A Study of Energy Related Greenhouse Gas Emissions of High Income Urban Residents in the city of Accra, Ghana

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Abstract: The objective of this study was to examine the energy related Greenhouse Gas emissions (GHG) of high-income suburban residents of the city of Accra in Ghana based on the perspectives of residents of Devtraco Estates. Activity data was gathered and default emission factors from the IPCC 2006 GHG Inventory Guidelines were employed to calculate emissions. A survey was conducted for 60 randomly selected households of Riverdale Cluster at Devtraco Estates, with a response rate of 42% (n=25) to assess activity data. The results were that: the average mobile combustion emission was calculated as 0.001516 Gg CO_2e, average stationary energy combustion emission was calculated as 0.0003666 Gg CO_2e. Based on fuel combustion alone, the average household combustion GHG emission was determined as 0.00287446 Gg CO_2e. The study conclusions were that residents who are aware of climate change had higher emissions than those who were unaware of climate change. And, households with higher income presented higher GHG emissions, and also households that used generators frequently had strikingly higher emissions than those who did not. The study participants recommended that national and local government authorities in Accra and other cities in Ghana would have to consider investing heavily in climate change and GHG awareness programs and improve upon the current urban public transportation systems and consider alternative energy sources to ensure a cleaner air and sustainable options for our cities.

Keywords: Energy, Greenhouse Gas Emissions, High-income, Urban Residents, Accra, Ghana

Introduction

It is not coincidental that climate change and rapid urbanization have drawn the attention of the international community simultaneously in recent times. According to the UNFCCC, climate change refers "to a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable periods of time" (IPCC, 2007, p.2). Globally, urban areas represent only 2.8% of landmass, yet as at 2008, these urban areas contained 50% of the population (Sioufi, 2010). Since urban areas are concentrations of people and economic activities, with ever increasing demand for food, energy, water and space, they have also have been identified as major contributors to global greenhouse gas emissions (UN-Habitat, 2011). The rapid rate of population growth in these urban areas inconspicuously adds onto the stress of potential climate change impacts. According to the International Energy Agency, urban areas are responsible for about 70% of global energy-related GHG emissions and are mainly sourced from transportation use, industries and cooling and heating of residences (IEA, 2009).

As the trend continues, rapid urbanization in developing nations implies that emission of GHG and land use change will also increase rapidly, if GHG emissions continue under business as usual scenarios (Sioufi, 2010). Urbanization itself however, is usually accompanied with increase in socio-economic status and corresponding demands. India for instance, has experienced a 7% increase in Gross Domestic Product over the last decade and in 2007, India was identified as the 12th largest consumer market (Boao, 2013). Factors that contributed to this high consumption ranking are the size of the population as well as the emerging non-poor population, as seen in other developing countries such as South Africa, China and Brazil. Increased income makes room for higher consumption of food, energy, and space (UN-Habitat, 2011, p.13; Delgado, 2003).If developing countries are not given appropriate climate finance, knowledge and capacity, to also reduce their GHG, reversing climate change would be nearly impossible and can impede sustainable development (Glemerac, 2010).

Ghana, in West Africa, is beginning to exhibit similar signs of economic growth and consumption patterns. According to the recent 2010 census in Ghana, mobile phone consumption, water consumption and even Internet consumption have increased since the last census, particularly in the capital city Accra. Ownership of vehicles and motorcycles in Ghana for instance has risen by 8.1% since 2006 (Pezzini, 2012). The purchase of houses, have also increased by 64.9% since 2000 (GSS, 2012). In view of these increases, corresponding GHG emissions have not been adequately investigated. Accra is a thriving city with a population growth rate of 3.1% from 2000 to 2010. It is the wealthiest city in the country with an annual average income of ¢1,517 (AMA, 2006). 56% of the residents of Accra obtain their household income from employment wages and spend over 50% of their income on food, transportation and utilities (GSS, 2008). Trends from the 2010 census show that the population of Ghana and Accra will double by 2028 (GSS, 2012), As seen from the case of India and New Delhi above, the potential for GHG emissions to rise tremendously as a result of the increase in economic stability can pose as a serious threat to global climate change mitigation. Accra is just one of many cities in developing countries with the potential to influence global GHG emissions. Increased income of residents of Accra, transportation systems, urban sprawl, are a few drivers of urban GHG emissions which shall be described in detail in the next chapter. There is the need for a thorough assessment of the GHG emissions of the activities of residents of Accra, so that appropriate climate change mitigation strategies can be enforced to ensure sustainable development of the city.

This study therefore examines the energy related household activities of high- income residents of Accra that contribute significantly to rising GHG emissions of the city. The study will involve an assessment of energy consumption behaviors of these residents and determine their corresponding GHG emissions to provide local governments with information on the emission habits and potential of their citizens. The objective of this study is to provide an in-depth descriptive analysis of the GHG emissions that are associated with the energy consumption of high-income households of Accra, the capital city of Ghana.

Cities and Climate Change

For the last 20 years, climate change has held centre stage at many international meetings with the aim of investigating the most appropriate and timely ways to mitigate it as well as adapt to it. However, in more recent times, rapid urbanization has also drawn international attention. These two man-made phenomena are beginning to converge in dangerous ways that can be a threat to human life and development (UN-Habitat, 2011, p.1). Urban areas are concentrated with large numbers of people and economic and social activities, with increasing demands of food, energy, water and space. According to Sioufi (2010), cities harbour 50% of the world's population hence they are very critical in conversations about development and the environment. This is because cities which are associated with population growth and economic development have direct implications for the environment due to the change in land-use to accommodate the people, provision of food and energy and management of waste (Sioufi, 2010). These same demands of urban living however, have also been identified as sources of greenhouse gases, and contribute to climate change. Cities that are richer, less dense and use coal as a primary source of energy are major emitters of GHG (World Bank, 2010a). Although cities occupy only 2% of global landmass, they are responsible for 70% of global GHG emissions (UN-Habitat, 2011). According to Dulal and Akbar (2011), emissions from cities are attributable to four main factors. First is the economic base of the city, whether it is industrial or service oriented; second is the density and location of settlements; third, is the transportation network, which contributes greatly to the emissions and finally, is the waste management system (Dulal, & Akbar, 2011). These four factors however, contribute to climate change in two main categories; 1) land-use change related and 2) changes related to aerosols, GHG, and solid wastes (UN-Habitat, 2011, p.12).

Changes related to GHG energy

The main sources of GHG from urban areas are the consumption of fossil fuels either for transportation, electricity supply or industries (UN-Habitat, 2011, p. 36). Electricity is generated by various sources of energy including coal, natural gas, oil thermal plants, hydro-electricity, nuclear and recently emerging solar and wind. Over the past years however, world energy production has been mainly through coal, natural gas, oil and hydropower. In 2011, 41% of electricity produced worldwide originated from coal, while 21.6% of the world's electricity was produced from natural gas (IEA, 2013, p. 24). Coal production generated 9.2 billion tonnes of CO_2 in 2005, and although it is the most abundant fossil fuel used to produce electricity, its production is only 35% efficient (UN-Habitat, 2011, p.39). The type of energy that is used to produce electricity greatly determines how much GHG emissions are released from a specific country or city. Cities such as Johannesburg and Shanghai generate electricity mainly from coal-powered plants. Such cities may have higher GHG emissions than cities that are powered by hydro or nuclear energy (UN-Habitat, 2011, p.39).

For instance, the Sustainable Energy Africa (SEA) group conducted a study in 15 South African cities in 2004, to identify the sources and consumption of energy in these cities to help in the implementation of sustainable energy sources in the country. It was found that the six main metro cities studied produced 6.5 tons of CO_2 per capita, which was more than the global average per capita (SEA, 2006, p. ix). The industrial cities also produced much higher GHG emissions than non-industrial cities. In the study it was discovered that electricity was responsible for 66% of the study areas' carbon dioxide emissions in 2004 (SEA, 2006, p. ix). It stated, "…electricity contributes substantially to the global carbon emissions of the study cities. This is largely due to the heavy carbon footprint of our, coal-fired electricity". This shows that the Cape Town government is aware that their coal-fired electricity poses as a threat to reduction of their GHG emissions.

In the transportation sector, urban areas have the potential to be primary culprits of high GHG emissions, but also, can be sources of high transportation efficiency. Globally, transportation is responsible for 13% of total GHG emissions, and 23% of energy related GHG emissions (UN-Habitat, 2011, p.40). Urban centers depend heavily on the transport networks for the movement of people and its economic activity. However, the main factor that affects the GHG emissions of a city is how far and frequent private transportation moves as opposed to public transportation. Urban density greatly affects the amount of energy that is consumed in transportation, particularly in private passenger consumption (p.40). Densely populated cities usually have lower per capita emissions than those that are sparsely populated. Cities like London, New York and Washington DC have high population densities but lower GHG emission per capita than cities such as Sao Paulo and Toronto (UN-Habitat, 2011, p.40). A study conducted by Heinonen and Junnila (2011) in Finland showed that the city of Helsinki which has a more efficient transportation, had fewer carbon emissions than Porvoo, which had a less dense city and less efficient public transport system.

Urban sprawl has an adverse effect on climate change. Due to the rapid expanding nature of urban areas, vehicles are required to travel longer distances thus contributing to higher GHG emissions. As income levels also rise, the purchase of private vehicles also increases, particularly in developing nations. In Malaysia for instance, motor vehicle increased from 6.8 million in 1995 to 18 million in 2008 (Dulal & Akbar, 2012). In India, as wealth of a family increases, another car is added to the family as a sign of higher social status (Dulal & Akbar, 2012). The type of motor vehicles used, also determine the amount of GHG emitted. According to the UN-Habitat report, on Cities and Climate Change, developing countries tend to be stocked with low efficiency, second-hand vehicles which themselves are high emitters (UN-Habitat, 2011, p.40). The increase in motor vehicular purchases indicates an increase in GHG emissions and traffic congestion of all cities, particularly cities in developing nations (UN-Habitat, 2011, p.40). Bangkok reports that transportation is responsible for 38% of its total GHG emissions (Bangkok Metropolitan Administration, 2009).

Urban areas are centres of economic activity, hence many businesses and industries can be found in cities or within city locations. Most North American and European cities developed around industries (UN-Habitat, 2011, p. 41). In the South Africa Sustainable Energy Agency report of 2006, it was found that cities within the study group that had industries located within them, had higher GHG emissions than others. The industrial towns of uMhlatuze and Saldanha Bay, produced over 40 carbon emissions per capita which is even higher than many country averages such as Australia (SEA, 2006, p. ix). Industrial cities such as Beijing and Shanghai in China also experience similar high GHG emissions as a result of their industries. It is important to note however that due to the arrival of transnational corporations, many companies from the developed world have exported their industries and manufacturing locations to other countries (UN-Habitat, 2011, p.43).

High income, urbanization and GHG emissions

The debate on climate change has unfortunately been polarized according to the wealth of nations. Developed and OECD countries as known as Annex 1 and Annex 2 countries, which are the major culprits of GHG under the UNFCCC. This implies that as far back as 1994, when the conversation on climate change evolved, economic growth and wealth were the determining factor for economic growth and greenhouse gas emissions (World Bank, 2011). Most economic activity is centred in urban areas hence it is safe to establish that most economic growth takes place in cities. Agricultural systems as far back as 10,000 years ago, led to the development of current economic systems. The ability to produce food and sell surpluses was the goal of many farmers, who as years progressed, brought their surpluses to markets for trading (IEA, 2009). The industrial revolution itself was effective because it provided an alternative source of energy to power food production and economic growth. The market centres served as the seat for trading and commerce of these consumption products. This launched the mainstreaming of fossil fuel combustion and fuelled the development of countless developed cities and countries. At the same time, greenhouse gas emissions in the atmosphere rose significantly. The Intergovernmental Panel on Climate Change (IPCC) continuously makes reference to greenhouse gas levels in the atmosphere before industrialization in the late 1700s. The panel does this by highlighting the difference between post and pre-industrial levels. For instance, "Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004" (IPCC, 2007b). The major cities of the world such as New York, London, Toronto, are products of rapid economic growth as a result of the industrial revolution. However, these same cities, also contribute majority of global greenhouse gas emissions. The 50 largest cities in the world combined produce a total population of 500 million, a GDP of 9,564 billion and total GHG emissions of 2,606 M tCO_2 (World Bank, 2011b).

The largest growth in GHG emissions between 1970 and 2004 came mostly from energy supply, transport and industry, while residential and commercial buildings grew at a slower rate (IPCC, 2007b). According to the World Bank, as development continues, greenhouse gas emissions would be less driven by industrial activities, and more by energy-end use activities such as lighting, heating and cooling of buildings, and supporting urban lifestyles (World Bank, 2011). This has direct implications for urban areas, because by 2030, over 80% of the world's population would reside in urban areas (Sioufi, 2010). As urbanization tends to increase with socio-economic development, the levels of urbanization are generally expected to rise in developing countries in the near future (Dulal & Akbar, 2012).

In fact, developing countries are already showing signs of potential rapid economic growth and urbanization. In the early 1990s' India, was considered as one of the poorest countries in the world. Its population growth rate, as other developing countries remained relatively high, hence were producing more people. A report by Mckinsey and Co showed that if the Indian economy grew by 7.3% between 2005 and 2025, 583 million people in India, would be in the middle class (quoted by Mukherjee & Satija 2012). It has also been projected that these 583 million people will spend 66% of their income on food, transportation, utilities and personal products (Mukherjee & Satija, 2012). Diesel use for transportation has increased from 73% in 1991 to 81% in 2000 (Zhou & McNeil, 2009). This corresponds with a direct increase in GHG emissions from the residents of India. If this trend continues without appropriate interventions, sustainable development and climate change mitigation will not be achieved.

Wealth as a driver of GHG emissions

Affluence has been recognized to be a contributing factor to increase in urban GHG emissions. However, it is not just the presence of wealth, but also the ability to purchase technologies, equity and natural endowments that have environmental impacts (UN-Habitat, 2010). The affluent nations and affluence within cities, contribute to climate change due to their high consumption patterns, yet the impacts of this same climate change disproportionately affects the urban poor than the wealthier people in cities (p.32). The UN-Habitat report on Cities and Climate Change boldly states that, "It is the affluent and politically enfranchised ... groups and communities ...who consume more, travel more and become the highest GHG emitters" (UN-Habitat, 2010). This is occurs both across and within countries and cities. The research in the drivers of the anthropogenic activities that emit GHG has been divided into two main streams. One well-investigated stream, according to Rosa and Deitz (2012), is focused on land-use change and the implications for ecosystems. The impacts of deforestation and conversions of agricultural or built environments have been duly investigated by researchers. For the second stream of research, a growing number of studies are being conducted to examine the household level consumption (Rosa & Deitz, 2012). The development of research in the later stream bears witness to other already known significant drivers of environmental change: "population, affluence and consumption, choice of technologies, institutional arrangements and culture" (Rosa & Deitz, 2012). Environmental stress not only continues to increase as a result of population growth, but also the pattern of consumption which in recent times resembles those of Western countries and is being witnessed all over the world (2012). The Environmental Kuznets Curve (EKC) has been investigated continuously in these times of climate change and greenhouse gas emissions. However, researchers are still unable to confirm the hypothesis of this theory with data. The EKC theory suggests that at lower levels of economic development, environmental degradation is relatively lower however, as economic growth increases, degradation also increases and peaks at this stage, mostly within industrial economies and declines as the economy changes to a service oriented economy (Panayotou, 2003).

GHG emission and the City of Accra, Ghana

In January 2013, the Economist identified Ghana as the 10th fastest growing economy of the world, with a GDP growth rate of 7.3% (The Economist, 2013). Ghana has become an ideal destination for many foreign companies such as Tullow Oil, which exploits Ghana's oil reserves, and Newmont Gold, which exploits Ghana's gold reserves. The growth of the economy however, corresponds with the increase in GHG emissions.In Ghana, total GHG emissions between 1990 and 2006, grew by 97.5% (UNFCCC, 2006). According to Ghana's Second National Communication to the UNFCCC, the energy sector was responsible for 40% of the nation's GHG emissions, with transportation and residential use constituting the majority of those energy related emissions (MEST, 2011). Figure 2. 3 show the distribution of emission sources from the energy sector in 2006 in Ghana. The 2nd communication also reported that an increase in fuel consumption contributed significantly to the rise in GHG emissions of the energy sector in the country. Unfortunately, the report did not mention if the emissions were mostly from rural or urban areas.

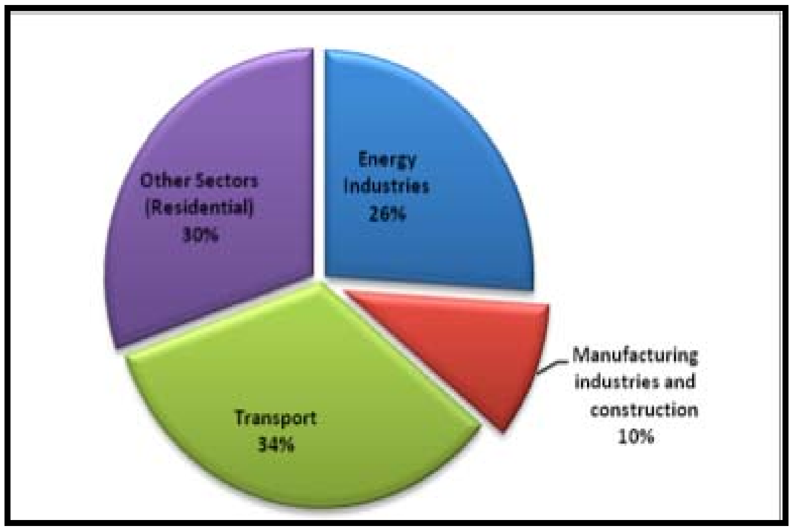

Figure 2.3 *Shared sources of GHG emissions in the Ghana's Energy Sector*
Source: MEST, (2011).

According to the 2010 census, 4,010,054 people live in the Greater Accra region, with 90.5% of that population living in urban Accra (GSS, 2012, p.3). Accra has been the capital city of Ghana since 1877 and currently has a population of about 3.5 million (AMA, 2006; World Bank, 2010b). Average annual household income of Accra is GH¢ 1,529, with an average annual per capita income of GH ¢564 (GSS, 2008 p.107). 47% of the population earn between GH¢100-500 a month while 21% earn less that GH¢100 a month (World Bank, 2010b). Compared to GDP of the country, residents of Accra are well off; Accra has a GDP of $915, which is more than double the $350 GDP of Ghana (AMA, 2006).

An interesting feature of Accra however, is not only the increasing wealth of its residents but also the ever-expanding size of the city. The Greater Accra region is currently experiencing the expansion of the periurban parts of the region into residential areas. Dodowa, Oyarifa, Kasoa, Tema, and Dawenya, are all on the outskirts of the city center; Dodowa and Oyarifa are to the north, Kasoa to the West and Dawenya to the East of the city. The expansion to these areas however, occurs as real estate companies meet the new market demand of gated communities (Boakye-Asiedu & Arku, 2009). This urban sprawl is causing the loss of the coastal savannah plains of the greater Accra region. The 2006 National GHG communication of Ghana showed that forest and grassland conversion to built land contributed over 72,000 Gg CO_2e to the national GHG emission (UNFCCC, 2006). The economic growth of the country corresponds with increase in houses being purchased across the city. These new estate developments however, are mostly targeted at the upper middle-high income earners of Accra. According to the Accra Metropolitan Assembly, residential areas in Accra have been grouped by first, second, third and fourth class residential areas (AMA, 2006). These residential areas are classified by annual household income during the 2000 census; 1st class residential areas have an annual income of $1,519, for 2nd class areas, $883, for 3rd and 4th class residential areas, the annual income is $793, or less than $793 respectively (World Bank, 2010b). The newer residential areas however, are not found within these traditional residential classes, but have segregated themselves on the outskirts of the city, as a unique population of their own.

The rising middle and high-income class of Accra residents produces a new challenge to the city and the region in relation to GHG emissions and climate change mitigation. The consumption of energy and its corresponding GHG emissions is likely to increase as a result of this new increasing demographic group of the city. Yet, assessments of their emissions have not been adequately conducted to inform further mitigation policies for these urban residents. Ghana submits inventories to the UNFCCC, yet on the local front, almost no public document contains adequate information the emissions of a city, town or village. Unlike the cities of Cape Town and Bangkok that have been described above, a consolidated description of the emissions and its sources within the Accra Metropolitan area was not available. This presents a serious problem and can even serve as an indicator as to how important the local government of Accra considers climate change. In the absence of information on the sources of emissions within the Accra area and its environs, it would be difficult for the local government to strategize and implement effectively any appropriate climate change mitigation policies.

Methodology

Demographic Description of Participants

Based on the frequency analysis, 52% of the respondents were male (n=13) and 48% were female (n=12). Majority of the respondents, (56%), were aged between 30-39 years, 16% (n=4), reported to be 20-29, and 40-49 years old. One person, was between 60-69 years old. 72% (n=18) of the respondents have more than 16 years of formal education, 16% reported to have between 13 and 15 years of formal education while 12% (n=3), reported to have less than 13 years of formal education.

Majority of the residents in the Devtraco estates represent smaller and young families, which was confirmed in the results. 32% of the respondents, (n=8), reported to have a family size of four, while the remaining 42% reported to have a family size less than four (n=11). Six of the respondents however, had a family size greater than 4, with one family containing 9 people. Concerning the average household income, 48% (n=12) reported an average income between GH¢ 2001-5000, another 28% (n=8) reported an average income between GH¢ 5001-10000. Four respondents reported an income below GH¢ 2000. Table 4.1 provides a summary of the demographic information of the respondents.

Household Mobile Combustion

This section of the survey sought to investigate the amount of vehicular fuel that was consumed by each household as well as the (amount of information) level of knowledge of respondents pertaining to fuel consumption and efficiency of their vehicles. Every household reported to own at least one vehicle. 48% of the respondents (n=12) have one vehicle that is used, while 44% (n=11) reported to have 2 vehicles, and two households reported to have 3 vehicles. Concerning the type of car, 76% (n=31) of the total respondent cars were light duty passenger cars while the remaining 20% (n=8) were heavy duty passenger cars which for purposes of this study represented four wheel-drive vehicles. 88% of reported cars (n= 36) use petrol, while the remaining 12% (n=3) use diesel. Most of the respondents admitted that they work in Accra hence 56% of reported vehicles (n=23) travel more than 50km a day, 12% (n=5) travel between 31-40km a day, 6 vehicles travel between 11-30km per day while 4 vehicles travel less than 10km a day.

The amounts of fuel purchased each month varied among the respondents. 38% (n=16) of reported vehicles purchase more than GH ¢300 of fuel every month, while 32% purchase between GH ¢100-300 of fuel each month. 19 % of reported vehicles owners (n=8), purchase between GH ¢51-100 of fuel each month. When asked about the age of their vehicles, 17% of respondents surprisingly did not know the age of their vehicles, 40% (n=18) of vehicles were 5 years old or less, while 21% (n=9) of the vehicles are between the ages of 6-9 years old. One aspect of the survey asked respondents about the fuel consumption of their vehicles. This was intended to find out if respondents knew how many liters/km their vehicles consumed. Surprisingly, only three respondents reported the fuel consumption of their vehicles. Out of the 32 responses to this question for each vehicle, 81% (n=26) reported that they did not know the fuel consumption of each of their vehicles.

Table 1 A Summary of the Demographic Information of Survey Respondents

Demographic Information of Respondents	Number (n=25)	Percentage (%)
Gender		
Male	13	52
Female	12	48
Age (years)		
20-29	4	16
30-39	14	56
40-49	4	16
50-59	2	8
60-69	1	4
Average Household Income (GH¢)		
501-1000		
1001-2000	1	4
2001- 5000	3	12
5001-10000	12	48
	7	28
Average Household Size		
1	2	8
2	3	12
3	6	24
4	8	32
5	2	8
6	1	4
7	2	8
9	1	1
Number of years of formal education		
1-6	1	
7-9	1	4
10-12	1	4
13-15	4	4
16+	18	16
		72

Source: Field Survey, 2016.

As shown under the methodology section above, emissions were calculated for carbon dioxide, nitrous oxide and methane. The emissions of nitrous oxide and methane were negligible hence, almost all the emissions from each fuel, either petrol or diesel were carbon dioxide emissions. Figure 4.1 below is a graphical presentation of the total mobile combustion GHG emissions for all 18 households that reported their monthly vehicular consumptions.[1]

From the graph in figure 1 below, it can be seen that the mobile emissions varied greatly between households. Households which exhibited relatively high emissions are those households that purchase more than GH 300 of fuel each month as a result of long distances travelled on average over 50km each month. Figure 4.2 shows the GHG emissions in relation to average monthly distance travelled. As expected, households which travel further distances each day to work, school or other social events are more likely to have higher GHG emissions than those who do not.

[1] Appendix 2 contains a summary of all the conversions and determined emissions for all 18 households that reported their monthly vehicular consumptions.

Table 2: Summary of Vehicle Information of Survey Respondents

Number of Vehicles	**Response (%)**	**Percentage**
1	12	48
2	11	44
3	2	8
Type of Vehicle	**Number of reported cars**	
Light Duty Passenger	31	76
4 Wheel Drive	8	20
Vehicle Fuel Type Used	**Number of reported cars**	
Diesel	3	12
Petrol	36	88
Average Monthly Distance Travelled (km)	**Number of reported cars**	
1-10	4	9
11-30	6	14
31-40	5	12
51+	23	56
Average Amount spent on fuel each month (GH ¢)		
51-100	8	19
101-300	13	32
301+	16	38
Age of Vehicles (years)	**Number of reported cars**	
I DON'T KNOW	7	17
Less than 5	18	40
6-9	9	21

Source: Survey Data, 2016.

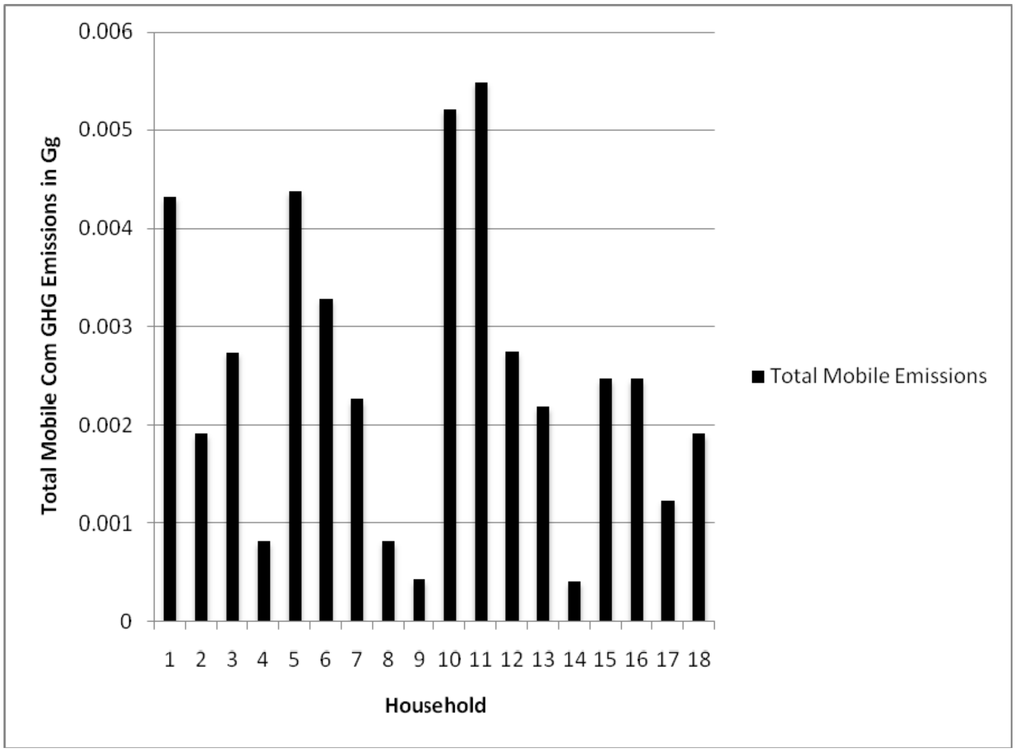

Figure 1: Total Households Mobile Combustion GHG Emissions
Source: Survey Data, 2016.

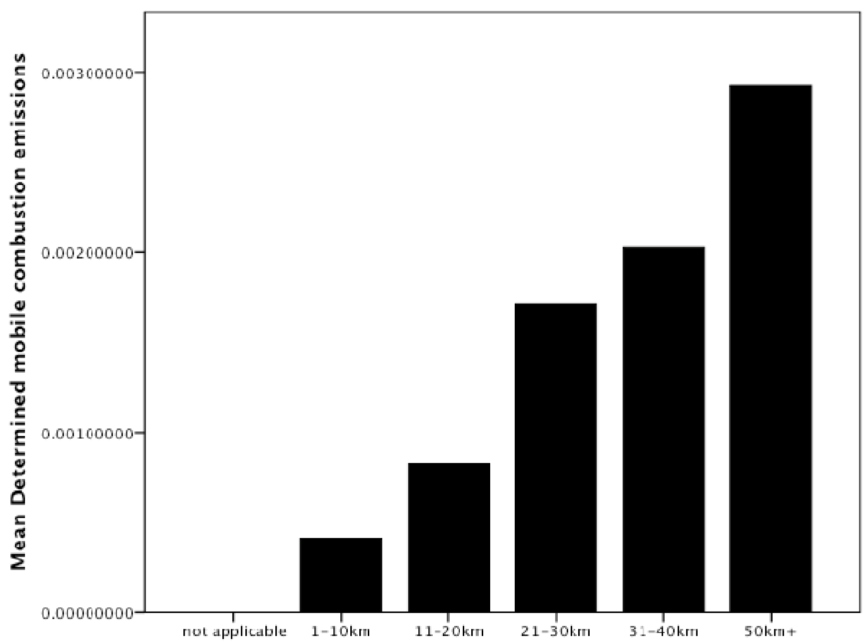

Figure 2 Total Mobile Combustion and Distance Traveled with First Car
Source: Survey data, 2016.

Household Stationary Combustion

The study also solicited information from interviewees about the amount of non-movable fuel that is combusted to provide energy to the house. This is mostly found in the kitchen and also in generators in case of power outages. According to the survey responses, not many households reported to have generators. About 36% (n=9) stated that they have generators, while the remaining 64% mentioned that they do not use a stand-by generator. Out of the nine reported generators, eight (8) use diesel fuel and one uses petrol fuel to run the generator. The capacities of the various generators also varied greatly for each household. The capacities ranged from 7kW, to 15kW, with 12% of the households (n=3) reporting that they have a 15kW generator. One person however, did not know the capacity of their generator.

When asked about their main source of energy for cooking, an overwhelming majority of 96% (n=24) of respondents use LPG gas as their main source of energy for cooking, and 12% use electricity as a secondary cooking energy source. Four families stated that charcoal is a third source of fuel for cooking. Majority of respondents, 52% spend GH ¢20-50 on LPG purchase a month, while 44% spend GH ¢51-120 a month on LPG gas. However, although respondents knew how much money was spent on LPG purchase, 44% (n=11) did not know the size of the LPG cylinder used in the house. 20% (n=5) stated that the household LPG cylinder had a weight of 14kg, 1 respondent reported that their LPG cylinder weighed 19kg, another 20kg and yet another two respondents reported 29kg while one family reported a size of 30kg.

Table 3 LPG consumption of Survey Respondents

Cooking Energy source	**Responses (%)**
LPG as Primary source	24 (96)
Electricity as secondary	3 (12)
Charcoal as tertiary	3 (12)
Amount spent on LPG (GH¢)	
20-50	13 (52)
51-80	9 (36)
81-120	2 (8)
LPG Cylinder Size (kg)	
I don’t know	11 (44)
14	5 (20)
19-20	2 (8)
29-30	3 (12)

Source: Field Survey, 2016.

Electricity Consumption

This section of the questionnaire intended to find out how much electricity the average household consumed, and also to investigate if residents are fully away of the individual consumption rates of their various electrical gadget. 36% of respondents (n=9) pay GH ¢20-50 a month on electricity, 24% pay GH ¢50-100 a month for electricity, while the remaining 40 % (n=8), spend between GH ¢100-301+ for electricity each month. Table 4.4 below provides a summary of various electrical appliances consumed in the household. When asked of the wattage of each appliance, no one respondent was able to provide the wattage of his or her electrical appliances. The researcher therefore obtained default appliance wattages, which was determined by the average wattage of leading appliance brands in Ghana. This default wattage however, increases the uncertainty of the study and decrease its internal and external validity hence, was not used to determine GHG emissions from electricity consumption of appliances.

Table 4 Summary of Electrical Appliance Use of Survey Respondents

Electrical Appliance	**Number of appliance in households**	**Response**	**Number of hours used a day**	**Response (%)**
Fan	1-3	10(40)	<1-7	14 (56)
	4-6	9(36)	8-12+	6 (24)
Irons	1	18 (72)	<1	7 (28)
	2	2 (8)	2-4	4(16)
Washing Machine	1	16(64)	<1	8 (32)
			2-4	8 (32)
Electric Dryer	1	7 (28)	<1	6 (24)
			2-4	1 (4)
Rice cooker	1	9 (36)	< 1	16 (64)
	2	2 (8)	2-7	3 (12)
Microwave	1	18 (72)	<1	16 (64)
	2	1 (4)	2-7	3 (12)
Electric Stove	1	7 (28)	<1	5 (20)
			2-4	8(32)
Blender	1	17 (68)	<1	18 (72)
	2	2 (8)	2-4	1 (4)
Fridge	1	16 (64)	12+	20 (80)
	2	2 (8)		
	3	1 (4)		
Deep freezer	1	15 (60)	12+	14 (56)
Sound System	1	11 (44)	<1-4	5 (20)
	3	1 (4)	5-12+	6 (24)
TV	1	11 (44)	<1-7	12 (48)
	2	8 (32)	8-12+	7 (28)
	3	1 (4)		
Electronic Tablets	1	6 (24)	<1-4	9 (36)
	2	6 (24)	5-7	2 (8)
Computers	1	10 (40)	<1-4	11 (44)
	2	6 (24)	5-12+	13 (52)
	4-5	3 (12)		
Air condition	1-3	15 (52)	<1-4	6 (24)
	4-5	3 (12)	5-12	8 (32)
Vacuum cleaner		3 (12)	<1	2 (8)
Light Bulbs	1-10	5 (20)	<1-7	3 (12)
	11-20	9 (36)	8-12+	8 (32)
Mobile Phones	2-4	12 (48)	<1-7	12 (48)
	5-8	8 (32)	2-12	7 (28)

Source: Survey Data, 2016.

To fully comprehend the stationary combustion of the reported fuels, Figure 4.3, presents a graphical presentation of total household stationary combustion. As mentioned above, due to the absence on the information of the watt consumption of each appliance, the electricity consumed could not be calculated, hence the corresponding emissions are also absent. This information would have greatly increased the precision of stationary combustion since the various electrical appliance energy consumption also contributes greatly to amount of fuel that is used in the stand-by generator.

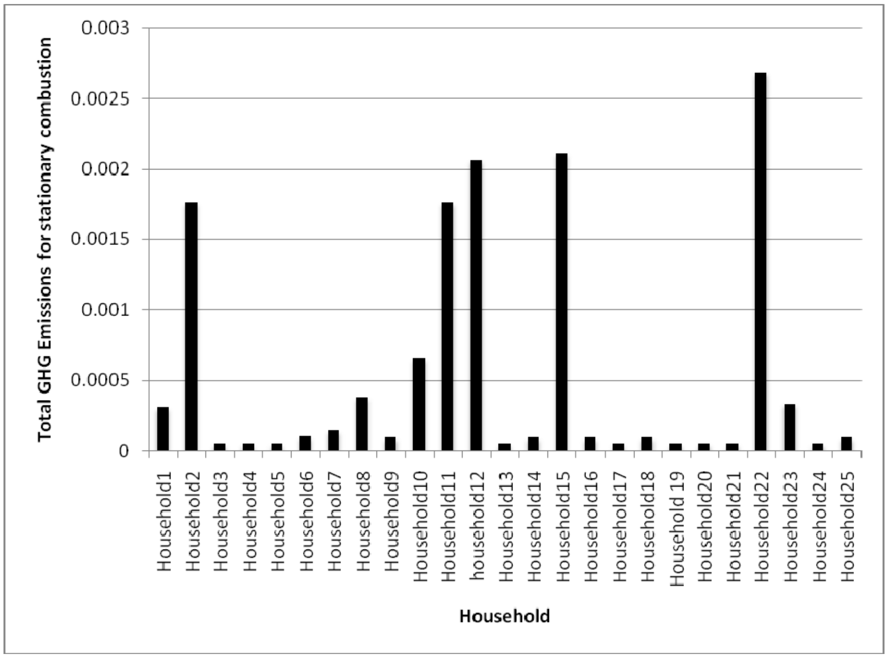

Figure 3: Total Stationary Combustion Emissions in Each Household
Source: Survey Data, 2016.

From the graph above, it is evident that again, emissions vary greatly among the households that participated in the survey. As can be seen, households 2, 10, 11, 15 and 22 have high stationary combustion emissions. From the data collected and corresponding analysis, it was observed that these households spend over GH¢100 a month on fuel for their generators.

Climate Change Awareness

This section of the questionnaire simply sought to investigate the awareness of participants on climate change related issues. An overwhelming majority of the participants (96%) admitted to being aware of climate change and global warming (n=24), and only 1 person reported to not be aware of climate change. However, 76% mentioned that they were aware of what greenhouse gases were, while 24% (n=6) admitted that they did not know about greenhouse gases. Even more interesting however, is that when asked if there are any activities in there households that contribute to greenhouse gas emissions, 36% (n=9), mentioned that they did not know, while 32% (n=8) admitted that there are activities in there households that contribute to greenhouse gas emissions. The remaining 32% (n=8) stated that there are no activities in the households that contribute to greenhouse gas emissions. Table 4.5 below summarizes the respondents' awareness of climate change and greenhouse gas emissions.

Table 5 Climate change awareness of Survey respondents

Climate Change Issue	**YES responses (%)**	**NO responses (%)**	**'I don't know' (%)**
Climate change awareness	24 (96)	1 (4)	0
Global warming awareness	24 (96)	1 (4)	0
GHG emissions awareness	19 (76)	6 (24)	0
GHG emission household activities	8(32)	8(32)	9 (36)

Source: Field survey, 2016.

Finally, the total combustion emissions of each household are presented below in Figure 4.3. This was determined by the combination of the carbon, methane and nitrous oxide emissions of each household's mobile and stationary combustion emissions. Based on the total combustion emissions, the average combustion emissions of the survey respondents is 2.8745 * 10^{-3}Gg. From figure 4.4 below, it is evident that there are wide variations between the GHG emissions of each household. As presented from the results above, the variations could be as a result of the difference in average monthly distance travelled, average monthly fuel used in the stand-by generator and the household LPG use.

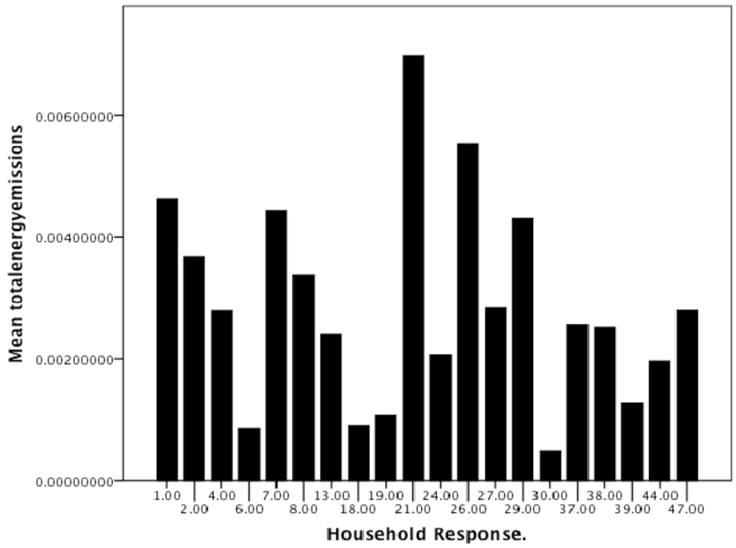

Figure 4 Total Household Combustion Emissions

Source: Field Survey, 2016.

After determining the total household energy combustion GHG emissions, other interesting results emerged. According to figure 4.5, survey respondents who are aware of climate change have higher emissions that those that are not aware of climate change. This is strikingly interesting because from Table 4. 5, it is evident that almost all survey participants were aware of climate change. The one respondent who is unaware of climate change has a relatively lower emission than the remaining 24 respondents who claimed to be aware of climate change.

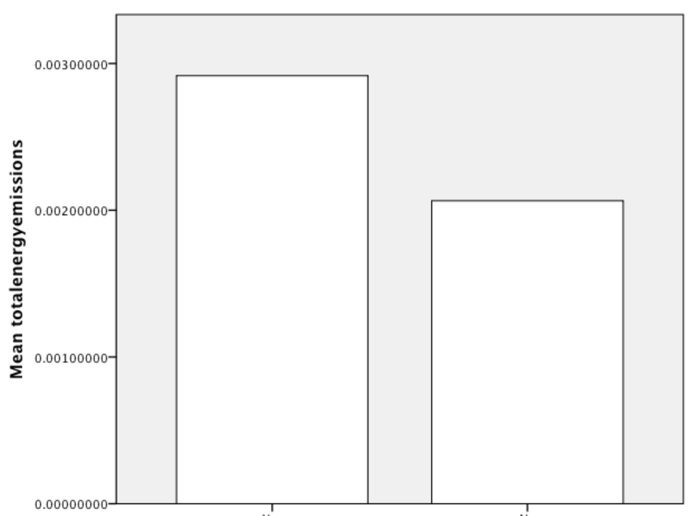

Figure 5 Total Household Energy Combustion GHG Emissions and Climate Change Awareness

Source: Survey Data, 2016.

The representation in Figure 4.5 above is rather interesting because it is expected that once one is aware of climate change, their emissions would be lower. This however is confirmed by figure 6 below. In table 5, 36% of the respondents reported that they do not know that there are activities in their household that contribute to GHG emissions. From figure 4.6 below, it is observed that people who claim that there is no activity in their households that contribute to GHG emissions as well as those who are unaware, have higher emissions that those who admitted that there are activities in their households that contribute to GHG emissions.

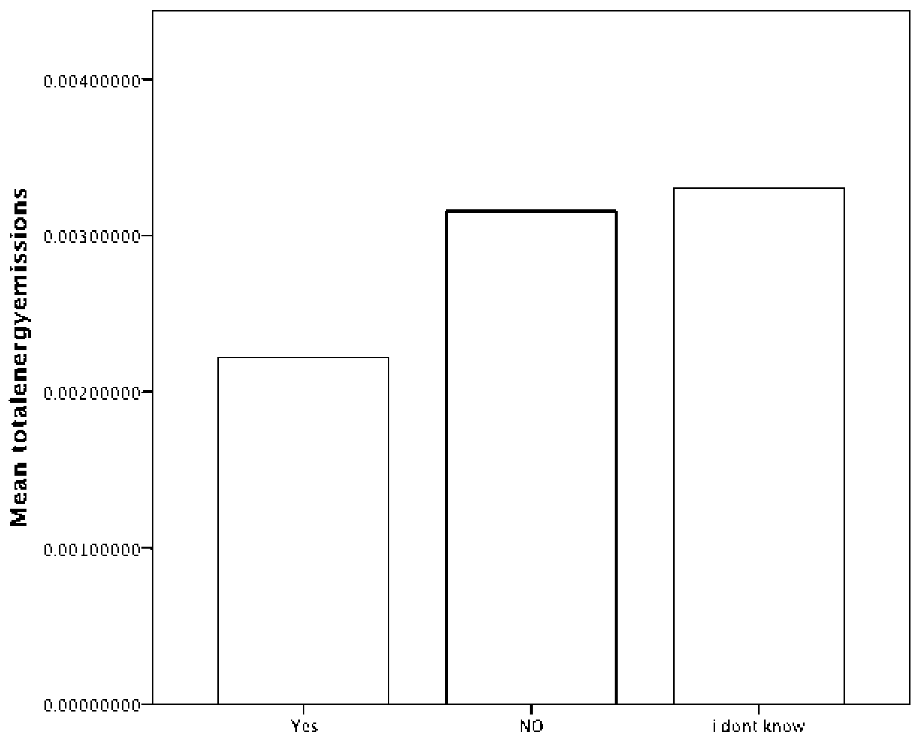

Figure 6 Total Household Combustion Emissions and House GHG activities
Source: Survey Data, 2016.

Also, an interesting relationship between average monthly income and GHG emissions emerged. Although majority of the respondents to this survey are within the Accra 1st class residential status with average income above GH 1,549, within the responses, there are still variations with income levels. Figure 7 below shows a graphical representation of the relationship between total combustion emissions and average monthly income.

According to the results of the study, one respondent reported an average monthly income of GH ¢501-1000, however, that household also purchases over GH ¢300 of diesel fuel for their generator hence, the high emissions. However, it can be seen even from Figure 4.7 above that aside from that one respondent, emissions rise as income levels also increase. This then suggests that the theory that affluence is a significant driver of emissions could be further investigated in this income bracket.

Looking at the relationship between total combustion emissions and age, surprisingly, younger ages showed to have higher emissions than older generations as is evident from Figure 4. Since the results and analysis are based on combustion of fuels, it suggests that younger people move about more than older people, hence a youth population is likely to have higher emissions than an older one.

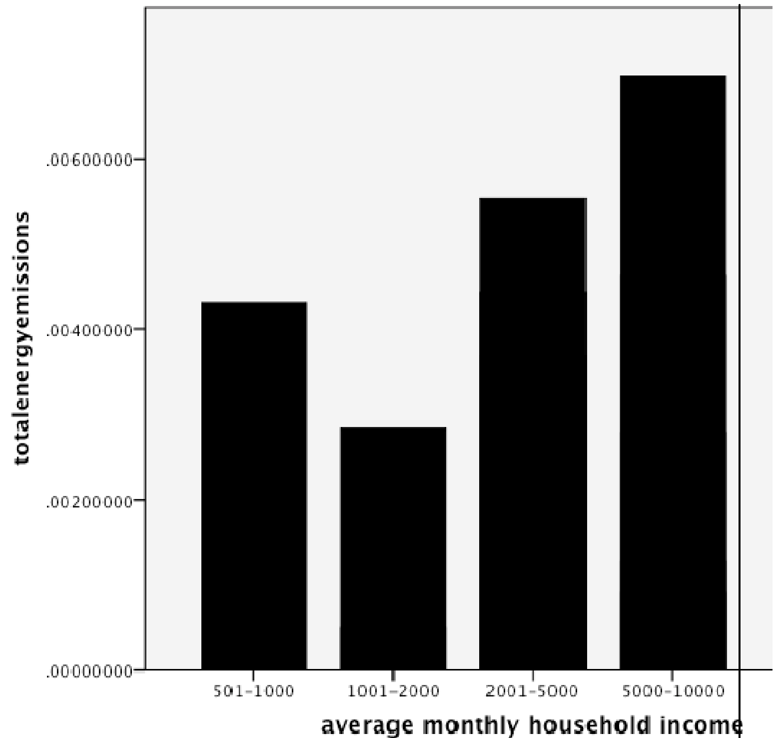

Figure 7 Total Household Combustion GHG emissions and Average Monthly Income
Source: Survey Data, 2016.

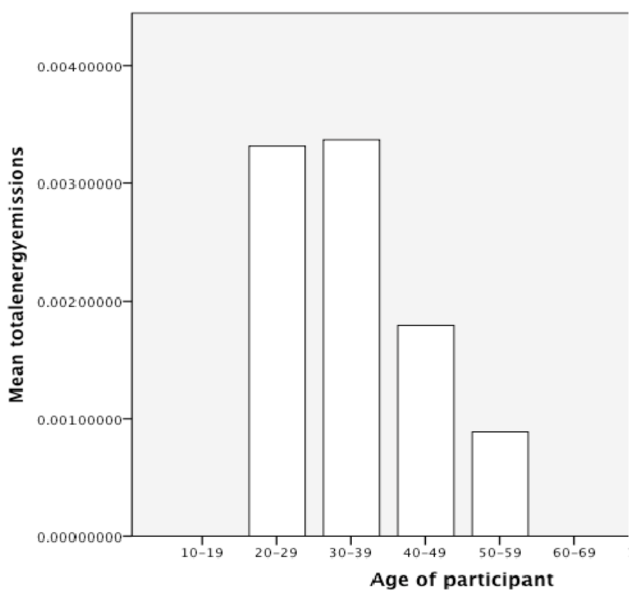

Figure 8: Total Household Combustion Emissions and Age of Participants
Source: Survey Data, 2016.

Finally, and interestingly, is the observed link between the emissions and gender. According to table 1, 52% of the respondents were male and according to figure 4.8, the males have higher emissions than females.

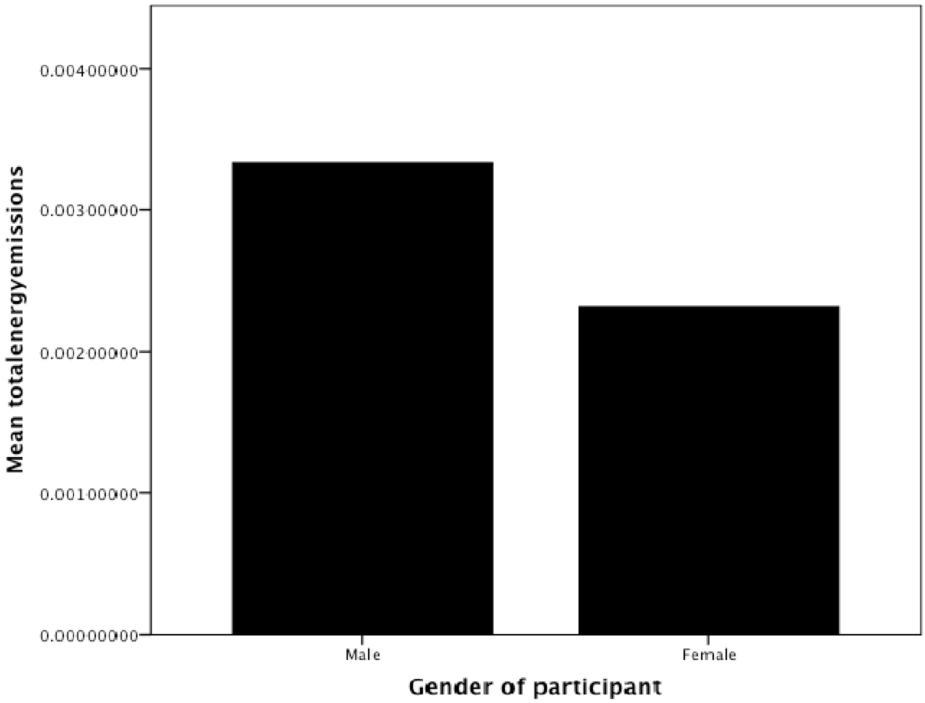

Figure 9: Total Household Combustion Emissions and Gender
Source: Survey Data, 2016.

Conclusions, observations and policy research directions

Even though the study population for this research was randomly selected, they also present an interesting and insightful contribution to the climate change conversation particularly in reference to land use change and urban sprawl. The Riverdale Cluster at Devtraco Estates, Dawenya is 38km away from Accra and from the results of the study in Table 3, 56% of the respondents reported to travel more than 51km each month. Due to the long distance that is travelled, residents who travelled longer distance each month, have higher GHG emissions than those who travel less, as seen in figure 2.

These results confirm the worries of the UN-Habitat Report (2010) on Climate change and cities. The report mentions that urban areas that are sparsely distributed have higher emissions because residents have to travel longer distances using their own private vehicles (UN-Habitat, 2010, p.40). In the study conducted in Finland by Heinonen and Junnila (2011) as discussed on page 18, section 2.4, the city which had a more efficient public transportation system had lower carbon emissions than the one which did not. Since urban transportation emissions are as a result of movement of residents of that city, from this research, residents of Devtraco contribute significantly to the rising GHG emissions of Accra. In Bangkok as illustrated in Table 2.1, over 37% of the city's emissions come from transportation alone.

In an era where diversion from fossil fuel energies are becoming more urgent, cities which continue to be sparse must have efficient public transportation systems to transport goods and services from one point to the other. From this study, it is evident that even in the city of a developing country, Ghana; this is also an emerging problem and must be addressed as soon as possible. Climate change is such an important issue that urgent attention must be paid to this issue to ensure sustainable growth of the city and its environs.

Urban Household Energy Emissions and Affluence

On page 23, Section 2.4.2, affluence is boldly described by the UN-Habitat as a significant driver of GHG emissions. The report mentioned that affluent nations and also the affluent within cities contribute significantly to higher emissions due to their high consumption habits. It is interesting also, that as nations get wealthier their emissions also increase as was seen in the case of Bangkok and Cape Town. From this research study, similar results were found. Although the study population for this research were already within the high-income range of Accra, some differences still emerged from within the income classifications of the respondents. According to figure 7, higher income was associated with higher emissions. Aside from the respondent who reported an average household income GH ¢501-1000 yet had relatively high emissions from the frequent use of a stand-by generator, the other emissions increased as average income increased. This also supports the report of the UN-Habitat and provides another geographical perspective to the concept. As the wealth and standard of living of many Ghanaians and residents of Accra continue to improve, the foregoing results suggest that local governments must put appropriate mitigation measures in place before such energy consumption behaviours become mainstream. The World Bank has already warned that in the near future, energy consumption will be directed at heating and cooling of residences and support of urban lifestyles (World Bank, 2011). It is likely that in the near future, Accra can become a major emitter of GHG mainly from residential emissions and transportation.

Urban Household Energy Emissions, Age and Gender

In the UN-Habitat report on climate change and cities, it was also mentioned that males have higher emissions than females. This is usually expected because on average, males have higher income than females and this concept was also supported by the current study. 52% of the respondents to the survey were males and these males had higher income and higher emissions than their female counterparts. A study that was conducted in Canada gathered statistics of the paid employment and residential sources and identified which gender dominated the various sectors and their corresponding emissions. Of the total GHG 692,000MtCO_2e, 76.5% of those emissions are from males (Cohen, 2014). Many of the industrial and manufacturing jobs, possession of vehicles and even homes are geared towards males hence; their emissions are expected to be higher, as has been supported by this work.

In this study also, it was shown that only one respondent reported an average monthly income of less than GH 1000. It is interesting to note that the respondent was a female who reported that in her household, over GH 300, was spent on diesel for their stand-by generator. From this unique report, it shows that even in lower or middle-income status, regardless of the gender involved, the use of a stand-by generator presents a serious threat to reducing household energy combustion emissions.

Last but not the least, it emerged that there is a relationship between emissions and age. According to the results of the study, as seen in figure 4, emissions were higher for younger respondents than older respondents. The modal age range of the participants was 30-39 years with 56% of the respondents falling within this bracket. This finding was never expected and has presented a new platform for research into GHG emissions and age in Ghana.

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