Calculating the Carbon Footprint of Asian University for Women– aUniversity Located in an Asian Developing Country

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Abstract

Many of our day-to-day activities emitgreenhouse gases to the atmosphere. The impacts on the environment of an organization, product or person can be measured by calculating the carbon footprint. This study attempts to calculate the carbon footprint of Asian University for Women (AUW) in the fiscal year 2017 (FY2017), using the Campus Carbon Calculator (CCC) of Sustainable Institute of the University of New Hampshire. This has been the first attempt to quantify the total emission in one year of AUW since the university was established.

In FY2017, AUW's total emissions were 1,492.6 MT CO_2e. The emissionsper capita were 1.9 MT CO_2e andemissions per square foot building space were 0.02 MT CO_2e. Of this total, CO_2 emissions were 952,056.1 kg, CH_4 emissions were 20,518.6 kg, and N_2O emissions were 12.4 kg. The major emission sources of AUW's carbon footprint were solid waste (34%), international students' air travel to/from home (21%), purchased electricity (17%), directly financed air travel (13%), and other on-campus stationary (7%). It is suggested that the biggest opportunities for reducing campus GHG emissions are related to these categories. The calculated offset due to the preservation of approximately 42.9 acres of tropical forest and 42.9 acres of tropical undergrowth jungle in AUW-owned land were 765.0 MT CO_2e. This emphasizes that forest preservation has a significant role in reducing emissionsof AUW because the net emissions after including offsets were only 727.6 MT CO_2e, less than half of the total emissions.

The carbon footprint of AUW is relatively low when compared to that of other universities in developed countries. AUW represents a large part of universities in developing world, where the life standards and operation scale are not high to generate huge emissions but in contrast, lack of advanced technology such as renewable energy and effective waste treatment to reduce greenhouse gas emissions. In this scenario, offsets from natural forest preservation became important for organizations which want to reduce their carbon footprint. Since most developing countries are located in Asian tropical regions which forestshavethe highest sequestration rate, purchasing forested land and promoting forest preservation programs are the most practical solutions for the universities in developing countries if they want to increase their carbon offsets.

1. INTRODUCTION

Over 90 percent of climate scientists believe that climate change is happening and it is mainly due to anthropogenic greenhouse gas (GHG) emissions. Although many of our daily activities emit GHGs to the atmosphere, the majority of the population are not aware of their damage to the planet's climate. Some countries, organizations and businesses are already committed to becoming carbon neutral; many are not. Being members of academic institutions, when it comes to sustainability practices, it is our responsibility to model ideal behavior. However, it is the lack of long-term thinking that has inhibited large-scale, global changes.By measuring our GHG emissions through time, the process is also known as calculating carbon footprint, we can plan ahead for future generations an effective, economicaland sustainable development.

In order to complete an adequate assessment of carbon footprint, a proper understanding of greenhouse effect and climate change is necessary.

1.1. The greenhouse effect and climate change

According to most recent assessment reports of the Intergovernmental Panel on Climate Change (IPCC), National Aeronautics and Space Administration (NASA), and a significant number of organizations as well as scientists, global climate change is occurring with an accelerating pace. Climate change has become a worldwide issue with visible signs and consequences. IPCC defines climate change as "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer." This definition refers to any changes in climate over time caused by natural variability or human activities (Eggleston *et al*., 2006).

As parts of the Earth's carbon cycle, carbon dioxide (CO_2) is naturally present in the atmosphere beside the carbon stored biomass, fossil fuels and ions in ocean. However, since the industrial revolution in the late 18th century, human activities, especially the combustion of fossil fuels (coal, natural gas, and oil) and deforestation,have heightened the level of GHGs, especially CO_2 in the atmosphere. The present rate of CO_2 production is now greater than the offset capacity of natural sinks such as forests (Pidwirny,2006). The GHGs in Earth's atmosphere include water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and some insignificant others (Chen *et al.,* 2007). These GHGs absorb and trap the longer infrared wavelengths radiated by sun-warmed objects and prevent most of them from escaping into space, creating the greenhouse effect and changing the climate (Solomon*et al*., 2007).

Although water vapor contributes the highest proportion of the greenhouse effect, its contribution is not growing rapidly as CO_2 is; in addition, humans do not have as much control over water vapor as they do over CO_2 emissions (Solomon *et al.*, 2007). NASA considersthe CO_2 amount as one of thevital signs for climate change (NASA, 2017). Different studies also confirm the correlation between the temperature changes with the increase of CO_2 concentration in the atmosphere, and state that anthropogenic factorsare the major cause for this rapid rise. This change has vastly affected the natural balance of the Earth's climate and led to serious consequences. Ice is melting faster than previously estimated, rising sea levels, causing catastrophes and extreme events in low altitude areas. Changing in raining patterns are also reported in different areas of the world. While some areas are having precipitation increased greater than the average, resulting in floods; many places are getting drier or even facing droughts, affecting agriculture and causing hunger. Biodiversity is also affected as a result of changing seasons (Solomon *et al.*, 2007; NASA, 2017).Absorption of the emitted carbon dioxide in the oceanssince the beginning of the industrial revolution has increased the acidity of surface ocean water by about 30% and affected marine ecosystems (NASA, 2017).

According to a recent review of the World Meteorological Organization (WMO), a new high record of the amount of GHGs in the atmosphere was marked in 2013: the concentration of CO_2 reached nearly one and half times (142%) compared to that in the pre-industrial era (1750) and other GHGs were also at higher concentrations, methane (CH_4) concentration increased to 253% of what it was during pre-industrial and nitrous oxide (N_2O) concentration increased to 121% (WMO, 2014). Between 2003 and 2012, CO_2 emissions from burning fuels such as oil, gas and coal, and from thermal power plants, refineries, factories and automobiles - has been rising globally on an average of 3.3% per year according to the Global Carbon Atlas. At that pace, it was not surprising that the atmospheric CO2 concentration passed the symbolic thresholdof 400 ppm for every month in 2016, and many scientists revealed their concerns that we will not see a monthly value below 400 ppm ever again for the indefinite future (Ritchie, 2017). Solomon *et al.* stated that even if carbon dioxide emission is stopped now, its effects on climate could last in 1000 years' time (Solomon *et al.*, 2009).

1.2. International framework of global climate change

Climate change was first recognized as an international concern during the United Nations conference of Stockholm in 1972. In the reunion, 113 countries made a Declaration about Human environment and created the United Nations Environment Programme (UNEP). In 1983, United Nations created Brundtland commission, a world commission for the Environment and Development. Four years later, this commission has published a report called "Our Common future", which showed the importance of sustainable development (United Nations, 1987). In 1992, the United Nations Organization organized an Earth Summit in Rio de Janeiro, a joint strategy was defined to protect the environment during the summit (Meakin, 1992). The Agenda

21, a plan action with regard to sustainable development, was adopted by 170 countries. The three conventions Convention on Biological Diversity, Framework Convention on Climate Change (UNFCCC) and United Nations Convention to Combat Desertification were signed (United Nations, 1992). In 1997, the Kyoto Protocol was created by the UNFCCC to establish targets of GHG emissions in industrialized countries from 2005 onward. The convention was signed by 195 countries and those countries were divided in two groups: Annex I and Non-Annex 1. Annex I include the industrialized countries that were members of the OECD (Organization for Economic Co-operation and Development) and countries which were categorized as economies in transition. The countries in Annex I group were expected to report regularly and reduce their emissions of GHGsin the period between 2008 and 2012 by at least 5.2% compared to the 1990 levels. Non-Annex countries refer to developing countries that were not obliged to a targets under the Kyoto Protocol, but they are expected to take precautionary measures to anticipate, prevent or minimize the causes of climate change as well as its adverse effects (United Nations, 1998). The UN Climate Change conference in 2009 acknowledged a two-degree rise in global average temperature as the threshold of dangerous human interference in the climate system. To reduce the effects of global warming, it is necessary to stabilize the concentration of CO_2 below 400 ppm. The Annex I and non-Annex I countries are expected to take approaches to reduce GHG emissions during a time frame of 40 years, from 2010 to 2050 (ISSC, 2005).

1.3. Why calculating carbon footprint of AUW and higher academic institutions?

Asian University for Women (AUW) is an independent, international liberal arts university in Chittagong, Bangladesh. AUW seeks to graduate young generations of women leaders and promoters of intercultural understanding, sustainable human and economic development in Asia and throughout the world.

There are no global, national, or local regulations that require AUW to conduct a carbon footprint inventory or any regulations that restrict or require AUW to reduce GHG emissions. However, as a student of the university, the author found that it was imperative to voluntarily define the university's GHG emissions for multiple reasons. As one of its missions, AUW promises to support sustainable development and tackling environmental problems. One way to demonstrate that is to reduce our GHG emissions, our energy use and costs, and our impact on human-induced global climate change. Completing this GHG emission inventory in accordance with recognized international standards is a necessary first step. The GHG emissions will be categorized by emission sources so that informed decisions can be made.Hopefully, AUW can maintain and update this carbon footprint inventory each fiscal year.The carbon footprint provides the needed emissions baseline and trends that is necessary for the university to understand its emissions in order to develop an effective GHG reduction strategy.

In addition, the subject of provision of GHG emission inventorymay be a new subject for higher education institutionsof developing countries but this has taken place in many developed countries for over the last few decades. Through this initiate, the author hopes AUW can be an example to encourage and facilitate the same practice in other universities in Asian developing countries since there is an obvious lack of GHG emission inventory of higher academic institutions in this region.

To overcome the climate change crisis, academic institutions plays a crucial and important role to promote real practices and actions.In the battle to resist climate change, participation and cooperation from both developed and developing countries are required.Universities and colleges are expected to be early adopters of new ideas and have a special responsibility to educate and motivate young people who will determine our future. This leadership can create positive influence on other organizations and communities.The call for more sustainability initiatives such as calculating carbon footprint in universities in developing countries can help raise awareness, encourage an element of healthy competition between universities in the region, and ultimatelypromote the transition to more sustainable campuses and organizations in the future.

1.4. Objectives of the study

The main objective of the study is to measure the total carbon footprint of AUW in FY2017. From the results, the major sources of GHG emissions will be analyzed and identified. Based on the analysis, a baseline for the development and future GHG emission reduction strategies will be suggested. The second objective of this thesis is to compare GHG emissions of AUW with the emissions of other universities.

The primary objective is to create awareness about the direct and indirect impacts of daily human activities to climate change. Consequences of the anthropogenic factors to climate can be clarified by quantifying GHG emissions. Calculating and reducing the carbon footprint not only help conserve the environment but also reduce the expenditures of the university and portray a better image of the university to students, employees and the community in general.

2. LITERATURE REVIEW

As the consequences of climate change become dramatically visible in recent years, being aware of our own GHG emissions to take further actions become important. Organizational activities such asfossil fuel usage, electricity consumption, product manufacturing, transportation, paper utilization and even waste disposal emit GHGs (Wiedmann& Minx,2008). Using carbon footprint concept can help calculate the overall emissions and the emission amounts which are correlated to each kind of activity. This thesis will apply that concept to calculate the GHG emissions of AUW and points out the key sources of emission of the university.

2.1. What is carbon footprint?

In the literature, there is no exact definition of carbon footprint. In most cases, “carbon footprint” is used as a generic term referring to the calculated emissions of CO_2or GHGs expressed in tons of CO_2 equivalents instead of CO_2 in particular during one year. The exact origin of the concept is unknown but according to some perspectives, carbon footprint is related to the ecological footprint concept formulated in the 1990s(Wackernagel& Rees, 1998).

Ecological footprint is an accounting tool designed to track the amounts of resources utilized and emissions produced by humans, thus estimate human demand on the biosphere’s regenerative capacity (Wackernagel*et al*., 1999; Wackernagel*et al*.,2002). According to World Wide Fund (WWF), ecological footprint measures the impact of human activities in terms of an area with biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated. In a simpler way, ecological footprint is the amount of the environment necessary to produce the goods and services necessary to support a particular lifestyle and is expressed in units of area (Galli*et al*., 2012).Carbon footprint can easily be confused with ecological footprint but in fact, ecological footprint covers wider aspects.

On the other hand, carbon footprint calculates the total amount of GHGsemitted directly or indirectly by an activity or accumulated over the life stages of a product (Wiedmann*et al*., 2006). Despite its name, carbon footprint is not expressed in terms of area but in mass units of the total amount of GHGs calculated. Any conversion of a particular carbon footprint into a land area would have to be based on a variety of assumptions whichmight involve a lot of uncertainties and errors (Galli *et al*., 2012).

Carbon footprint has become a tool to investigate the impact of individuals, communities, nations, companies or products on the climate. Many countries and sub-national regions, institutions such as schools, products, businesses and investment fundshave used carbon footprints to calculate their GHGs emissions. Possible emission sources can be transport, electricity, paper, manufactured products, food, drink, health and hygiene products (Wiedmann& Minx, 2008).

2.2. Selection of GHGs

Emissions-emitting activities usually do not emit any particular greenhouse gas but rather emit a variety of gases, with the most common being CO_2, CH_4, and N_2O. When calculating carbon footprint, selection of GHGs depends on the type of activities accounted. Some authors include only CO_2 emissions in carbon footprint calculations (Wiedmann& Minx, 2008) while others include the six Kyoto gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6)(Bokowski*et al.*, 2007). In this study, with the use of the Campus Carbon Calculator (CCC), emissions are accounted for the total amounts of CO_2, $CH_4$and N_2O that are directly and indirectly emitted. Activity data (e.g., fuel consumed, kWh electricity purchased, air miles traveled, etc.) is multiplied by its suitable emissions factor (e.g., kg CO_2/kWh, kg CH_4/tonne of solid waste) to yield emissions for that activity by specific GHG type.

Each GHG type are converted to its carbon dioxide equivalent based on its Global Warming Potential (GWP) relative to CO_2 provided by the IPCCsothat comparisons and evaluations can be made (Table 1). For example, one metric ton of $CH_4$is equal to the emission of 23 metric tons CO_2. All emissions are reported in a common unit of measurement, namely, metric tons of carbon dioxide equivalent (MTCO_2e).

Table 1: Global Warming Potential and Atmospheric Lifetime of Greenhouse Gases (US EPA, 2007)

Greenhouse Gas (GHG)	Atmospheric Lifetime (Years)	Global Warming Potential (100 Years)
Carbon Dioxide (CO_2)	50-200	1
Methane (CH_4)	9-15	23
Nitrous Oxide (N_2O)	120	296
HFC 134A	15	1,300
HCFC 404A	>48	3,260
Sulfur Hexafluoride (SF_6)	3200	23,900

2.3. Setting the boundaries for sources of emission

It is helpful to set theboundaries when including operational activities in the assessment. The Greenhouse Gas Protocol, developed by the World Resources Institute and the World Business Council for Sustainable Development, is the most widely-used international accounting tool for quantifying GHG emissions. It provides the accounting framework for nearly every GHG program and standard in the world, including the Chicago Climate Exchange and the California Climate Action Registry. The GHGProtocol categorized sources of emissions into three different scopes (Figure 1) in which in the case of an organization like university will be (Ranganathan*et al*., 2004.):

- Scope 1 -Core direct emissions: Direct emissions resulting from activities and sources within the organization's control. These include on-site fuel combustion, manufacturing and process emissions, refrigerant losses and the organization's vehicles. It is mandatory to include such emissions.
- Scope 2 -Core energy indirect emissions:Indirect emissions from electricity, heat or steam purchased and used by the organization. These are emissions from operational activities of the university but occur from sources owned or controlled by other companies. Inclusion of such emissions is also mandatory.
- Scope 3 - Other non-core indirect emissions: Any other indirect emissions from sources not directly controlled by the organization. For example, employee business travel, outsourced transportation, waste disposaland employee commuting. It is optional to include of these categories. There is broad discretion about which (if any) Scope 3 emissions should be included – for example, organizations may choose to include (or not include) categories such as waste disposed to landfill and employee business travel.

Using the GHG Protocol to set the boundaries for sources of emission ensures that the organization's report and results will be prepared in accordance with international best practice. As this procedure was also used in numerous previous studies, the results can be used for references, temporal comparisonor appropriate caveats (Cleaner Production Promotion Unit, 2013)

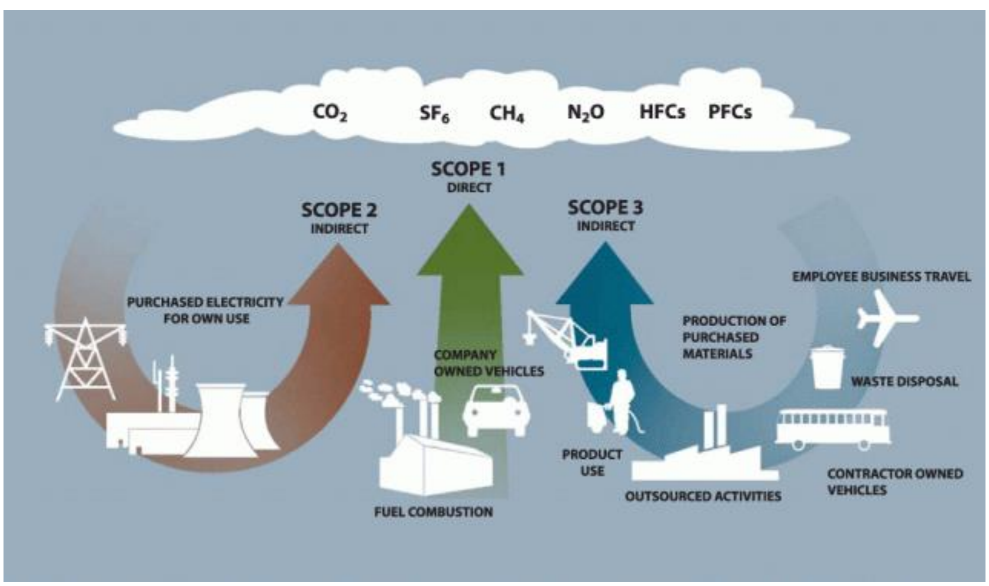

Figure 1: Operational Boundaries of GHG Emissions (WRI, 2009)

2.4. Emission Factors

An emission factor is a normalized measure of the amount of carbon that can be attributed to the consumption of a single unit of energy in a particular process. This value can vary depending on the fuels and processes, reflecting their purity, efficiencies of conversion and transmission. From the agreement of experts in the field, carbon is typically reported in metric tons (MT) of carbon equivalent, which is 1,000 kg or 2,205 lbs. For calculations and analysis, emission factors are standardized to the appropriate units of energy, kWh or mWh for electricity, and MBtu for thermal sources, for example in "tons CO_2e/MBtu" or "MT CO_2e/kWh." In some cases, the amount of CO_2e per MBTU is sufficiently small, that it will be reported in kilograms, "kg CO_2e/MBtu" (University of Pennsylvania, 2007).

The emission factors for direct scope 1 sources such as natural gas, gasoline or other fuels are relatively precise, and largely derive from the physics of combustion of different fuels. For indirect scope categories, such as scope 2 and scope, emission factors, however involve estimates of the mix of fuels or processes involved in the energy imported through centralized utilities. Estimation is especially complex with purchased electricity that draws from a regional grid that includes multiple power plants, each with unique emissions patterns, and is itself interconnected with other regions. This report has used the CCC to organize data and calculate the result with given emission factors derived from the world standards. This tool has been used at many campuses all over the world, and widely automates the carbon accounting standards jointly established by the World Business Council for Sustainable Development and the World Resource Institute (WBCSD/WRI). Nevertheless, identification of local fuel mixes or efficiencies is necessary, and for each emission calculation, the sources of information and assumptions have been noted (University of Pennsylvania, 2007).

2.5. Previous studies on carbon footprint of universities

Universities have an important role in increasing awareness of environmental issues and motivating the society, particularly the youth, to take approaches and shape a sustainable future. According to Owens and Halfacre-Hitchcock (2006), many researchers acknowledge both positive and negative impacts of the higher education institutions onsustainable initiatives. Higher education institutions are stable and improved through time, with long-term thinking and educative goals, they conduct research, educate and inspireyoung generations about sustainability. These institutes successfully incorporate local and global knowledge, and combine that with the talents of faculty, students and staffs to create synergies to cultivate new solutions. However, higher educationis also a fast growing service sector which consumes energy and resources, and generates emissions and waste. For instant, the total energy used of the UK higher education building stock in 2002-2003 was 7.4 TWh, which is equals to 1.6 percent of the UK's industrial, commercial and public sector energy (Roy, Potter& Yarrow, 2008).

As a result, many leading/top universities all over the world have made a strategic commitment to environmental sustainability and calculated their carbon footprints using different methods. In the United States, more than 90% of the U.S. colleges and universities use the CCC to track their GHG emissions and publish their reports (UHN Sustainable Institute,n.d.). The CCC is a standardized calculator developed by the Clean Air - Cool Planet, an American non-profit organization that is dedicated to finding and promoting solutions to global warming, and the Sustainability Institute of the University of New Hampshire. Based on the GHG protocol, the CCC is specifically designed for calculating GHG emissions of universities (UHN Sustainable Institute, 2017). For example, Colgate University (New York, USA) is one of the universities that had done their inventory for carbon emissions using the CCC. It was calculated that in 2009, the university's gross emissions per full time student were 6.81 MT CO_2e and 8.14 MT CO_2e per 1000 square feet. Highest sources of emissions were identified to be air travel at 44% of total emissions, fuel oil at 20%, electricity at 9% and faculty and staff commuting at 9% (Taylor, 2010).

As another example, the carbon footprint of Carnegie Mellon University was found to be approximately 164,000 MT CO_2e in 2006, after thorough research and the use of the CCC. They revealed that they also assessed their carbon footprint with other calculators but the CCC was proved to be the most comprehensive to them, and it generally had the most accurate assumptions and was considered to be the best suited for universities like Carnegie Mellon. The analysis showed that the four major contributors to the carbon footprint of Carnegie Mellon were electricity, steam, faculty air travel, and student air travel (CMU, 2008).

Some other universities calculated carbon footprint using bottom-up (Process Analysis) and top-down (Environmental Input-Output Analysis) approaches. Process Analysis Method aims to identify all the environmental impacts of individual products for a life span. As this method is a bottom-up approach system, boundary determination is a critical issue. They suffer from a system boundary problem - only on-site, most first-order, and some second-order impacts are considered (Lenzen, 2001). This method can be useful in macro ormeso levels of calculation. On the other hand, environmental Input-Output (EIO) analysis provides an alternative top-down approach to carbon foot printing. Economic system acts as a system boundary in such analysis. This analysis works well in micro system levels (Wiedmann*et al.*, 2006).

For example, the Universidad Nacional Autónoma de México (UNAM) calculated their carbon footprint by process analysis (PA). They considered electric energy generation, vehicle fleet, purchased electricity, commuting, air travels, courier shipments, paper consumption and solid waste in their assessment. CO_2, CH_4 and N_2O gases were considered. From guidelines of IPCC and other sources, emission factors were obtained. The total estimated carbon footprint was 1,577 tons of CO_2e where 42% were caused by electricity, 50% by transportation (own fleet and commuting vehicles), 5% by air travel, 1% paper and another 1% by final disposal of solid waste. They also concluded that commuting was the main source of CO2 emissions (Güereca, Torres &Noyola, 2013).

The carbon footprint of the Norwegian University of Technology and Science (NTNU) was calculated using an Environmental Extended Input-Output (EEIO) model. They found Life Cycle Assessment (LCAs) to be insufficient, less accurate and more time consuming than EEIO. On the other hand, the financial framework applied by governmental entities provides a detailed and a standardized setup that were appropriate for EEIO modelling. Nevertheless, the scope 1 and 2 were calculated with hybrid approach (Process and Input-Output) to be more detailed. The results showed that energy, buildings and equipment contributed equally (about 19% each), travel accounted for 16%, followed by consumables (11%) and services (5%). The total emissions were estimated to be about 92,000 tons of CO_2e for the year 2009 (Larsen *et al*., 2013).

In addition, the Instituto Superior Técnico (IST) had it carbon footprint calculated by a hybrid model of Process Analysis (PA) and Input-Output (IO). In the first approach, the author followed the GHG Protocol and considered the following categories: transport, energy, food and solid waste. For input-output approach, accounts report, balance sheet and IST invoices were used to account for goods and services. The physical and monetary inputs was classified in economic activities and then combined with data from National Statistics Institute to perform the model. The carbon footprint in 2013 was estimated at 21,557 tons of CO_2e which corresponds to 1.68 tons per person enrolled in IST. About 71 % of these emissions are indirect emissions resulting from transport, purchase of goods and services, solid waste and canteen; 27% were indirect emissions from purchased electricity and 2% are caused by the direct burning of natural gas and the shuttle, which is a bus provided by IST (Carrilho, 2015).

2.6. Limitations of Carbon Footprint Study

Different carbon footprint can express different information, depending on how they are calculated and on how much responsibility the entity in question is willing to assume (Matthews, Hendrickson& Weber, 2008). There exists an intrinsic trade-off between comprehensiveness of the measure developed on one hand and practicality of data collation and analysis on the other. It is also difficult to evaluate the extent to which final consumers and intermediate businesses can affect emissions during the supply chain (Matthews, Hendrickson, & Weber, 2008). In addition, nontrivial shortcomings in the collection and aggregation of GHG emissions data can influence the credibility and relevance of sustainability reports, such as those presenting carbon footprint results (Dragomir, 2012). To ensure the validity of the reported findings and avoid such issues, this report tried to follow strictly the procedure guided by the GHG protocol and the CCC.

3. METHODOLOGY

In this study, the Campus Carbon Calculator™ v9.0 (CCC), a Microsoft Excel-based tool, was used to record the GHG emissions data collected and compute the carbon footprint of AUW. As explained previously, the CCC was created by Clean Air-Cool Planet and the Sustainability Institute of Universisty of New Hamsphire for use as a carbon emissions calculator for a college or university's carbon inventory. The calculator uses standardized methodologies codified by the GHG Protocol, thusprovides procedural protocols and a framework for investigation of the emissions of greenhouse gases which are attributable to the existence and operations of an institution. The excel file incorporates three main modules: an input, an emissions factor, and a summary module. The spreadsheets were originally based on the workbooks provided by the IPCC for national-level inventories, and incorporated data from the Fourth Assessment Report of the IPCC. These methodologies are currently considered the most accurate and are widely accepted amongst policy makers. Inventories produced by the calculator are compatible with current standards used to craft forthcoming cap-and-trade policy (UNH Sustainable Institute, 2017).

Prior to conducting the AUW's carbon footprint calculation, the operational and organizational boundaries were defined. The CCC's rules and guidelines that constitute these boundaries were strictly followed for relevance, completeness, consistency, and accuracy.Firstly, data about the total building space and campus population was collected. The second step of the protocol is identifying and calculating the GHG emissions associated with campus activities (such as energy use, commuting, solid waste management) (Ranganathan, 2004). The emission factor module of the calculator converts the data into the appropriate amount of carbon footprint. These figures are then reduced by carbon offsets that were already in place by the university. The module consists of several worksheets with coefficient tables used to perform the unit conversion from the input data to tons of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The result of those calculations is recorded in the summary module of the calculator. The summary module contains results of the emissions categorized by each kind of GHGs separately, as well as the emissions by scopes, emissions sources and the total carbon footprint (UNH Sustainable Institute, 2017). The last steps of the process include managing inventory quality, accounting for GHG reductions, reporting and verifying emissions (Ranganathan, 2004). The procedure ensures the accuracy of the obtained data, and helps set reduction goals and guidelines.

3.1. University operational and organizational/spatial boundaries

Selection of the organizational/spatial boundary was based on the principle that the buildings or flats are operated and controlled by AUW or for which the university paid the utility such as electric-power bill. This definition includes the entire area of AUW's temporary campus as well as rented residence buildings and flats: AUW's buildings (20A, 20B, 20C, 20H, 20G and 20J), and off-campus Panchlaishbuilding and a number of Khulshi flats (for faculty and staff housing). This organizational/spatial boundary is located in Chittagong and consists of approximately 1.5 acres (equal to 65,340 square feet).

For university operational boundary, the activities referred to as GHG emissions includes all those outlined in the GHG protocol mentioned before. For AUW:

- Scope 1 - Core direct emissions: emissions associated with the university fleet (gasoline, diesel, and compressed natural gas), and on-campus stationary sources (including the university co-generation machines and cooking gas).
- Scope 2 - Core energy indirect emissions: emissions associated with purchased electricity.
- Scope 3 - Other non-core indirect emissions: emissions associated with students and faculty/staff commuting, air travel for university related activities (including direct finance air travel and international students' air travel), paper usage, and emissions that resulted from university generated solid waste.
- Offset: Forest preservation in AUW-owned land

The off-campus activities of community members (such as energy consumption from student and faculty/staff off-campus housing, tourism) were considered outside the scope of this study. Also, upstream GHG emissions associated with the production of materials (e.g., office paper), equipment (e.g., electronics), and infrastructure (e.g., construction materials) used by the university were not included. The GHG protocol requires organizations to account for Scopes 1 and 2, but leaves Scope 3 optional. This study took an aggressive approach in defining campus emissions and included a number of Scope 3 emissions which data can be obtained. As carbon accounting methods are improved and additional Scope 3 emission protocols become available, the scopes of the campus inventory can be expanded as appropriate.

3.2. Inventory Procedure & Data Sources

The data collection was conducted simply through personal communication (both via email and meetings) with personnel from relevant AUW offices, and partly through small interviews with students, faculty and staff. Below is a brief description of the procedures used to acquire and calculate each of the required data for all sources of campus GHG emissions.

3.2.1. Institutional Data

Student, faculty, and staff community membership numbers; and total building space were required by the CCC to estimate some energy-use categories and to describe per capita GHG emissions. Faculty and staff populations were provided by the Human Resources Office. The number of students (both full-time students and day-scholars) was provided by the Academic Registry Office. AUW's total building space and sketch were obtained from the Security & Logistics Office.

3.2.2. Scope 1 - Core direct emissions

3.2.2.1. Vehicle Fleet

The inventory calculator categorized the vehicle fleet by fuel type (i.e. gasoline fleet, diesel fleet, natural gas fleet). AUW currently has seven licensed vehicles and one rented van. The vehicles refuel from fuel-servicing stations on the streets. This process is managed spontaneous by AUW's drivers, the drivers then report it to the Transportation Supervisor of the Travel and Logistics Office. These vehicles are considered under Scope 1 emissions because the university has direct control of these sources. On the other hand, the emissions associated with faculty, staff, and student commuting are included in Scope 3 later because they are not under the direct control of AUW.

There were no official records of fuel purchased for or miles driven by the campus fleet by the Travel and Logistics Office or Finance Office. Fortunately, the Transportation Supervisor of the Travel and Logistics Department provided his personal records of fuel purchased for each vehicle in three months. The average amount of fuel purchased in those three months was calculated and converted into gallons (for gasoline and diesel) and MMBTU (for compressed natural gas/.CNG), and then scaled up to the whole year.

3.2.2.2. On-campus Stationary Sources

Diesel Generators

In addition to the energy purchased, the university's generators burn diesel and produce electricity to meet AUW's electricity demand in urgent occasions. Each building is equipped with one generator. The fuel usage data were provided by the Maintenance Office.

Household gas

The kitchens of 20A, 20B, 20C, Panchlaish buildings and Khulshi flats are connected to the national household gas system for cooking purpose. It is difficult to quantify the exact amount of gas purchased since in Bangladesh, most of the domestic connections are without meter. Users only need to pay per flat or per connection and have unlimited use.

However, based on an investigation done in a university student hall in Bangladesh during June 2014 to May 2015 (Habib, Elahi&Khandaker, 2016), we can estimate that the average consumption was 0.15422 m^3/person/day (cite). In that study, total number of dine-in students were 300 to 550, which is similar to AUW. Therefore, the scale can be applicable for AUW. Additional information regarding mass cooking at AUW was also obtained from the House Keeping Office. The supervisor revealed that in normal academic periods, the kitchen had to prepare food for about 500 people each day; and during long vacations (one month of winter break and three months of summer vacation), that number reduced approximately by 50%. Based on that information, the amount of natural gas purchased for one year was calculated and converted into MMBTU (1 m^3 of natural gas generate 0.03696 MMBTU).

3.2.3. Scope 2- Core energy indirect emissions

3.2.3.1. Purchased Electricity

The University's electricity was purchased from the commercial power company K.C.J Associated Limited. Purchased electricity data was available for each building ineach month of FY2017 and was provided by the Maintenance Office, Facilities Management. Annual data measured in kWh entered into the calculator were converted to GHG emissions using the general national fuel-mix of Bangladesh. The University did not purchase any steam or chilled water.

A certain percentage of electricity generated at the power station is lost in transmission and distribution to the end customer. Transmission and distribution (T&D) losses stemming from electricity (calculated as a percentage of total electricity consumption) is included in Scope 3 emissions of the CCC.

3.2.4. Scope 3- Other non-core indirect emissions

3.2.4.1. Commuting

Quantifying the GHG emissions from commuter traffic of AUW was one of the most challenging tasks in the study. The goal of the commuter traffic component of the calculator is to estimate GHG emissions associated with annual miles traveled to and from campus by students, faculty, and staff of AUW. Due to a lack of transportation-related surveys, data on commuter habits was not available. The CCC asks for data on the population of university members commuting to campus, number of trips per week, percentage of different means of transportation used and the average distance by each kind of vehicle. From the information provided by Academic Registry Office and Human Resources Office, the total number of student commuters was estimated to be 90, faculty and staff commuters were estimated to be 130.

A small survey on commuting was conducted to obtain more insights. Survey responses were collected and enlarged to their respective demographic population (student, administration, faculty, and staff). This survey had a total of 48 respondents, of this, 21 respondents were local students, 27 were local faculty and staff. The respondents from each demographic represent more than 20% of their respective commuting population. The survey questions were simply as followed:

- What is the distance between your house/residential address and AUW's campus?
- How many one-way trips per week do you make from and to campus?
- What mean(s) of transportation do you usually use to commute from and to campus? (walk, rickshaw, car, CNG, bus…)

The calculator does not have a section for CNG vehicles in the commuting sheet, thus the coefficient for automobiles was modified, based on the fact that CNG vehicles emit 20% less GHGs than gasolineor diesel-powered vehicles (NGVA Europe, 2017).

3.2.4.2. Directly Financed Outsourced Air Travel

The information about the routes of flights booked by AUW's Travel & Logistics Office was collected. However, the information only includes the places of departure and destinations of the flights, thus the distancestraveled between airports in miles were calculated and inputted manually with the help of Air Mile Calculator Tool (http://www.airmilescalculator.com/distance/).

Other mode trips financed by AUW such as bus or train was recorded with monetary value but not with the places of departure and destinations. Therefore, the data about these trips could not be used for the calculation.

3.2.4.3. International Students' Air Travel To/From Home

AUW attracts a huge population of students from different areas across Asia. Although the CCC notes that this category is optional to include and most institutions do not include this in their GHG emissions inventory, the author believes that the calculation was able to achieve a more accurate carbon footprint for AUW when the number of miles whichthose students fly to/from home for study abroad purpose is incorporated into the analysis. However, most of the students book the tickets to go home during vacations by themselves thus it is difficult to obtain a detailed record from any AUW departments.

A reasonable assumption was made which is that each international student take one round-trip flight per year from Dhaka airport to the airport in the capital of their respected countries. Bangladeshi students were excluded from this analysis under the assumption that they take bus or train and do not fly to and from the campus. Similarly, the distance in miles was calculated and inputted manually with the help of Air Mile Calculator Tool (http://www.airmilescalculator.com/distance/).

3.2.4.4. Paper Purchasing

The calculator can provide an estimate of the emissions from the paper products AUW purchases. The data on paper usage by AUW in one year was gathered from different sources since paper was not distributed to students, faculty and staff from just one source. The sources include Stationary Supplies Office, Procurement Office, the Office of Student Affairs, House Keeping Office and the photocopy shop in the campus. For each kind of item (e.g., a note book, a piece of paper, a toilet roll), the weight of each unit was measured and then multiplied with the quantity data to find the total paper usage. The total paper weight was converted to poundsbeforeinputting to the CCC.

3.2.4.5. Solid Waste

There is no departments of AUW which keep record and manage the solid waste generated by AUW. For estimation, the amount of solid waste in one day was weighed with the help of the House Keeping Department. This number was then multiplied by the days per year and then converted from kg to short tons (1 short ton = 907 kg). At the waste receiving and management facilities of Chittagong, allsolid waste generated by the AUWis land-filled with no methane recovery. The CCC assumed emission factors based on average composition of solid waste.

3.2.5. Offset

Carbon offsets are defined as reductions in the amount of CO_2 emitted by the campus due to emissions-reducing sources and activities such as on-campus composting, forest preservation, purchasing renewable energy credits (RECs), and off-campus carbon reduction projects. These carbon offsets help reduce the overall emissions that are already in place by the university and create net reduction. The net emissions are then compared with emissions that would have been without implementing such emissions-reducing programs. The only source of offset which AUW currently has is the CO_2 sequestration by the forest on AUW-owned land. At the very beginning time of establishing the university, the land was donated by the government to AUW for the purpose of building the permanent AUW campus.This valuable carbon offset option would be reduced once the permanent campus is built. The challenge would be to maintain and preserve this forest as much as possible by integrating with the construction.

The CCC requires the offset value of the carbon sequestration in $MTCO_2$ but does not provide calculation of the offset done by preserved land. To find this value, data regarding the land-type, biome classification, and the corresponding sequestration coefficients for the university-owned lands were required. The land cover, forest type data and the sketch of the property were obtained from the Security & Logistics Office. The area of each biome was then multiplied with the corresponding sequestration coefficients by forest provided by the IPCC. The coefficients help estimate the amount of carbon sequestered per hectare per year ($t\ C\ ha^{-1}\ yr^{-1}$) for a range of different biomes. By assuming a 1:1 ration of carbon to CO_2, the total mass of CO_2 sequestered per area per year was calculated. The total final value in metric tons CO_2 sequester by offset was inputted into the CCC.

4. RESULTS

4.1. Overview of the results

During the 2016-2017 academic year (FY2017), there were 601 students in total, of that, 533 students lived in AUW's dorms and 68 students were day-scholars (have house in the locality and do not stay in the campus' dorm). There were 53 faculty and 120 staff. These numbers made up the total community membership of 774 people.

The AUW's building space occupies approximately 1.5 acres (equal to 65,340 square feet) in Chittagong. This area includes the entire area of AUW's temporary campus and the rented residential buildings and flats: AUW's buildings (20A, 20B, 20C, 20H, 20G and 20J), and off-campus Panchlaish building and Khulshi flats. AUW's administrative board has a master plan to build the permanent AUW's campus on an area of 143 acres. However, the construction work is still very preliminary and do not have any significant impacts to the operation of AUW thus this area was not included in the building space input. Only the net sequestration of the forestson the land is included in the offset category of the calculator. Table 2 illustrate the institutional data of AUW in FY2017.

Table 2: Institutional data and normalized emissions of AUW in FY2017

Fiscal Year	Students	Faculty	Staff	Total Building Space (square feet)	Emissions per capita (MT CO2e)	Emissions per square feet (MT CO2e)
2017	601	53	120	65,340	1.9	0.02

In FY2017, the total GHG emissions of AUWwere1,492.6 MT CO_2e. When considering emission demographics, averaged AUW's carbon footprint per person (faculty, staff, and students) was 1.9 MT CO_2e. Considering the building space, it was 0.02 MTCO_2e per square feet (Table 2).

Of this total, CO_2 emissions were 952,056.1 MT, CH_4 emissions were 20,518.6 MT, and N_2O emissions were 12.4 MT. Of these amounts, 129 and 256.8 and 1,106.8 MTCO_2e, respectively, are attributed to Scope 1, Scope 2 and Scope 3 sources. The contribution of each scope is illustrated in the graph in Figure 2.

The major emission sources of AUW's carbon footprint were solid waste (34%), international students' air travel to/from home (21%), purchased electricity (17%), directly financed air travel (13%), other on-campus stationary (7%). These results suggested that the biggest opportunities for reducing campus GHG emissions are related to these categories. Other categories such as commuting, paper usage, and direct transport each accounted for less than 3 percent of emissions and did not affect total emissions greatly. The contribution of each source is illustrated in the graph in Figure 3.

The calculated offsets due to the natural forest preservation of approximately 42.9 acres of tropical forest and 42.9 acres of tropical undergrowth jungle in AUW-owned land were 765.0 MT CO_2e. This suggests that forest preservation had a significant role in reducing emission of AUW because the net emissions after offset were only 727.6 MT CO_2e, less than half of the total emission. The total emissions and net emissions were illustrated together in Figure 4.

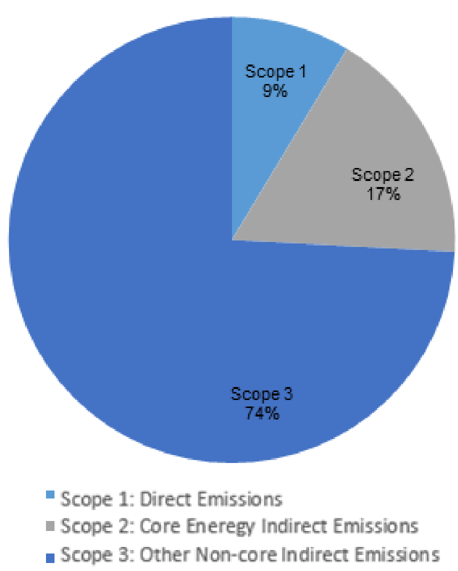

Figure 2: Total emissions by scope of AUW in FY2017

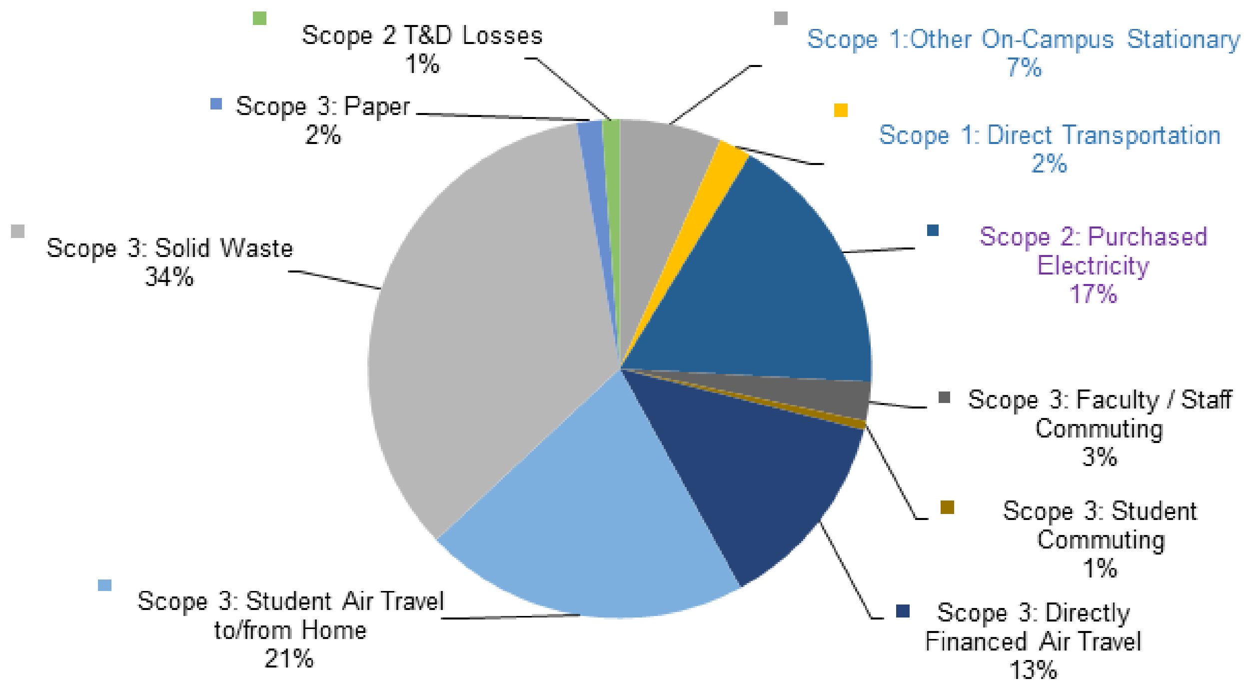

Figure 3: Total emissions by source of AUW in FY2017

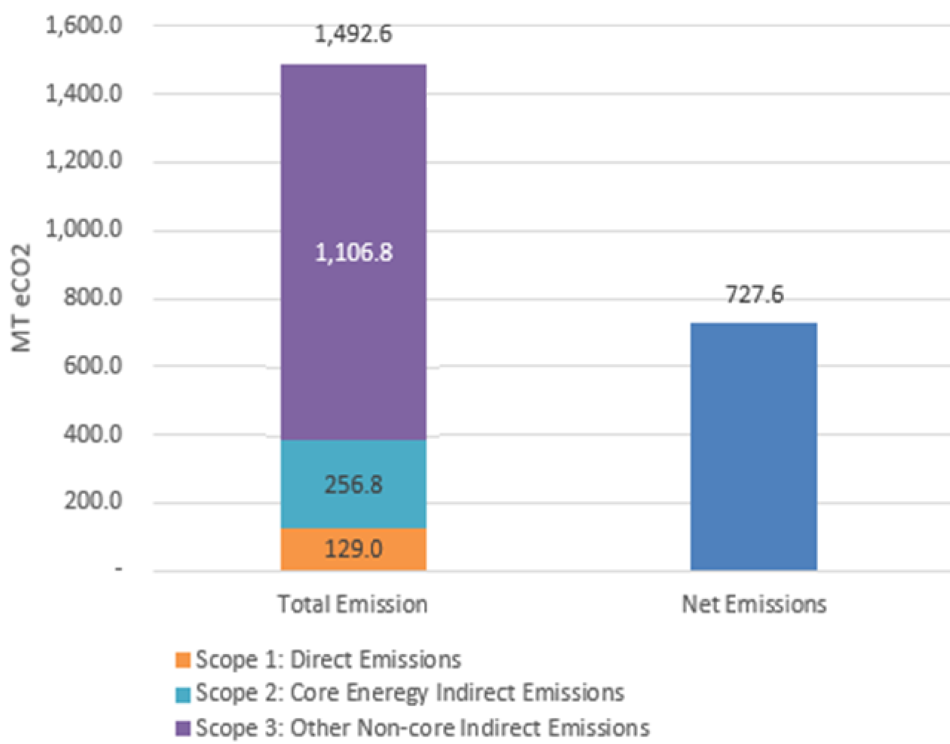

Figure 4: Total emission and net emission (with offset) of AUW in FY2017

4.2. Emissions by Categories

4.2.1. Scope 1 - Core direct emissions

4.2.1.1. Direct Transport

AUW currently has seven registered vehicles and one rented van, detailed information of these vehicles are described in Table 3. The university fleet are used for different purposes such as transporting faculty and fellows to and from campus, travel for university-related events, delivering different or performing maintenance tasks to maintain the campus. Of these vehicles, all the vans and cars are octane powered; the school bus and jeep are diesel powered; and only the rented van is CNG (compressed natural gas) powered.

The amount of fuel purchased for the whole FY2017 is illustrated in the Table 4 below. In FY2017, AUW purchased 8328 liters of gasoline, 1356 liters of diesel and 4800 m^3 of CNG. The total emission of the fleet was 31.3 MT CO_2e. This contribution to the overall carbon footprint was minimal, only 2% of the total emission.

Table 3: Asian University for Women Transportation Vehicles

Vehicle No	Vehicle type	Fuel type
51-1334	Van	Gasoline
51-1982	Van	Gasoline
11-0849	Pick-up truck	Diesel
12-8123	Sedan car	Gasoline
51-1695	Van	Gasoline
11-0029	Big bus	Diesel
11-0967	Jeep	Gasoline
5579	Rented van	CNG

Table 4: Amount of fuel purchased for AUW's direct transport (university fleet) in FY2017

Fuel type	Gasoline	Diesel	CNG (Compressed natural gas)
Amount Purchased	8328 (liters)	1356 (liters)	4800 (m^3)
After converted for input	2,200 (gallons)	358 (gallons)	153 (MMBtu)
Total CO_2e emitted	31.3 MT		

4.2.1.2. Other On-campus Stationary

The University's on-campus stationary sources of GHG emissions include the electric generators and cooking gas used in residence kitchens.

In FY2017, AUW's generators consumed5,231 gallons (19,800 liters) of diesel to meet the electricity demand.

In AUW, mass cooking is practiced to meet the demand of most students, faculty and staff. Using the average consumption 0.15422 m3/person/day for mass cooking in a study done in a university student hall in Bangladesh, it was estimated that AUW's kitchens consumed 22,500 m^3 of natural gas (equivalent to 831.6 MMBTU) to prepare food for about 500 people each day in normal academic periods; and about haft of that population during long vacations (one month of winter break and three months of summer vacation) in FY2017.

In total, these two on-campus stationary fuel sources emitted 97.7 MT CO_2e, representing 7% of the total carbon footprint.

4.2.2. Scope 2- Core energy indirect emissions

4.2.2.1. Purchased Electricity

All the buildings are connected independently to K.C.J. Associated Ltd.'s grid and billed for that usage directly. Electricity bills of all the buildings in a monthly basis were provided by the Maintenance Office. There was no information about the grid fuel mix on the website of K.C.J Associated Ltd.,thus the general grid fuel mix for Bangladesh in 2016 was used to have a more accurate emissions estimate. Power plants in Bangladesh use multiple fuel sources including natural gas, coal, oil, hydroelectric, and imported power. The precise mix of sources changes from year to year, depending on many factors. In 2016, the regional mixture of sources was 61.8% natural gas, 21.7% furnace oil, 7.7% diesel, 2.0% coal, 1.9% hydro power, and 4.9% imported power (Buckley, Nicholas& Ahmed, 2016).In FY 2017, AUW purchased 559,263 kWh electricity in total, this emitted 256.8 MT CO_2e. Purchased electricity made up 17% of the total carbon footprint of AUW in FY2017.

A certain percentage of electricity generated at the power station is lost in transmission and distribution to the end customer. Transmission and distribution (T&D) losses stemming from electricity (calculated as a percentage of total electricity consumption) is included later in Scope 3 emissions of the CCC. In FY2017, transmission and distribution (T&D) losses generate 17.2 MT CO_2e, representing only 1% of the total emissions.

4.2.3. Scope 3- Other non-core indirect emissions

4.2.3.1. Commuting

Only a small part of faculty, staff and students (mostly day-scholars) population is from the Chittagong locality and have the need to commute from and to AUW's campus on a daily basis. Although it is a small emission source, including this input category in the calculating process can increase the details and accuracy of the result.

From the information provided by Academic Registry Office and Human Resources Office, the total number of student commuters was estimated to be 90, faculty and staff commuters were estimated to be 130 (Table 5). In addition, from the year planner and survey responses of some faculty and staff, this analysis assumed that faculty and student commuters commute 10 one-way trips to and from AUW in 38 weeks per year; staff commuters also commute 10 one-way trips to and from AUW but in 48 weeks per year since they still have to work during academic breaks. The national holidays and permitted leaves were also taken into accounts in the calculation.

The survey also asked about the major mean of transport and the respective commuting distance by those means of transport. The Table 6 sums up the trip distribution by modes and trip distance for each mode. For faculty and staff, 9.26% of the surveyed faculty and staff said they drive car, 29.63% take CNG taxi, 14% use bus, 36% take rickshaw and 11% walk. For each mode listed, the data from the surveyed faculty and staff reveals that the average trip distance for car and CNG taxi is 3.76 miles, average trip distance for bus is 4.97 miles, average trip distance for rickshaw is 1.55 miles, and average trip distance for walking is 0.72 miles.

For student commuters, the survey results suggest that most of the day scholars live very near the campus and only either take CNG taxi, rickshaw or commute by walking from and to the campus. The distances from the residential addresses of the surveyed students to AUW are mostly below 2.5 km (1.55 miles). The choices for means of transport are also more flexible when compared to those of faculty and staff. Thus from the responses of the students, it was roughly estimated that 25% of the commuting trips are done by car, 25% by taking CNG taxi, 25% by taking rickshaw, and 25% by walking. The average trip distance is estimated to be approximately 1.55 miles (2.5 km) for those students who commute by car and CNG taxi, and to be approximately 0.6 miles (1 km) for those students who commute by walking or taking rickshaw.

Table 5: Number of commuters and commuting trips made by AUW's students, faculty and staff

	No. of commuters	One-Way Trips / Week	Weeks / Year
Faculty	20	10	38
Staff	110	10	48
Students	90	10	38

Table 6: Trip mode distribution and trip distance of AUW's commuters

	Trip Distribution (% Trips by Mode)					Trip Distance (Miles per One-Way Trip for Each Mode)				
	Car	CNG taxi	Bus	Rickshaw	Walk	Car	CNG taxi	Bus	Rickshaw	Walk
Faculty and Staff	9.26%	29.63%	13.7%	36.3%	11.11%	3.76	3.76	4.97	1.55	0.72
Students	25%	25%	0%	25%	25%	1.55	1.55	0	0.6	0.6

In FY2017, AUW's student commuting generated 8.6 MT CO_2e, represent only 1% of the total carbon footprint. Faculty and staff commuting emitted 37.6 MT CO_2e, contributing 3% of the total emissions. The amount of CO_2e emitted from student commuting was 4.3 times less than faculty and staff commuting, it is due to the fact that the size of staff commuter population is larger since most of them are from Chittagong. In addition, most of the student commuters (day-scholars) live nearer to the campus than many staff commuters. The staff also have to commute more days in a year since they still have to work during academic breaks.

4.2.3.2. Directly Financed Air Travel

Every year, AUW's Travel and Logistics Department has to book a great number of flights, both domestic and international for university-related travel. These are mainly official financedfights for working purpose of faculty and staff, inviting guests and speakers to university-related events and programs, and a small part is flights of students for studying purpose, internships and various kinds of international programs. In FY2017, the total air miles for directly financed air travel of AUW was 405,413 miles. This category emitted 195.6 MT CO2e, represent 13% of the total carbon footprint.

4.2.3.3. Student Air Travel To/From Home

AUW attracts a huge student population from different areas across Asia. International students' air travel comprises a large portion of the total carbon emissions. Most of the students book the tickets to go home during vacations by themselves thus it is difficult to obtain a detailed record from any AUW departments.A reasonable assumption was madewhich is that each international student takes only one round-trip flight per year from Dhaka airport to the airport in the capital of their respected country. Bangladeshi students were excluded from this analysis under the assumption that they take bus or train and do not fly to and from the campus. Detailed data regarding international population and the flight distance are illustrated in Table 7.In FY2017, international students'air travel to/from homeaccounted for 312.4 MTCO_2e, represent 21% of the total carbon footprint. This value is the result of the large international student population (47% of total student population).

Table 7: Population of students in country wise and air miles traveled per year if one student take one round trip per year.

Country	No. of students	Air miles for one one-way trip	Total air miles traveled
AFGHANISTAN	66	1478	195,096
BANGLADESH	318	0	0
BHUTAN	41	263	21,566
CAMBODIA	7	1271	17,794
CHINA	3	1881	11,286
INDIA	18	885	31,860
INDOSESIA	3	2346	14,076
MALAYSIA	1	1609	3,218
MYANMAR	23	605	27,830
NEPAL	32	415	26,880
PAKISTAN	30	1469	88,140
PALESTINE	6	3431	41,172
SRILANKA	10	1356	27,120
SYRIA	9	3315	59,670
USA	1	7876	15,752
VIETNAM	33	1003	66,198
SUM			647,658
Total CO2e emitted		312.4 $MTCO_2e$	

4.2.3.4. Paper

The data regarding paper usage by AUW in one year was gather from different sources since paper was not distribute to students, faculty and staff from just one source. The sources included Stationary Supplies Office and Procurement Office (providing printing papers for offices and notebooks for faculty and students), the Office of Student Affairs (providing printing papers and year planners for students), House Keeping Office (providing tissues paper for students' dorm) and the photocopy shop (printing service for books and documents)in the campus. The amount of each item is provided in Table 8. In addition, from the Housekeeping Office and Academic Support Service, it was known that only ainsignificant amount of paper and photocopy books are reused and recycled. Therefore, the data was inputted in '0% recycled' box. In FY2017, AUW consumed 17,474 pounds paper items, this generated 23.9 MT CO_2e, accounted for 2% of the total carbon footprint.

Table 8: Paper usage by AUW in FY2017

Item	Unit Weight (g)	Amount	Total Weight (g)
Printing Paper	5	1145000 piece	5725000
Notebook	227	4000 piece	908000
Year planner	240	600 piece	144000
Tissue paper	88	13056 rolls	1148928
Total			7925928 (g) =17474 (lbs)
Total Emissions		23.9 MT CO_2e	

4.2.3.5. Solid Waste

Solid waste is collected from bins in the university residence dorms and academic buildings and is disposed at the end of the day. From observation, much of this solid waste was kitchen waste and household waste. From the waste measuredin one day (410 kg/day), it was estimated that a total of 165 short tons of waste was sent to landfills each year by AUW.It is noted that at the Chittagong solid waste treatment, our university solid waste ultimately ends upbeing landfilled with very modest technologies to capture the methane produced (BMDF, 2012).

Waste emissions were entirely composed of emissions from CH_4, which amounted to 20.46 MT. Equivalent MT of CO_2 emissions were calculated by multiplying MT of CH_4 emissions by 23. Emissions from waste were 511.5 MT CO_2e, which represented 34% percent of total emissions.

4.2.4. Offset

The only source of offset which AUW currently has is the CO_2 sequestration by the forest on AUW-owned land. The AUW-owned property area was reported to be 143 acres (57.87 ha), 30% of the area is still natural forest, 30% is undergrowth jungle, and the other 40% is currently under construction or for other usage. The rates of CO_2 uptake by forestin different regions areprovided by the IPCC (IPCC, 2000). The area of natural forest was multiplied with the coefficient 8 t C ha^{-1} yr^{-1}, and the area of undergrowth jungle was multiplied with the coefficient 4 t C ha^{-1} yr^{-1}. The total CO_2 offset of university-preserved land indicates a CO_2 sequestration of approximately 765 MT CO_2e.However, we should beware of the fact that when this forest is cut due to the planned construction (university will be built there in few years) and if not replanted somewhere else most of the carbon benefits are gone in the future.

5. DISCUSSIONS

Most of the contributing factors to the emissions have been discussed in the previous sections, but some basic comparisons can help us evaluate the university's performance. The most common and useful measures are normalizations of the emissions to the population and size of the university. The two commonly reported carbon performance measures are emissions per community member (faculty, staff, or student), and emissions per square foot of campus building. When considering demographic emissions, averaged AUW's carbon footprint per capita was 1.9 MT CO_2e. This calculated per capita emissions per year of AUW is 3.8 times higher than the Bangladesh's per capita CO_2 emissions (0.5 MT CO_2e), and 2.4 times lower than the world per capita emissions (4.6 MT CO_2e) (WBG, 2017).

AUW's total emissions and emissions per capita are much lower than most of the data reported so far by many other institutions (mostly are from developed countries since there are very few institutions in developing haveconducted and published their carbon inventory). It is because that the university is relatively small and does not require elaborate facility systems. However, AUW's carbon footprint is not the lowest as we can see below (Table 9). There are still a lot of opportunities to reduce emissions since AUW's current operation is not at the most efficient it can be and the behavior of the university's community has not been the most eco-friendly.

It is not very practical to compare AUW's carbon footprint with that of other universities in developed countries because of the huge differences in population, building space, climate, and different profiles for energy, utility, product usage and operation scale. Besides, the methodologies and the boundaries, and emission sources included in each study can also be different. However, as an attempt to illustrate different scenarios of carbon footprint of universities around the world, universities of varying geographic and climatic regions were chosen with their latest GHG emission reports available to be compared (Table 9).

Table 9: Comparison of carbon footprint of different universities and AUW

University	Country	Total emission MT CO_2e/year	Total population	MT CO_2e per capita
Lancaster University	UK	71,700	14,500	4.94
De Montfort University	UK	51,080	25,580	2.0
Instituto Superior Técnico	Portugal	21,557	12,847	1.68

Norwegian University of Science and Technology	Norwegian	92,100	25,500	3.61
University of Illinois	USA	275,000	57,417	4.79
University of Virginia	USA	305,030.1	39,565	7.7
University of Queensland	Australia	188,607	52,096	3.62
University of Hong Kong	Hong Kong	98,550	32,654	3.02
University of Cape Town	South Africa	84,926	36,322	2.34
National Autonomous University of Mexico	Mexico	1,577	1,076	1.47
Tongji University	China	N/A	N/A	3.84
SuanSunandhaRajabhat University	Thailand	N/A	N/A	2.16
UniversitiTeknologi MARA	Malaysia	11842	4873	2.43
Asian University for Women	Bangladesh	1,492.6	774	1.9

From observation, most of the universities from developed countries have their emissions per capita higher than 3 MT CO_2e, and in contrast, most of the universities from developing countries have their emissions per capita below 3MT CO_2e. However, there are still exceptions such as Instituto Superior Técnicolocated in Portugal(only 1.68 MT CO_2e), and Tongji Universitylocated in China (3.84 MT CO_2e). Particularly, the Instituto Superior Técnico is located in Europe and still manages to maintain a lower carbon profile when compared with AUW. This shows that there are opportunities to reduce the inefficiencies lie in energy and resource consumption at the AUW.

The carbon footprint of AUW represents a large part of universities in developing world, where the life standards and operation scale are not high to generate huge emissions but in contrast, lack of advanced technology to reduce emissions.

The major emission sources of AUW's carbon footprint were solid waste (34%), international students' air travel to/from home (21%), purchased electricity (17%), directly financed air travel (13%), other on-campus stationary (7%). These results suggested that the biggest opportunities for reducing campus GHG emissions are related to these categories.

While the solid waste of AUW is mostly landfilled without methane recovery, other universities in developed countries have different methods of waste treatment to reduce the emissions from waste such as landfill disposal with methane recovery, recycling and composting practices. For example, The Edith Cowan University recycles paper, grease trap oil and some co-mingled materials found in waste. The emissions avoided from this recycling have been calculated as: Cardboard & paper: 180.22 MT CO_2e, Co-mingled: 16.58 MT CO_2e, Grease trap: 82.39 MT CO_2e, and Green waste: 243.60 MT CO_2e. Emissions from waste after excluding waste sent for recycling were 400.40 MT CO_2e. It demonstrates that recycling has helped Edith Cowan University avoided a large amount of emissions (522.79 MT CO_2e) (Favacho, 2016). Likewise, the University of Cape Town had their percentage of waste recycled by 60% in 2013 by providing recycling infrastructure, training and awareness campaigns (Rippon, 2014). As another example, the landfills that take University College Cork waste incorporate methane recovery & electricity generation from waste, thus help reduce emissions significantly. The emissions from solid waste in 2012 of University College Cork accounted only 3% of the total emission (CPPU, 2013). For AUW, from observation, much of the solid waste was kitchen waste and household waste. It is noted that at the Chittagong solid waste treatment, our university solid waste ultimately ends up being landfilled with very modest technologies to capture the methane produced. This made solid waste become the most significant source of emission of AUW. It was not surprise since AUW is an international university which hosts, provides housing and dining services to the majority of the population of students, faculty and staff (75.7% of the total population). These activities produce a large amount of solid waste. This could be improved with methane recovery equipment and services, they help capture methane and use it to produce energy, resulting in a lower carbon footprint than a landfill that uses no such program. Besides, since the large proportion of the waste is organic kitchen waste, initiating composting programs or sending these to local composting facilities and services can potentially reduce a great amount of emission. In addition, raising awareness, initiating waste reductionand recycling programswill help encourage students to reduce the generation of waste, especially household waste from residence dorms.In addition, it was known that only a negligible amount of papers and photocopy books are reused and recycled. Although paper usage does not contribute a lot of emissions, it is recommended that the used papers should be classified, reused and recycles.

The results regarding the emissions from purchased electricity demonstrate that the choice of energy supply might have a significant impact on the emissions as most of the operational energy emissions come from electricity use. Electricity is AUW's second largest contributor to CO_2e emissions and yet is essential to the operation of the university. Electricity powers university cooling elements, computers, lights, and other necessary electrical items. One way to reduce emissions from this source is to use a more efficient energy supply system. However, as AUW does not need to have its own cogeneration plants like large universities, there are limited choices for energy supply except the national grid. The purchased electricity is mostly generated from natural gas (61.8%), furnace oil (21.7%) and diesel (7.7%). Although natural gas is considered a cleaner and cheaper energy source with higher efficiency to generate electricity when compared to other fossil fuel sources, it still releases significant quantities of GHGs compared to renewable energy. Renewable energy has yet to make a significant impression on the Bangladesh electricity system, only hydroelectricity with 2% in the national fuel mix. It is because of the flat geography of Bangladesh which limits the potential for hydro generation, besides, other forms of renewable energy such as solar, wind, nuclear still contribute a very negligible role due to the technology gap (Buckley *et al*., 2016). In contrast, for other developing countries which has high percentage of renewable sources in their fuel mix, the emissions will be lower. For example, in 2011, about 76% of electricity of France camefrom nuclear generation and 12% from hydro. This makes the electricity specific emission factor of France (0.070 $kgCO_2/kWh$) is less than about 9 times compared to the electricity specific emission factor of Bangladesh (0.637 $kgCO_2/kWh$) that year (Brander *et al*., 2011). This means the amounts of emissions are directly related with the fuel type of electricity produced nationwide thus it is not likely for AUW itself to improve this situation. However, we can encourage initiatives, research, and projects which promote renewable energy and the transformation to a lower emissions intensive electricity system in Bangladesh.

On the other hand, promoting energy saving practices and improving energy efficiency can help reduce emissions. Behavioral changes that reduce energy consumption will reduce the amount of GHG emitted. Especially, raising public awareness can be the first step of an overall approach for consuming electricity more efficient. Examples of these changes include setting computers to go into sleep mode and turning off electrical devices when not in use. Structural changes that can be implemented include improving buildings' heating or cooling retention, increasing efficiency of lights, computers, ACs and other electrical equipment.

In addition, as a small university in a developing country, AUW does not have co-generation power plant like many large university in the developed world but only use some generator machines for urgent electricity demands. In contrast, several universities in developed countries such as the U.S. use combined heat and power (CHP) systems, also known as cogeneration. The cogeneration is an operating system consisting of electrical and mechanical equipment, the system operates and converts fuel energy into both electric power (which range in size from 150 kilowatt to 500 megawatt) and useful thermal energy (US EPA, 2008; FEMP, 2004). Carbon emissions are typically reduced by 30% when CHP replaces central-station electricity generation (US EPA, n.d.).

As AUW is located in a tropical region, the university does not need to purchase lots of stationary fuel sources for heating, or have heating plants/systems like in many developed countries in have temperate and cold climate zone. To illustrate, on-campus stationary fuels used for heating of the University of Virginia accounted for 89,917.5 MT CO_2e, or 28.5% of the UVA'stotal net emissions (UVA, 2016). For St. Lawrence University, campus heating is responsible for 91% (8,729 MTCO_2e) of the total of Scope 1 emissions (Bailey &LaPoint, 2016).

Air mile is a big source of AUW's emissions (34% of the total carbon footprint). One part of the reason is that AUW attracts a huge population of international students(47% of total student population) from different areas across Asia. International students' air travel to/from home comprises contributes a big portion(312.4 MT CO_2e, 21% of the total carbon emissions). Furthermore, AUW also finance a lot of fights for working purpose of faculty and staff, inviting guests and speakers to university-related events and programs, and a small part is flights of students for studying purpose, internships and different kinds of international programs. Direct financed air travel contributes 195.6 MT CO_2e, represent 13% of the total footprint. However, it will be unreasonable to ask people not to travel to by planes for long distance, one way we can reduce this emission is to encourage the reduction travelling if the task can be done through other means of communication such as video conferencing. For other universities, air miles also account for a considerable part of the total carbon footprint for the same reasons like AUW's, depending on the number of international students and faculty, and the need for air travel for the operation of the university. For instant, emissions from total air travel (official and student air travel) of Carnegie Mellon University in 2007 were 65,256 MTCDE, which represented 39.9 percent of total emissions. Of this, 46.4% of air travel was due to student air travel and 53.6% of air travel was due to official air travel (CMU, 2008).

Besides, it is noted that commuting contributes a considerable amount of emissions in other universities in developed world. For instant, although having residence dorms on campus, the commuter population of St. Edward University accounted for 62.8% of the total population. Of that, 60% of student commuter, and 64% of staff/faculty commuters drive alone in personal vehicles. The average distance commuted when using automobiles are more than 10 miles for both students and faculty/staff. This is one of the reason why emissions from commuting contributed 15.5% (2887.9 MT CO_2e) of the total emission of the university in that year (Bailey &LaPoint, 2016). Similarly, in the University of Cape Town, 44% of the commuters use private cars and the average distance commute by car is 7.5 miles. This made commuting contribute 11.3% (9 634.20 MT CO_2e) to the total carbon footprint (Rippon, 2014). In contrasts, for AUW, only a small part of faculty, staff and students (mostly day-scholars) population are from Chittagong locality and have the need to commute from and to AUW's campus in a daily basis. The rest of the students and faculty (75.7%)live in the campus' residence dorms. As a result, emissions from commuting contributed only a small percentage to the total carbon footprint because non-carbon modes of transportation such as rickshaw and walking, and low carbon modes such as CNG taxi and bus are used more often by most of the commuters rather than cars. In addition, the university fleet also helped reduce a part of faculty and staff commuting since it helps transport faculty and fellows to and from campus to the rented residential flats. Besides, the trip distances of AUW's commuters are also shorter compared to the commuters in other universities which have reported their emissions. The average trip distance by car and CNG taxi of AUW's student commuters is estimated to be approximately 1.55 miles, and 3.76 miles for that of AUW's faculty/staff commuters. It was noted that some students and staff commute by car though the distance from their home to AUW is less than 2 km (1.2 miles). Although emissions from commuting does not contribute a large part to the total carbon footprint, it is still recommended to encourage commuters use non-carbon means of transportation such as rickshaw, bicycle or walking to commute for short distances. It should also be taken into account that road congestion is a big problem in Chittagong. Although the distance is short but more often than not these vehicles have to wait for 20-30 minutes for just to commute only this distance. The engine is still working while the vehicle wait in the congestion.

Offsets is important for organizations which want to reduce their carbon footprint. These include emissions-reducing sources and activities such as on-campus composting, forest preservation, purchasing renewable energy credits (RECs), and off-campus carbon reduction projects. For AUW, net reduction resulted from the forests on the AUW-owned land was equal to 51.2% (765.0 MT CO_2e)of the total emissions. After including the offsets, the net emissions were only727.6 MT CO_2e, while the total origin emissions were 1,492.6 MT CO_2e. This demonstrates the significance of carbon sequestration by forest preservation to reduce carbon footprint of an organization. Since most developing countries are located in tropical region in which forestshave the highest sequestration rate. Forest preservation is one of the most practical options for universities in developing Asian countries while in other developed countries, most universities choose to purchase or produce renewable energy to increase their offsets.

6. SUMMARY AND CONCLUSIONS

This report presents the results of the first Greenhouse Gas Inventory, or Carbon Footprint, of AUW. Sustainable development and environmentally conscious actions are not only important to prevent and mitigate climate change impacts but also are parts of AUW's missions. From the results, the major sources of GHG emissions areidentified and analyzed. The carbon footprint of AUW was also compared with the data reported by many other institutions so far (mostly are from developed countries since there are very few institutions in developing countries which haveconducted and published their carbon inventory).

To calculate the carbon footprint of AUW in FY2017, the following steps were followed. The first step was to review the literature for similar studies in universities which already calculated their carbon footprint. After literature review, the scope of the thesis was determined according to the GHG Protocol and available data. Subsequently, all available data was collected from relevant offices. The study used the Campus Carbon Calculator™ v9.0, which wascreated by Clean Air-Cool Planet and the Sustainability Institute of Universisty of New Hamsphire for use as a carbon emissions calculator for a college or university's carbon inventory. All available data and formulations are transferred to the CCC to calculate the total carbon footprint for the university. At the end, shares of each emission source and key sources with highest GHG emission valueswere determined.

The carbon footprint of AUW in FY2017 was found to be approximately 1,492.6 MT CO_2e. Of this total emissions, CO_2 emissions were 952,056.1 kg, CH_4 emissions were 20,518.6 kg, and N_2O emissions were 12.4 kg. Of these amounts, 129 and 256.8 and 1,106.8 MTCO_2e, respectively, are attributed to Scope 1 (Core direct emissions), Scope 2 (Core energy indirect emissions) and Scope 3 sources (Other non-core indirect emissions).

The major emission sources of AUW's carbon footprint were solid waste (34%), international students' air travel (21%), purchased electricity (17%), directly financed air travel (13%), and other on-campus stationary (7%). These results suggested that the biggest opportunities for reducing campus GHG emissions are related to these categories. The emissions per capita were 1.9 MT CO_2e, emissions per square foot building space were 0.02 MT CO_2e. This suggests that the carbon footprint of AUW is relatively low when compared to that of other universities in developed countries.

With the calculated offset due to the natural forest preservation of approximately 42.9 acres of tropical forest and 42.9 acres of tropical undergrowth jungle in the AUW-owned land, the net emissions after reduction were 765.0 MT CO_2e, this was equal to 51.2% of the total emissions.

The carbon footprint of AUW represents a large part of universities in developing world, where the life standards and operation scale are not high to generate huge emissions but lack of advanced technology to reduce emissions. In this scenario, offsets from forest preservation became important for the organizations.Since most developing countries are located in tropical region which forestshave the highest sequestration rate. Forest preservation is one of the most practical options for universities in developed Asian countries while in other developed countries, most universities choose to purchase or produce renewable energy to increase their offsets.However, these developing countries are also experiencing a rapid growth, forest lands are increasingly used for construction that reduces the potential of offset.

7. RECOMMENDATIONS

In order to achieve sustainable developmentmission, AUW should continue recording its GHG emissions in the future.It was not possible to gather information regarding AUW's emissions in the past since the year of establishment, records of many aspects are not kept systematically by AUW's offices such as commuting, air travel, direct transport (university fleet), paper usage, waste. Consequently, only data for the FY2017 was complete enough to be analyzed. To identify the trends in GHG emissions in the past and predict future emissions/emission trajectory, data of incoming years should be collected and calculated. Since identifying these trends is a fundamental step in reducing emissions, this is the first area where improvements must be made. If offices are made to keep records of our emissions in the upcoming years, the university will be able to keep track and plan for reduction of its carbon footprint in the long run. It is recommended to improve data collection and analysis of AUW's footprint over time as well as for any other institutions that are striving to do likewise. Particularly, transportation (air travel, commuting…) was the most difficult measure to obtain and also one of the most impactful. In order to increase the quality of transportation data, it is recommended that a more detailed survey regarding commuting and air travel should be done annually by students, faculty and staff. This carbon footprint analysis took approximately three months to perform. In the future, it should take only a few days or weeks to do the same if the data gathering systems are improved and made more accessible.

This study represents only the beginning of one of the university's current initiatives, attempting to make the campus more environmentally friendly. There was no previous value from the past for comparison and projection of emissions. Although the current carbon footprint of AUW is relatively small compared to other universities, it is expected that the carbon footprint of AUW in the future will increase. The AUW's population has expanded fairly steadily in recent years since the university has become more influential in the region as well as on international level. AUW has enlarged its operation scale with the aim to become a preeminent liberal arts university for women from various cultural, religious, or economic backgrounds. Especially in the future, when the new campus is built, there will no longer exist the offset from natural forest in the AUW's property and the campus will operate on a higher scale with a larger population of students, faculty and staff. As a result, early analysis and plans to reduce GHG emissions is necessary. Despite some uncertainty and lack of data, this study hopes to serve as a baseline for decisions and recommendations to reduce GHG emission. In order to achieve that goal, AUW has to continue recording its GHG emissions, keeping record every year in the future. It is very important to note that, once an institution begins to assess its carbon footprint thoroughly, there is a simple strategy to perform a similar assessment on a yearly basis. The university needs to make improvements in the process of collecting data

Other recommendations are that the university community should adopt behavior changes to reduce waste generation, reduce unnecessary usage of electricity, choose non-carbon modes of transportation to commute if possible, and have the practice to recycle waste and paper. Besides, the administrator should attempt to use composting services to reduce emission from solid waste, purchase cleaner electricity than the current one it is using, and improve efficiency for the university fleet, electric facilities, cooking gas burners. Establishing a structured sustainability office or person responsible for monitoring, tracking and advocating for sustainability initiatives on campus is one of the best approaches to promote practices of sustainability in the university.

This inventory aims to serve as a reference point for the universities in the region and also in developing countries to examine their carbon footprint. Although developing countries are not complied to restrict their GHG commissions, as universities, we should promote awareness and actions to move toward a more sustainable, neutral-carbon system. This study also hopes to call for more institutional research to improve the sustainability initiatives on campuses and to encourage an element of healthy competition between the universities in developing countries.

8. LIMITATIONS

As there were not such carbon dioxide emission calculation practices in AUW, administrative units also have some difficulties in providing data. Some activities were not included because the adequate activity data was not available and emissions were deemed to be insignificant, these include other modes of directly financed travel (bus, train …), agriculture sources and refrigerants & chemicals. Construction of an integrated information system is recommended for the university.

The commuting and student air miles data werethe most difficult to obtain, the data used for this calculation was based mostly on estimation and would be more accurate with a detailed survey.

Food and university restaurants represent one area of embodied emissions which the CCC do not incorporate and not many universities include this in their emission inventory, thus our report did not address it.

In addition, presently most of theBangladesh's specific emission factors are not up to date or available to the public so the calculations are made using most factors from the CCC.

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