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EMPIRICAL ASSESSMENT OF FUEL-WOOD INDUCED CARBON FOOTPRINT IN UDU LOCAL GOVERNMENT AREA OF DELTA STATE, NIGERIA

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ABSTRACT

Most studies of carbon footprint (CFP) in relation to climate change focus on the generation of greenhouse gases (GHG) by human activities such as electricity, industrialization and transportation in urban areas with little attention on rural areas. Against this background, this study aims to identify sources of Carbon dioxide (CO_2) emission, and estimate the amount of CFP generated through fuel-wood consumption in Udu LGA of Delta State, Nigeria. Data for the study were obtained from a sample of 200 households in four (4) rural settlements chosen randomly from 32 villages. Mixed survey technique which involved questionnaires, field observations and measurement were employed to collect data for the study. Data obtained were analysed using descriptive statistics, Pearson Correlation Analysis and calculation of CFP. The study reveals that the major source of CO_2 emission was fuel wood (82.0%), which is used for various domestic and production activities with an average of 39.58kg consumed by each sampled household; thus, generating between 7.24314 MT daily. The amount of CFP also varies directly with the sizes of the sampled households. The study recommends that alternative sources of clean energy should be developed and utilized for sustainable development of the environment and mitigation of climate change phenomenon.

Keywords: Carbon footprint, Climate change, Fuel wood, Greenhouse gases, Sustainable development.

INTRODUCTION

The world's climate is dynamic due to emission of numerous greenhouse gases into the atmosphere which alters its gaseous composition. Most of these gases are generated from various human activities on the surface of the Earth (IPCC, 2013). The dynamism in climate, which is referred to as climate change impacts mankind negatively in various ways, such as extreme or harsh weather conditions, food insecurity, urban local drying climate and health instabilities amongst other environmental and developmental problems (UNFCCC, 2007; UNDP, 2007; Budescu *et al.*, 2009; Igben, 2013, Igun *et al.*, 2023).

The United Nations for Climate Change Convention (UNFCCC) (2000) defines Climate Change as long-term weather dynamics which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and natural climate variability observed over comparable periods. Igben (2013) defines

climate change as dynamics in the average condition of the atmosphere as a result of global warming, a condition of a noticeable or measurable increase in the average temperatures of the earth's atmosphere, oceans, and landmasses. The increased temperature is caused by rising levels of heat-trapping gases, also known as greenhouse, in the atmosphere as a result of human activities. In sum, the phenomenon can be described as vicissitudes in weather patterns. The degree of distortion in the gaseous composition of the atmosphere vis-a-vis the Earth's ecological equilibrium is measured by the concept of Carbon Footprint (CPF). Globally, carbon footprint is the main cause and measure of human-induced climate change (Boucher, 2011)

Besides the wide-spread usage of the concept as a measure of global warming, there is no uniformity over its exact meaning (Wiedmann and Minx 2008; East, 2008; Finkbeiner, 2009; Peters, 2010). Nevertheless, a carbon footprint is the total amount of greenhouse gases, carbon dioxide and methane inclusive, that are directly and indirectly caused by human actions (Wiedmann and Minx, 2008). It includes direct emissions, such as those that result from fossil-fuel combustion in manufacturing, heating, and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. In addition, carbon footprint also includes the emissions of other greenhouse gases, such as methane, nitrous oxide, or chlorofluorocarbons (CFCs).

Anthropogenic activities including electricity generation, agriculture, burning of fossil fuels, industrial processes, rapid population growth and urban transportation that characterize urban areas are commonly conceived as major sources of greenhouse gas emission (O'Neill, 2010; EPA, 2023). For instance, O' Neill (2010) asserted that rapid population growth is one the reasons for increasing carbon emissions. His study of 35 countries suggested that slowed population growth could save between 1.4 to 2.5 billion tonnes of carbon emission by the year 2050 as slowing population growth could provide 16 to 29% of emission reduction. In addition, urban transportation and household energy use make up the largest component of the population's carbon footprint. In contrast, the use of fuel wood accounts for most individual and household energy needs and subsequently, carbon footprint in the rural areas (Igben et al., 2014: Joshi et al., 2020; Akter and Malaviya (2022). For instance, Joshi et al. (2020) asserted that fuel-wood burning is a major component of meeting energy requirements in rural Uttarakhland in western Himalaya, India. In the study, 351 households were surveyed, of this 28 %, were between 1000-2000Mtr., 55.8%, of households were sampled in villages between 2001-2300 Mtr, and 16% of households were sampled between 2301 - 3200 Mtr. respectively. The average fuel-wood consumption at households' level in categories (I) was 11 kg/ day, in category (II) was 14.6 kg/day and in category (III) it was 17.2 kg/day. The overall average value of fuel-wood consumption in all three categories was 14.26 kg/day/ household at the state level. Furthermore, the annual carbon emission values for sampled villages in five rural districts of Uttarakhland are; Almora 1081.4 $MtCO_2$, Bageshwer 479.1 Mt CO_2, Champawat405.6Mt CO_2, Pithoragarh 829.8 Mt CO_2, and TehriGarhwal 1025.7 $MtCO_2$. The total CO2 emission value for all five districts was 3 from 821.6 $MtCO_2$ annually through fuel-wood burning. Annual carbon emission from fuel-wood burning in rural areas was also estimated using the formula provided by the Inter-governmental Panel on Climate Change (IPCC 1996).

Similarly, Akter and Malaviya (2022) analysis of CFP in Village Chak Chua, in Jamm, J&K district of India revealed that the main source of CPF in households in the rural area is petrol, which emanates from the use of vehicles. Other sources identified in the study include fuel wood, electricity, transportation etc. In contrast, however, wood fuel

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accounted for over 60% of the total energy use in Ghana as a bulk of the energy in the rural areas is obtained from fuel wood (Economic Commission, 2006). Similarly, Egwunatum (2022) identified fuel wood as the main source of energy and the major source of carbon emission in the rural and peri-urban areas of Koko in Delta State, Nigeria.

Conceptual Framework

This study is predicated on the conceptual framework of Ecological Footprint proposed by Wackernagel and Rees (1996). The framework depicts climate change in a comprehensive way beyond measuring carbon emissions. It shows how carbon emissions compare and compete with other human demands on the Earth; such as food, fibers, timber, and land for dwellings and roads. In other words, it refers to the biologically productive land and sea area required to sustain a given human population expressed as global hectares. It seeks to sustain equilibrium of the ecosystem; where the various components; namely, physical and biological relate mutually for the sustenance of the entire system. Thus, carbon footprint can be regarded as a component of "ecological footprint"

The frameworkalso shows the ecosystem in a greater context, one which unites all the ecological threats such as climate change, biodiversity loss, deforestation, overgrazing, fisheries collapse and food insecurity bedeviling humanity today. The carbon footprint is currently 60 percent of humanity's overall Ecological Footprint and its most rapidly growing component. Humanity's carbon footprint has increased 11-fold since 1961, and reducing humanity's carbon footprint is the most essential step to achieving equilibrium within the earth (Wackernagel and Rees, 1996).

In relation to the ecological footprint, carbon footprint refers to the land area required to assimilate the entire CO_2 produced by mankind during its lifetime. It measures the degree of distortion to the composition of the atmosphere vis-a-vis Earth's ecological equilibrium. In due course of time as the global warming issue took prominence in the world environmental agenda, the use of carbon footprint became common independently, although in a modified form (East 2008).

Following the paucity of studies on CFP particularly in rural areas and the prevalence of fuel wood as a source of domestic energy, there is need to estimate the amount of carbon emission from the use of fuel wood by individuals and households in the rural areas. Hence, this study aims to estimate the volume of carbon footprint generated from fuel wood use in the study area. Its specific objectives include the following; (i)identify the proportion of fuel wood use vis-à-vis other sources of domestic energy, (ii) estimate the quantity of fuel-wood used by households and (iii)calculate the amount of carbon footprint generated from fuel-wood use in the study area.

In this study, the null hypothesis that there is no significant relationship between household size and quantity of fuel wood utilized in the study area was postulated and tested. Furthermore, the study will elicit the contribution of rural areas to the emission of carbon dioxide and subsequently to the phenomenon of climate change. Also, the study will help in the planning for the reduction of carbon footprint and sustainable use of the environment particularly in the rural areas.

METHODOLOGY

Study Area

This study area, Udu LGA is one of the twenty-five geo-political divisions of Delta State, Nigeria. It is located approximately between Latitudes 5^0 45" and 5^0 50" north and Longitudes 6^0 20" and 6^0 50" east over an area of about 138 square kilometres. The general elevation of the area is below 10 metres above sea level (Lafua and Igben, 2019). The LGA is bordered in the north by Uvwie LGA, by Ughelli South LGA in the

south and east respectively, while the Warri Southwest LGA is the western border. It has a tropical climate characterized by uniformly high rainfall and temperature throughout the year. The area experiences two distinct seasons: dry and rainy seasons. The dry season occurs between November and April, while the rainy season begins in April and ends in October, though with minor annual variation. The average annual rainfall is high, about 266.5cm. Rainfall is heaviest in July and no month is completely rainless. January, which is the driest month, is characterized by rainfall of up to 2.5cm of rain in most years (Aweto and Igben, 2003). The period from December to February is usually marked by relatively cool, dry and dusty weather called the 'harmattan' **(**Aweto and Igben, 2003)

The 2006 provisional national population census put the population of the LGA at 142,480 persons, made up of 71,813 males and 70,667 females (NPC, 2006). The projected population of the study area in 2016 was 196,200 persons with population density of 1,432 persons per square kilometre (NBS, 2016). In 2019, using the national population growth rate of 2.7%, the population of the area was estimated to be 218,136 persons. However, following the creation of the LGA in 1991 coupled with the rapid influx of people from the neighbouring Warri Township, the population of the area is estimated to be over 300,000 persons, with some of the settlements such as Aladja, Ovwian and Orhuwhorun undergoing rapid urbanization (Igben, 2019).

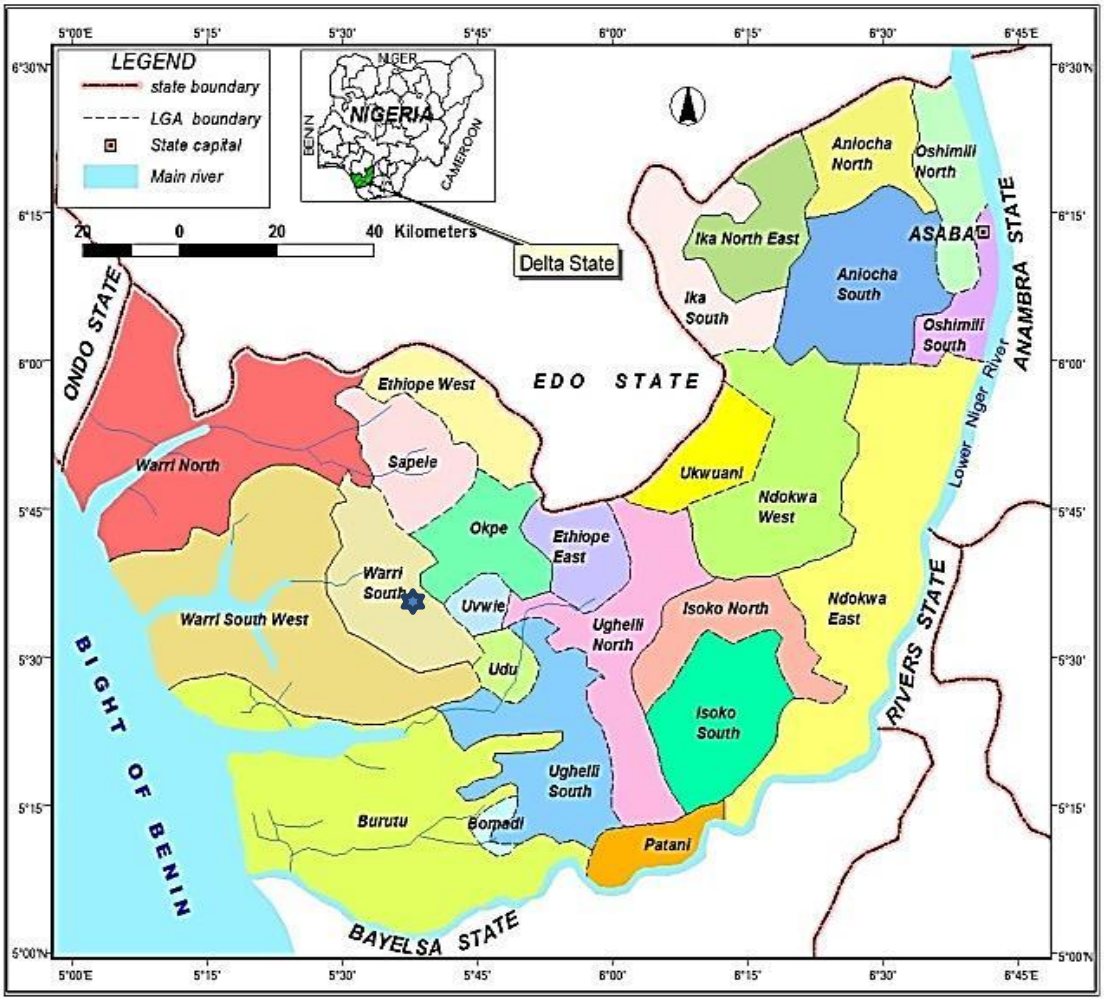

Figure 1: Map of Delta State showing Udu LGA

Adapted from Igben (2012)

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The major occupation of the people in the study area is farming. Other primary occupations include fishing, lumbering, hunting, and tapping of rubber trees and raffia palm, gathering of fuel wood, collection of non-timber forest products like bamboo, palm nuts, screw pines, thatches, mushrooms, snails, fruits and herbs for medicinal purposes, trading and craftwork such as making of baskets, etc.

Research Design

The descriptive design was adopted in this study. It involves mere description of variables as they occur over space and time. Ogundipe *et al* (2006) asserted that this design elicits understanding of the present condition through a scientific observation of a phenomenon or variable in the real-world situation. It was adopted to elucidate the use of fuel wood as a source of energy for domestic use of the study population.

Population and Sample

The target population for the study includes all residents in the rural areas. Data for the study were obtained from a sample of 200 households in four (4) rural settlements selected from a list of 32 villages in the LGA. The selected villages are Egiegi, Okolor-Burhie, Ubogo and Ogbe-Udu. In each of the chosen settlements, 50 household heads were selected by systematic random sampling. Thus, a total of 200 households were selected for the study. Mixed survey technique which involved the use of questionnaires, field observations and measurement were employed to collect data for the study.

Data Collection

Data for the study were collected from primary and secondary sources. Primary source involved the use of well-structured questionnaires, field observation and measurement. The questionnaire was administered to a sample of 200 household heads. The questionnaire covers the socio-demographic characteristics of the household heads, source and quantity of fuel wood use daily. The quantity of fuel wood use was measured by the researcher with the help of assistants and facilitated by the co-operation of household heads for one week (7 days). The daily average was then estimated. Information on fuel wood usage in the study was based on households and not on individuals because of the nature of the rural economy which is based on family units. This was done to avoid duplication of information. In addition, household survey commonly collects core socio-economic and demographic information on the topic of particular interest (OECD, 2023)

Data Analysis

Data derived from the questionnaire were coded, tabulated and analysed with the aid of descriptive statistics. The SPSS version 23 was used to facilitate the process of data analysis. In addition, the null hypothesis that there is no significant relationship between household size and quantity of fuel-wood utilized in the study area was tested using Pearson Correlation Analysis.

Calculation of Carbon Footprint

The study adopted the procedure proposed by Dimegani (2023) to measure and calculate CFP in the study area. The steps taken were (i) Identify human operations or activities that utilize fuel-wood for energy and therefore emits GHG into the atmosphere (ii) Collect data on quantity of fuel-wood used, and (iii) Operation-specific emission factor, using metrics such as Kilogramme to calculate fuel-wood consumption. Hence, the study is predicated on the assumption that one kilogramme of fuel wood emits approximately 183 kg of CO_2 and 1cubic metre of fuel wood emits between 61-73kg of CO_2 (IPCC 1996; Egwunatum, 2002; Tsietsi *et al.*, 2013). Therefore, to obtain the CFP per household daily, the sum total of household daily fuel wood consumption is divided by number of households and multiplied by 183 kg.

RESULTS AN DISCUSSIONS

Socio-demographic Characteristics of Respondents

The socio-demographic characteristics of respondents considered in the study include age and sex composition, marital status, educational attainment and occupational distribution

Table 1: Socio-demographic Characteristics of Respondents

Socio-demographic Variable	Frequency	Percentage
Age (Years)		
>20	23	11.5
21-30	45	23.5
31-40	53	26.5
41-50	31	15.5
51-60	26	13.0
> 60	22	11.0
Total	200	100.0
Sex		
Male	116	58.0
Female	84	42.0
Total	200	100.0
Marital Status		
Single	31	15.5
Married	139	69.5
Divorced	18	9.0
Widowed	22	11.0
Total	200	100.0
Education		
No Formal Education	80	40.0
Formal Education	70	35.0
Vocational Education	50	2.5
Total	200	100.0
Main Occupations		
Farming	105	52.5
Fishing	25	12.5
Hunting	12	6.0
Fuel wood gathering	15	7.5
Lumbering	17	8.5
Palm nut collection	6	3.0
Trading	9	4.5
Others	11	5.5
Total	200	100.0

Source: Fieldwork, 2023

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Table 1 shows that a majority of the sampled population, 98 households representing 50 per cent were between 21 to 50 years. Out of this percentage, 23.5per cent of them were in the age cohort of 21-30 years, and 26.5 % were between 31-40 years. The older age groups trailed behind, with 15.5 per cent for those between 41-50 years, and 13.0 per cent and 11.0 per cent respectively for 51-60and above 60 years old. Those below 20 years were 23 persons representing 11.5 per cent. The mean age of the sampled household heads is 50.3 years, indicating an aging population. Furthermore, 84 respondents representing 42.0 per cent were females, while116 respondents or 58.0 percent were males. The predominance of male-headed households is in agreement with the National Population Commission (NPC) documented Household statistics of 2000. The statistics showed that 83 per cent of households in Nigeria are headed by males while females headed only 17 per cent. However, the slight deviation from these statistics in the study area is because majority of the women bear the burden for the survival of their household unit, either as a primary bread winner due to unemployment of their husbands, who as a result had to be away, or of their unit within a polygamous homestead.

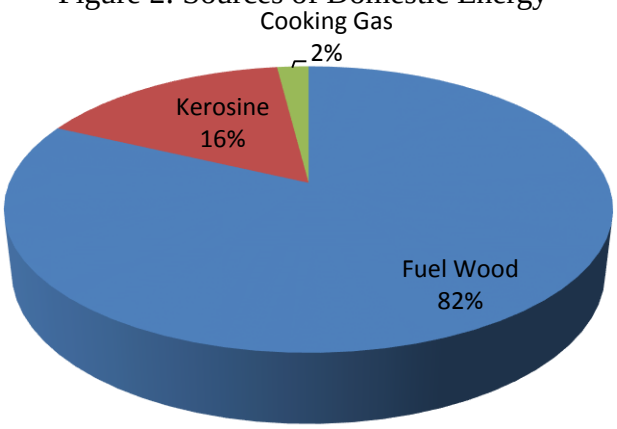
The table also reveals that a majority of 139household heads, representing69.5 per cent were married. While 31 households (15.5%) were single, 18 households (9.0%) were divorced. Widowed accounted for 22 households representing 11.0 percent. In addition, 80 respondents or 40.0 per cent of the sample population had no form of formal education. While 70 respondents or 35.0 per cent had formal education, 50 respondents representing 25.0 per cent of the sample had vocational training in motor-cycle and motor repairs, welding, tailoring and hair dressing, etc.

Furthermore, 180 households (90.0%) were engaged in the primary occupations as their main source of livelihood. Out of this number, 105 households or 52.5 per cent of the total sample population were into farming growing crops, such as cassava, yams, cocoyam, potatoes, maize, sugar cane and vegetables. The next important activity is fishing which engaged 25 households or 12.5 per cent of the total size; followed by fuel wood gathering (7.5%), hunting (6.0%), lumbering (8.5%) and palm nut collection (3.0%). A factor which might be responsible for the high percentage of people in the primary sector is the geographical nature of the area, which is mostly rural and the over dependence of people on land for survival (Igben, 2012). Furthermore, trading employed 9 respondents (4.5%). Other occupations including civil service, mostly teaching, transportation, artisans and unskilled labourers accounted for 5.5per cent. In addition, most of the sampled households engaged in multiple occupations as in line with Igben (2014) study.

Sources of Domestic Energy

The identified sources of energy for domestic use by the sampled households were fuel wood, kerosene and cooking gas. Figure 2 below indicates the distribution of the sampled households among the identified sources. Fuel wood is mainly used by 164 household heads, representing 82 per cent. While kerosene is used by 32 households or 16 per cent, only 4 households or 2 percent used gas as domestic energy. Fuel wood is used for cooking, processing most products or output of the various primary occupations that predominate in rural areas. For instance, fish caught from fishing expeditions, games from hunting, etc. are either cooked or dried before consumption or preservation. Similarly, farm produce is processed by subjecting them to varying degree by use of fuel wood. This finding corroborates earlier studies by the Economic Commission (2006), Egwunatum (2022) and Igben *et al* (2014).

Figure 2: Sources of Domestic Energy



Source: Fieldwork, 2023

Daily Quantity of Fuel-wood utilized by sampled Households and CFP Generation

The sampled households utilize varying quantities of fuel wood. Table 2 below presents the sizes of households, daily quantity of fuel wood and the estimated carbon footprint generated.

Table 2: Daily Fuel wood utilized by sampled Households and CFP Generation

HH Size	Frequency	Daily Average	Total	CFP ($MTCO_2e$)
1	8	47.3	378.4	69.247
2	17	49.2	836.4	153.061
3	12	46.4	556.8	101.894
4	26	43.4	1128.4	206.497
5	10	39.8	398.0	72.834
6	15	40.4	606.0	110.898
7	19	38.9	739.1	135.255
8	26	43.6	133.6	24.449
9	13	38.8	504.4	92.305
10	15	44.6	669.0	122.427
11	13	47.9	622.7	113.954
12	10	50.2	501.0	91.683
13	9	46.9	422.1	77.244
14	4	60.2	240.8	44.066
15	2	68.2	136.4	24.961
16	1	43.1	43.1	7.887

Source: Fieldwork, 2023

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Table 2 shows that the minimum size of the households is one person, while the maximum is 16 persons as indicated in the first column. The frequencies of the various household sizes are presented in the second column. The daily average of fuel wood utilized by the various household sizes is presented in the third column with the highest been 68.2kg consumed by household size of 15 persons and the lowest been 38.8kg consumed by 9 households. The fourth column presents the total fuel wood consumed by each household size obtained by multiplying the daily average quantity of fuel wood utilized by the frequency of the household size. The fifth column presents the total amount of CFP generated by each household size, obtained by multiplying total fuel wood consumption by 183 kg of CO2. Therefore to obtain the CFP per household daily,

(Sum Total of Household daily Fuel wood consumption / Number of Household X 183) /1000 (MT CO2e).

Relationship between Household Size and Quantity of Fuel-wood utilized by sampled Household

In this study, the null hypothesis that there is no significant relationship between household size and quantity of fuel wood utilized in the study area was postulated and tested using Pearson Correlation Analysis. The computed Pearson Correlation (r) of 0.440indicates a positive correlation between the two variables. Thus, the amount of CFP varies directly with the sizes of the sampled households.

Table 3: Correlation between Household size and Carbon Footprint

		Household Size	CFP
Household Size	Pearson Correlation	1	.440
	Sig. (2-tailed)		.088
	N	16	16
CFP	Pearson Correlation	.440	1
	Sig. (2-tailed)	.088	
	N	16	16

CONCLUSION

This study aimed to identify sources of Carbon dioxide (CO_2) emission and estimate the amount of CFP generated through fuel-wood consumption in rural areas of Delta State, Nigeria. Mixed survey technique which involved the use of questionnaires, field observations and measurement were employed to collect data from a sample of 200 households from four (4) rural settlements chosen randomly from 32 villages. Data obtained were analysed using descriptive statistics, correlation and calculation of CFP. The study reveals that the major source of CO2 emission was fuel wood, which accounted for 82.0% of the identified sources of domestic energy. Fuel wood is used for various domestic and production activities with an average of 39.58kg consumed by each of the sampled households; thus, generating 7.24314 MT CO2e daily. Furthermore, the amount of CFP also varies directly with the sizes of the sampled households. Following from the above, the study recommends the use of alternative sources of energy. To this end, clean energy such as electricity, solar energy etc. should be developed and utilized for sustainable development of the environment and mitigation of climate change phenomenon.

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