture and electronics products do you purchase?

I like to have the latest technology and latest home fashions ☐

I mostly buy new but generally keep things for more than 5 years ☐

I only buy essential equipment and use it until it wears out ☐

I only buy second hand furniture and appliances ☐

4.8 Do you recycle your waste products?

Everything I use gets recycled or composted ☐ Most of my waste is recycled ☐

Some of my waste is recycled ☐ I don't recycle at all ☐

4.9 What are your recreational activities?

I only do zero carbon activities, e.g. walk or cycle ☐

I occasionally go out to places like movies and restaurants ☐

I often go out to places like movies and restaurants ☐

I enjoy sport activities, e.g. quad biking, sky diving and flying ☐

4.10 How many car(s) do you own? ________

4.11 Do you use banking and other financial services?

I don't have a bank account ☐ I use the standard range of financial services ☐

SECTION 5: BACKGROUND INFORMATION

Please provide details on your personal background below:

5.1 Gender: Male ☐ Female ☐

5.2 Which of the following age group do you belong?

20 – 30 ☐ 31 – 40 ☐ 41 – 50 ☐ 51 – 60 ☐ > 60 ☐

5.3 In which district do you reside?________________________

5.4 Which Tertiary Education Institution do you belong to? ______________________________________

5.5 Which faculty do you belong to? ______________________________________

5.6 How would you best describe your role on campus?

Academic Staff ☐ Administration Staff ☐ Other:__________________________________

5.7 What is your monthly income range in Mauritius Rupees?

MUR 10, 000 or less ☐ MUR 11, 000 - MUR 25, 000 ☐

MUR 26, 000 - MUR 35, 000 ☐ MUR 36, 000 - MUR 50, 000 ☐

MUR 51, 000 or more ☐

5.8 If you would like to receive your carbon footprint by email, please write your email address below:

____

Thank you for giving up some of your time to complete this survey.