

CARBON (CO₂) FOOTPRINT: AN EMPIRICAL STUDY OF FAMILIES IN THE NIGER DELTA OF NIGERIA

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ABSTRACT

The emission of CO₂ has been greatly influenced by human activities over the years. This study aims to estimate the carbon footprint of households in Warri based on energy use and other factors that contribute to household emissions, and to suggest strategies for reducing CO₂ emissions. A quantitative research approach was adopted for data collection. Agbargho (Ughelli North), Uvwie Local Government Area, Warri South, and Udu Local Government Area in Delta State were represented in the study. A total of 300 questionnaires were distributed to households, of which 200 responses were obtained, alongside information gathered through oral interviews. Although some households reported family sizes of 11 or more persons, the majority had family sizes ranging between four and six persons, providing a broad representation of household sizes.

Data were obtained from household reports on alternative power supplies, transportation, household equipment and appliances, daily fuel consumption, automobile mileage, electricity consumption, and other household activities. The findings indicate that the average household in the study area emits approximately 11.52 tCO₂/year from the sources considered in this study, comprising transportation, household generator use, grid electricity consumption, and LPG use for cooking. Government policies and deliberate actions by households in the Niger Delta can contribute to reducing household CO₂ emissions, with potential benefits for climate-change mitigation. Reducing CO₂ emissions is a shared responsibility that can provide environmental and economic benefits while also helping families manage their energy-related expenses.

KEYWORDS: Consumption, Carbon, CO₂, Energy, Emission, Environment, Family, Household, Reduction.

1. INTRODUCTION

Nigeria's economy is entirely dependent on fossil fuels for energy production, manufacturing, which is responsible for the nation's carbon emissions, and national revenue, which accounts for roughly 86% of the country's domestic revenue (Dunne, 2020). According to UNDP (2010), since energy is essential to human progress, it is also critical to end poverty, enhance human welfare, and raise living standards. Climate change is a significant issue that must be resolved quickly. According to Adeyemi et al. (2019), one of the main causes of global warming is carbon dioxide, a gas emitted when fossil fuels are burned. According to Alimi et al. (2016), fossil fuels, which are sources of greenhouse gases, pose a threat to the environment. A steady increase in GHG is linked to decreased water supplies and rising temperatures, which raise the possibility of drought and cause crops and plants to wither and die. It is also crucial to remember that a persistent danger to the climate could result in famine and inevitable fatalities. However, Gershon et al. (2019) contend that the greenhouse effect is caused by human activity and the combustion of hydrocarbon fuel, which releases greenhouse gases like CO₂. Short-wave solar radiation penetrates and absorbs energy from the earth's surface due to the naturally occurring composition of greenhouse gases in the atmosphere. In order to lessen environmental degradation caused by the use of fossil fuels, Jeremiah et al. (2018) advise Nigeria to limit its reliance on fossil fuels, even if it may be challenging to completely stop using them. It is well recognized that one of the main causes of global warming is carbon dioxide, a gas emitted when fossil fuels are burned. The goal of this research project is to find areas for improvement with regard to CO₂ emissions to the environment since if we do nothing, the earth's temperature will continue to rise. Rich and poor countries should reduce their energy production by 4% to 5%, while industrialized nations should reduce their usage and consumption of fossil fuels, which contribute to greenhouse gas emissions, by 1%. Global energy consumption would drop from 1.1% to 0.65% per year if everyone cut productivity to 2.5% (Rezai et al, 2012).

Nonetheless, Jenny & Sara (2016) believes that there is a positive association between per capita GDP per capita, and carbon dioxide emissions, which shows expanding per capita GDP leads to greater carbon dioxide emissions. It backs up the assertion that, according to certain hypotheses, there is no turning point at which emissions begin to decline when GDP is at its peak. The outcome indicates that market economic processes are insufficient to reduce emissions, necessitating legal control to prevent additional environmental deterioration. Reducing environmental degradation can alter the ecosystem as a whole. Despite an increase in mitigation strategies, GHG emissions have grown over the past few decades, according to an

IPCC study from 2014. The earth's temperature will rise in tandem with the growth of green energy gases since there is a clear correlation between the two.

According to a 2014 assessment from the Intergovernmental Panel on Climate Change (IPCC, 2014), the ocean's absorption of CO₂ has caused the ocean to become more acidic due to the influence of CO₂ emissions since the start of the industrial age. This has resulted in a fall in P.H. of the Ocean surface by 0.1 (high confidence), corresponding 26% rise in acidity, assessed as hydrogen ion concentration. According to Adeyemi et al. (2019), burning of fossil fuels is the primary source of air pollution, which also mixes with other industrial activities, agricultural practices, wildfires, dust storms, etc. Furthermore, it caused 4.2 million premature deaths in 2016, about 300,000 of which were in children under five. Similar evidence of exposure to emission compounds such as nitrogen dioxide (NO₂) and sulphur-dioxide (SO₂) leading to adverse impacts on the environment and human health was presented by Pieprzyk et al. (2009) in support of this report. Humans may develop chronic respiratory conditions as a result of these exposures, as youngsters in the Niger Delta region have already shown. Additionally, the chemicals can exacerbate chronic bronchitis, leukemia, asthma, and blood diseases.

As a result, humans engage in activities that produce greenhouse gases (GHGs), such as carbon dioxide, carbon monoxide, and methane (CH₄). The total amount of GHG produced as a result of these activities is known as the carbon footprint. According to The Nature Conservancy (2021), the average carbon footprint per person in the US is 16 tons, which is among the highest rates worldwide. Globally, the average is closer to 4 tons; by 2050, it must be less than 2 tons. Avoiding a 2°C increase in global temperatures is one approach to accomplish this, according to the IPCC (2014).

2. LITERATURE REVIEW

The IPCC report makes it abundantly evident that due of human impact on the climate system, anthropogenic GHG emissions are at an all-time high. The atmosphere and oceans have warmed, sea level has increased, ice and snow have decreased, and the earth's surface has warmed more than in any other decade since 1850. The burning of fossil fuels, deforestation, changes in land use, fertilisation, livestock, etc. are some of the activities that lead to a net rise in emissions.

Susan et al. (2019) examined the impact of natural resource extraction while taking into account the Nigerian Niger Delta Region's economic performance. They discovered that extractive activities have a positive impact on the total state-level revenue in the form of production-based derivation funds from oil-producing states, which has a positive impact on their GDP. GHG emissions during these extraction operations are consistent with the positive correlation between GDP growth and GHG emissions. Gershon and Patricia (2019) looked into and evaluated the amount of greenhouse gases that Port Harcourt families create due to energy use and other causes. Families in Port Harcourt emit 5.21 tonnes of CO₂ on average, according to data collected using the input-output approach and questionnaire. According to the study, every household might significantly reduce greenhouse gas emissions by making little adjustments to their daily activities. They believed that tiny savings made by individuals would add enough to create climate change.

The Product Carbon Footprint (PCF) of small electronic devices is thought to produce fewer emissions due to their size, but Yung et al. (2018) investigated the amount of carbon emissions emitted by personal electronic products because he believed that this should not be the case. According to his findings, printed circuit boards were the primary source of carbon emissions, with the extraction of raw materials also having an impact. Sensitivity analysis conducted during the material extraction and manufacturing stages revealed that they produced the most amount of carbon emissions, according to the report.

Balogh & Jambor (2017) used a GMM model on a panel dataset with 168 countries and 24 years of testing to determine the relationship between CO₂ and its various causes by utilising a complex model involving economic growth, energy use, industry structure, tourist arrivals, foreign direct investment, trade, and agriculture worldwide. Their findings supported the classic environment Kuznets curve assumptions, showing that while energy from coal increased environmental pollution, nuclear and renewable energy contributed to a decrease in CO₂ emissions. Additionally, their findings demonstrated that financial development lowers air pollution.

80% of Nigeria's carbon emissions come from burning fossil fuels, according to a study on CO₂ emissions and their effects on the environment by Adeyemi et al. (2019) that used secondary data from the World Development Index (WDI) from 1970 to 2017 using the Johansen co-integration technique. An urgent establishment of a sustainable energy framework that highlights the risks of utilising contaminated fuel is another suggestion. Because millions of Nigerians lack access to electricity, the country has one of the highest energy poverty indices in the world. Nigeria is experiencing significant effects from climate change, including rising temperatures and a lack of access to electricity and air conditioning.

The extent to which population increase among the magnum cum is influenced by carbon emissions Daramola et al.'s (2021) study of oil-producing African nations found a strong and unfavourable relationship. Furthermore, it is crucial to recognise the connection between CO₂ emissions, economic growth, and the use of renewable energy. According to research by Ezenwa et al. (2020), there is a two-way causal relationship between economic growth and renewable energy consumption

(REC). While REC has a beneficial impact on GDP over the long term, it has a negative impact in the short term. Decarbonising Africa, according to Gershon et al. (2022), lessens the burden of diseases and other environmental issues.

Additionally, a study conducted by Romanus et al. (2019) to determine the effects of oil price shocks on net oil-importing countries revealed that an increase in oil prices temporarily raises GDP per capita in the short term, which contributes to carbon emissions and is consistent with the positive relationship between CO₂ and GDP growth. Premium motor spirit (PMS), another name for petrol, is known to release volatile organic compounds (VOCs), which have a negative impact on ground-level ozone production and health consequences. Obindah et. Al (2020) believes that the higher the evaporative quality of gasoline the greater the VOCs emitted into the environment, he therefore recommended that if we want to achieve a reduction equivalent gasoline loss by 97.67% and VOC emission it is important to reduce the vapor quality with efficient recovery and control regulation.

3. METHODOLOGY

The increased emission of CO₂ into the environment forms the objective for this study and the need to reduce carbon foot front in the Niger Delta while recommending measures to keep the rise in global average temperature well below 2°C and also limit the increase to 1.5°C (UN, 2015) by the United Nations Conference on Climate change International (UNCCCI). Transport, Food, Energy Use, waste management, electronic devices, and daily household activities are major factors that contribute to carbon footprint of the household in Warri.

For the purpose of this study, household carbon footprint refers to the estimated annual carbon dioxide (CO₂) emissions associated with selected household activities and energy uses within the study area. The assessment focuses on direct and electricity-related CO₂ emissions from household transportation, petrol generator use, grid electricity consumption, and liquefied petroleum gas (LPG) used for cooking.

The study therefore does not represent a comprehensive greenhouse gas (GHG) inventory of all household activities. In particular, other greenhouse gases, such as methane (CH₄) and nitrous oxide (N₂O), and emissions associated with activities such as solid waste decomposition, food consumption, and the production or disposal of consumer goods were not quantified because corresponding activity data were not collected.

Accordingly, the term “carbon footprint” is used in this study to describe the estimated CO₂ emissions within the defined assessment boundary. The results are reported in tonnes of CO₂ per household per year (tCO₂/household/year), rather than tonnes of CO₂-equivalent (tCO₂e), because the study quantified CO₂ emissions and did not convert multiple greenhouse gases into a common CO₂-equivalent measure.

The estimated household footprint was therefore calculated as the sum of the annual CO₂ emissions from the identified sources:

Household CO₂ footprint = Transportation + Generator use + Grid electricity + LPG cooking

This boundary was adopted to ensure that the calculated household footprint corresponds directly to the activity data collected through the questionnaire and the emission factors applied in the study.

The study adopted a quantitative research approach to estimate the annual CO₂ emissions associated with selected household activities in the study area. Primary data were collected using a structured questionnaire administered to sampled households. The questionnaire was designed to obtain information on household characteristics and activity levels relevant to the estimation of CO₂ emissions, including vehicle use and fuel consumption, petrol generator use and fuel consumption, electricity consumption, and LPG consumption for cooking.

Where necessary, oral interviews were used to clarify or supplement responses obtained from the questionnaires, particularly where respondents required clarification of questions relating to household energy use and fuel consumption. The interview responses were used primarily to support the interpretation and validation of the questionnaire data rather than as a separate source of quantitative emission estimates. These factors includes:

3.1 ELECTRICITY SUPPLY TO HOUSEHOLD:

Get Invest Opines that only 40% - 45% of Nigerian have access to electricity as of 2014 (Get. invest, 2021). According to them an average of 3.1 GW was supplied in 2015 which can only cater for one third of the country's minimum demand forcing customers to rely on privately owned generators" which is a major source of GHG. We deployed Questionnaire to households resident in Warri to find out the following:

- a) How often do they enjoy Power supply from BEDC
- b) What alternative they use to generate power supply as an alternative to insufficient or no power supply?
- c) How many electricity power generators they have, if their alternative is an electric power generator?

- d) How often they use these power generators and how many litres they use on weekly basis?

3.2 TRANSPORTATION

People prefer to drive from the comfort of their homes as a result of this, the transport sector is one of the biggest sources of anthropogenic greenhouse gases in houses. CO₂ is released when fossil fuels like petrol and diesel, which these cars need, are burned. The accumulation of CO₂ and other gases warms the atmosphere, leading to climate change. Transportation is responsible for around 28% of greenhouse gas emissions in the United States, according to the EPA (2021). The average passenger car generates 0.78 pounds of CO₂ per mile travelled, according to the Centre for Sustainable Systems (2020).

We would investigate the use of questionnaires to determine:

- a. The number of cars utilised by each household in Warri
- b. The frequency of use of these vehicles
- b. These vehicles are utilised to calculate mileage.

3.3 HOUSE HOLD ELECTRONICS AND GADGETS

According to a 2020 study by the Centre for Sustainable Systems, residential electricity accounts for 10% of all CO₂ emissions in the United States, while residential space heating and cooling accounts for 44% of energy used in homes. Additionally, they stated that the power plant releases an average of 0.953 pounds of CO₂ for every kilowatt-hour produced. Additionally, washing machines produce 26 mmt of CO₂ annually in the United States. Furthermore, we would investigate the use of questionnaires and spoken communication to ascertain:

- a. How many refrigerators are currently in use in your home?
- b. What is the number of gas or electric burners in a household?
- c. How many microwaves are used in each home?
- d. How many water (or other) heaters does each household use
- e. How many washing machines (Plates and cloths) does each household use

3.4 INDUSTRIES LOCATED AROUND COMMERCIAL AREAS:

The Niger Delta is bordered by enterprises that produce greenhouse gases by burning fossil fuels for energy in residential areas. According to the EPA (2021), industries accounted for 23% of greenhouse gas emissions in 2019. Additionally, we would investigate the use of questionnaires and spoken communication to ascertain:

- a. If homes have carbon soot (also known as black soot) deposits nearby

3.5 APPLICABLE EQUATION

For the purposes of this study, emissions were viewed from four different perspectives using data and parameters like average car mileage per gallon, energy sources, average driving rate, energy consumption rate, and family size, all of which have a significant impact on carbon emissions.

3.5.1 TRANSPORTATION

The following average carbon content values are used by organisations like the EPA to calculate CO₂ emissions: 8,887 grammes of CO₂ are released every gallon of petrol. Diesel emits 10,180 grammes of CO₂ per gallon. Diesel fuel produces 15% more CO₂ per gallon, according to the U.S. Environmental Protection Agency (2014). Nevertheless, vehicles that use diesel fuel have higher economy than comparable vehicles that use petrol, which typically compensates the higher carbon content of diesel fuels. The majority of cars in the Niger Delta run on petrol and travel an average of 4.8 km (3 miles) from a residential area like Energho to Airport Road (a commercial area), but some go an average of 20 km (12.4 miles) from Agbarho (a residential area) to Jakpa (a commercial and residential area). According to U. S. Environmental Protection Agency, (2014) a gallon of gasoline is burnt every 21.6 mile. Therefore an average vehicle burns

$$\text{CO}_2 \text{ emission per mile} = \frac{8,887 \text{ g CO}_2/\text{gallon}}{21.6 \text{ miles/gallon}} = 411 \text{ g CO}_2 \text{ per mile} = 0.000411 \text{ metric ton CO}_2 \text{ per mile}$$

A gallon of Gasoline = 3.7 litres

Based on an assumed average vehicle fuel economy of 21.6 miles per gallon (mpg), the CO₂ emission per mile was estimated as follows, therefore, for each household vehicle per year:

$$\text{CO}_2 \text{ emission} = (\text{CO}_2 \text{ emission per mile}) \times (\text{total mileage in a year}) \times (\text{emission factor})$$

3.5.2 ELECTRIC SUPPLY, HOUSEHOLD ELECTRONICS AND GADGET

According to (Gershon O. a., 2019) emission from Electricity consumptions can be calculated as

$$GHG_{em} = \frac{12 \times \left(\frac{\text{cost}}{\text{month}} \right) \times \text{emission factor}}{\text{tariff} \div \text{Number of Household Occupants}}$$

Main (Grid Electricity):

$$GHG_{em} = \frac{12 \times \left(\frac{\$}{\text{month}} \right) \times KWH \times \left(\frac{\text{tons CO}_2\text{e}}{\text{kWh}} \right)}{\text{Number of Household Occupants}}$$

$$= \frac{12 \times \text{CO}_2\text{e}}{\text{Number of Household Occupants}}$$

Household Generators:

$$GHG_e = \frac{12 \times \left(\frac{\text{liter}}{\text{month}} \right) \times \text{Energy density} \times \text{Emission factor}}{\text{Number of Household Occupants}}$$

$$= 12 \times \frac{\text{liter}}{\text{month}} \times \frac{\text{MJ}}{\text{L}} \times \frac{\text{tons CO}_2}{\text{MJ}}$$

$$= \frac{12 \times \frac{\text{tons CO}_2}{\text{month}}}{\text{Number of Household Occupants}}$$

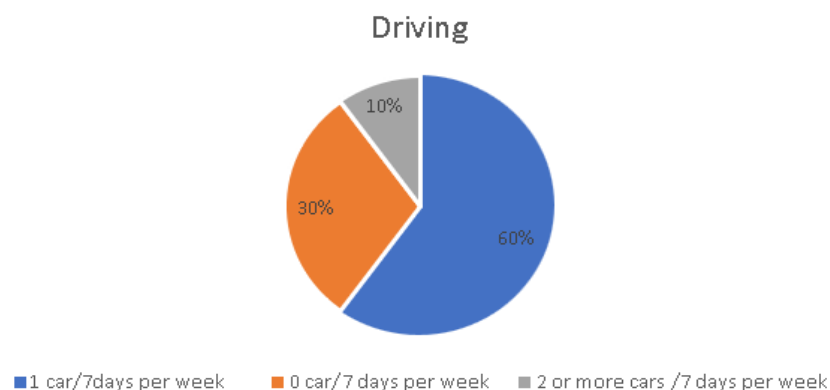
Industries and Commercial areas Located with residential areas: Depots, refineries, airports and commercial areas release CO₂ as result burning fossil fuels. Carbon Black Particles (Soot) reduces the quality of air within the environment.

3.6 ANALYSIS AND RESULT

A total of 200 completed responses were obtained from the 300 questionnaires distributed within Delta State, areas that were chosen, including Agbargho (Ughelli North), Uvwie Local Government, Warri South, and Udu Local Government. The questions aim to determine the annual CO₂ emissions of an average family in these areas. Using the primary data collection method and the previously indicated methodology, the carbon footprint of an average family in these areas was determined.

3.6.1 DRIVING

According to the data collected, over 60% of households said they now use one personal vehicle every day of the week, 30% said they use public transportation instead of a personal vehicle, and 10% said they use two or more personal vehicles every day of the week.



Those who use 0 car for 7 days per week use public transport for their movement.

3.6.1.1 CO₂ emission from Driving per mile in a year

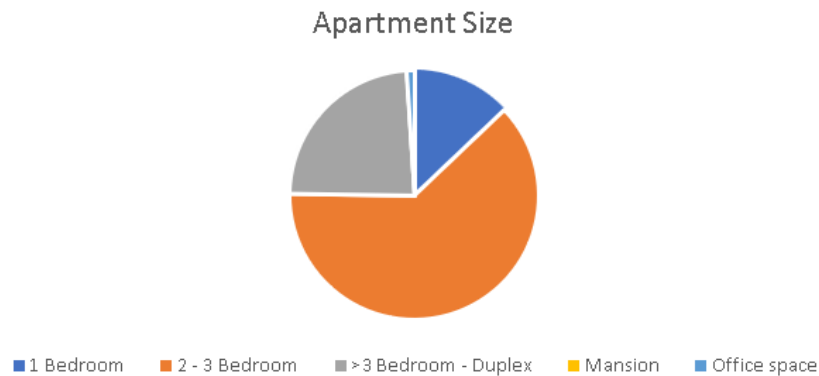
CO₂ Emission per mile is 411g Per CO₂ per mile = 0.000411 metric ton

An estimated average distance covered by vehicles in Warri per day = $(12.4 + 3.4)/2 = 7.7$ mile

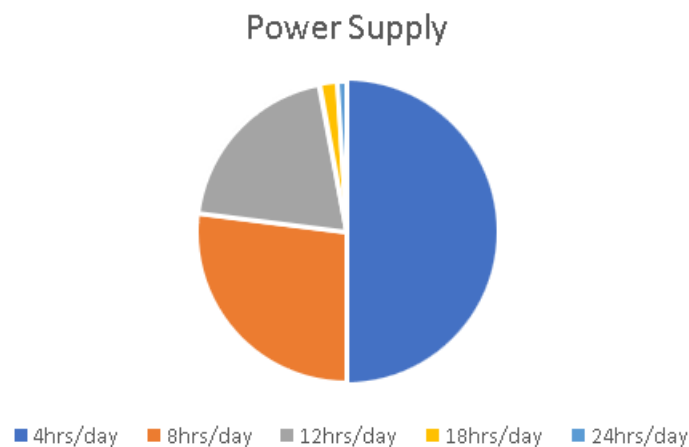
CO₂ emission per day = $0.000411 \times 7.7 \times 365 = 1.15$ metric ton CO₂ per average car per year

3.6.2 HOME ELECTRICITY

Approximately 62% of respondents said their household now resides in an apartment with two to three bedrooms, 13% said they live in a one-bedroom apartment, 24% said they live in a flat or duplex with more than three bedrooms, and 1% said they live in an office space.

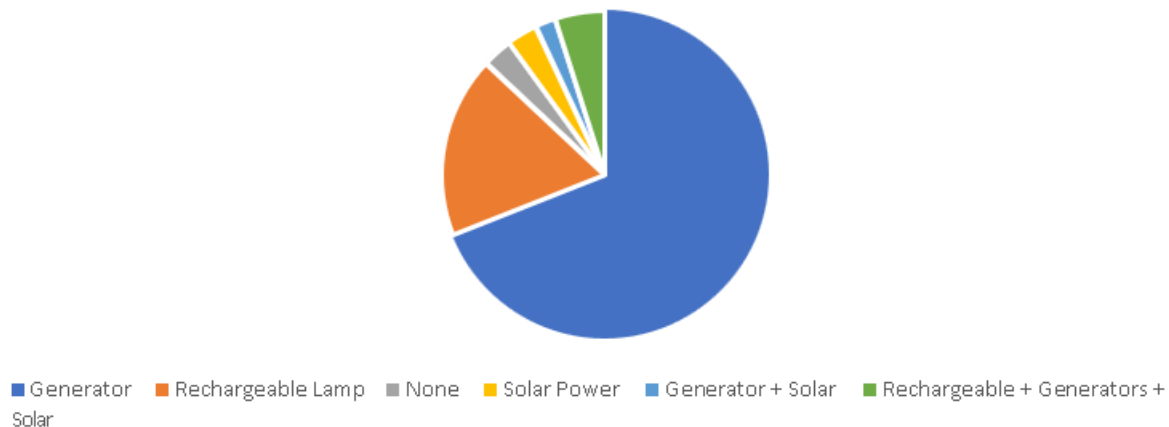


Based on the data collected, 50% of households in Warri receive power from BEDC for 4hrs/day, 27% for 8hrs/day, 20% for 12hrs/day, 2% for 18hrs/day, and 1% for 24hrs/day.



On average, 69% of people use a personal generator in place of a Grid power supply, 18% use rechargeable lamps in the event of a power outage, 3% said they have no light source during the power outage, 3% use solar panels to generate power, 2% use both solar panels, rechargeable lamps, and generators, and 5% use both rechargeable lamps and generators when the disco-BEDC (Grid) power outage.

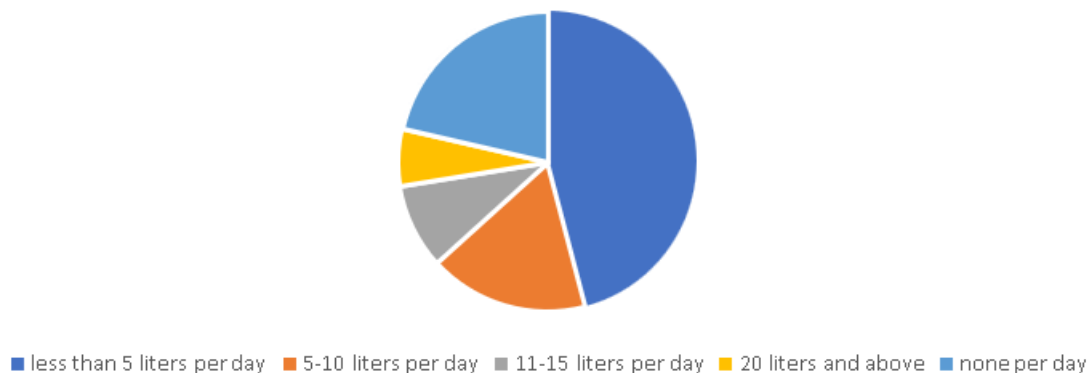
Alternative to Disco (BEDC) Power Supply



Fuel Usage Per day per household:

45% indicated 5-10 liters of gasoline per day 17% indicated 11-15 liters per day 9% indicated less than 5 liters per day 6% indicated 20 liters and above per day 21% indicated none, from verbal interview, some people in this category stopped using their personal generators because they lacked sufficient funds to maintain and refill their fuel tanks.

Fuel usage for personal power generation



3.6.2.1 CO₂ emission from Generator Usage per year:

Recall that 1 gallon of gasoline = 3.7 liters of gasoline = 8,887 g of CO₂ 1 Liter = 8,887 / 3.7 = 2,401 g of CO₂

Based on the questionnaire responses, 45% of households reported generator fuel consumption of 5–10 litres per day, 17% reported 11–15 litres per day, 9% reported less than 5 litres per day, while 6% reported consumption of 20 litres or more per day. The remaining 21% of households reported that they did not use a generator.

For the purpose of estimating household generator-related CO₂ emissions, a representative average fuel consumption of approximately 7 litres per household per day was adopted. This value was derived as an approximate whole-sample household estimate from the reported consumption ranges, with the non-generator households treated as having zero generator fuel consumption. Because the questionnaire recorded fuel consumption in ranges rather than as exact daily quantities, the 7 litres/day value should be regarded as an estimated representative value rather than a directly measured mean.

Using this estimated daily consumption, annual gasoline consumption was calculated as:

$$7 \text{ litres/day} \times 365 \text{ days/year} = 2,555 \text{ litres/year.}$$

Using the adopted gasoline emission factor, the corresponding annual CO₂ emissions from generator use were estimated accordingly. $7 \times 2,401 \times 365 = 6,134,555 \text{ g per year} = 6.13 \text{ ton of CO}_2 \text{ emission from Generator Usage per year}$

3.6.2.2 CO₂ from Power Supply (DISCO-BEDC)

According to Gershon et al (2019) who studied CO₂ footprint of families in Port Harcourt, he wrote that “Around 1.216 lbs (0.55 kg) of CO₂ is produced per kilowatt-hour for electricity at its source and 1.307 lbs CO₂e (0.59 kg CO₂) per Kilowatt-hour delivered electricity (at home)”.

An average household in Warri uses

1. Television (32 inch) – 70 watts
2. Iron – 800 watts
3. Fan – 100 watts
4. Fridge – 800 watts
5. Microwave – 800 watts
6. Water heater – 3,000 watts
7. Washing machine – 2,200 watts
8. Bulbs – 200 watts
9. Air condition – 1,500 watts

The combined rated power is 9,470 W. The total rated power of the appliances identified for the average household is 9,470 W. Since the appliances are not expected to operate simultaneously at their full rated capacities, an assumed aggregate utilization factor of 50% was applied to the total connected load to obtain an indicative average household electricity demand. Thus, the estimated household demand was calculated as:

$$9,470 \text{ W} \times 50\% = 4,735 \text{ W} = 4.735 \text{ kW.}$$

The 50% factor represents an assumed average utilization of the connected household load and should not be interpreted as a household ownership percentage. The estimate is intended to represent typical household electricity demand rather than instantaneous peak demand. Considering the percentage not using microwave, washing machine, air condition and water heater.

At an average electricity availability of 4 hours per day, annual electricity consumption is estimated as

$$4.735 \text{ kWh} \times 4 \text{ hrs} \times 365 \text{ days} = 6,913.1 \text{ kWh per year}$$

Using an emission factor of 0.59 kg CO₂/kWh, the corresponding annual electricity-related emissions are approximately 4.079 tCO₂

$$6.913 \times 0.59 = 4.08 \text{ ton CO}_2 \text{ per household from electricity use}$$

3.6.3 COOKING

All households indicated the use of cooking gas (LPG) in their homes. LPG is a relatively cleaner-burning fossil fuel compared with some conventional solid and liquid fuels and contains little or no emission (EIA, 2021).

Based on the survey responses, the average household was estimated to use approximately one LPG cylinder every three months. Since the survey did not record the specific cylinder size used by each household, a 12.5 kg LPG cylinder was assumed for the purpose of estimating annual LPG consumption. Therefore, the estimated annual LPG consumption per household was:

$$12.5 \text{ kg} \times 4 \text{ cylinders/year} = 50 \text{ kg LPG/year.}$$

Using an emission factor of approximately 3.0 kg CO₂ per kg of LPG consumed, the estimated annual CO₂ emissions from LPG use were:

$$50 \text{ kg LPG/year} \times 3.0 \text{ kg CO}_2/\text{kg LPG} = 150 \text{ kg CO}_2/\text{year} = 0.150 \text{ tCO}_2 \text{ emission from LPG usage per year.}$$

The LPG contribution was included in the household carbon-footprint estimate to account for emissions associated with cooking fuel consumption. The estimated LPG emissions should be interpreted as an approximation because the survey did not record the actual LPG cylinder size used by each household.

Therefore, the estimated average household carbon emissions from the identified sources were:

$$\text{Household CO}_2 \text{ footprint} = \text{Transportation} + \text{Generator use} + \text{Grid electricity} + \text{LPG cooking}$$

$$1.15 + 6.13 + 4.08 + 0.15 = 11.52 \text{ tCO}_2/\text{year.}$$

4. CONCLUSION AND RECOMMENDATIONS

This study assessed the carbon footprint of households in the Niger Delta, with particular attention to household electricity consumption, transportation, and other identified sources of CO₂ emissions. The findings demonstrate that household energy use and transportation activities contribute substantially to household carbon emissions and that opportunities exist to reduce these emissions through improved energy efficiency, cleaner energy sources, sustainable transportation practices, and greater public awareness.

Previous Studies by Jenny & Sara (2016), has identified a positive association between economic activity, measured by GDP, and CO₂ emissions in many countries and regions. However, a positive correlation does not imply that an increase in CO₂ emissions inevitably causes GDP to increase. The relationship between economic growth and emissions is influenced by factors such as energy intensity, technology, energy sources, economic structure, and environmental policies. Evidence also shows that some countries have achieved economic growth while reducing or slowing the growth of their emissions, demonstrating the possibility of decoupling economic development from carbon emissions.

Therefore, reducing household and national carbon emissions does not necessarily require abandoning economic development. Rather, policies and practices that improve energy efficiency, promote cleaner energy technologies, improve transportation systems, and encourage responsible consumption can contribute to both environmental sustainability and economic development. These actions consist of:

4.1 GROW A TREE CAMPAIGN

By absorbing CO₂, plants and trees help clean the air and offset some carbon emissions. According to reports, a fully mature tree can absorb 48 pounds of CO₂ annually (American Forest, 2021), which lowers the expense of heating and cooling a home by offering insulation and shade. Every home should think about planting at least two trees per 540 square meters and educate others to do the same. Additionally, I would suggest organising a "Go-Green campaign" for each estate or neighbourhood. This can be made feasible in large part by laws and actions of the government.

4.2 REPLACE GASOLINE VEHICLES AND DIESEL TRUCKS WITH COMPRESSED NATURAL GAS VEHICLES/TRUCKS

According to Consumer report (2021) the use of CNG can reduce carbon-monoxide emissions to the range of 90 to 95% and Nitrogen-oxide emissions by 35 to 60% compared to gasoline and also pegs fuel savings at about 30% less than gasoline on average although it suggests nearly 40% recently.

A report from Reuter (2021) during an interview with the Petroleum Products Pricing Agency "There is no price increase. The current (gasoline) price is being maintained while consultations are being concluded," On Thursday, the regulator posted an online notice listing the "guiding price" for "ex-depot", or wholesale, gasoline at 206.42 naira per liter - well above the previous pump prices of around 167 naira.

Nigeria's government can convert the subsidy funds for gasoline to subsidizing a one-time purchase of CNG-powered vehicles which will in turn save money for the citizens, diversify fossil consumption, decrease emission and save money from gasoline subsidies for the country.

In other words, the same principle can be applied to electric vehicles, but the issue would be the power supply.

4.3 ENERGY USE

A lot of households from data collected and oral interviews do not use high energy-efficient household equipment and devices that consume a lot of power and emit CO₂. E.g a household that uses a refrigerator 800w might decide to buy a 50w refrigerator of the same capacity and volume to replace the 800w refrigerator. The W.H.O. (2008) Suggest that Placing a refrigerator of a Fridge next to a cooker or boiler consumes much more energy than if they were standing alone. Households are also encouraged to use CFL or LED light in place of incandescent bulbs and also switch off lights when they don't need them. Another recommendation for the WHO (2008) is switching off five lights along the hallway could save costs and avoid about 400kg of CO₂ emission per year.

4.4 ELECTRICITY GENERATION THROUGH SOLID WASTE

Waste disposal contributes to high CO₂ emissions to the environment, Power Supply which is a major challenge in Warri and Nigeria can be mitigated through the Waste-To-Energy Technology. According to AKHATOR, et al (2016) "with about 14 million tonnes of combustible waste available in Nigeria, about 4.4TWh of electricity could be generated annually if WTE development in the country receives similar support from the Nigerian government". This will help keep the environment clean at the same time provide electricity at same time saving the environment from CO₂ emission.

4.5 WASTE MANAGEMENT

The principle of Reuse, Reduce and Recycle should be applied as often as possible. This should include: i. Reduce the use of bottled water and as much as possible use reusable water cans for daily operations. ii. Reuse shopping bags and as much as possible use product that offer refill services.

4.6 TRANSPORT

CO₂ emission will reduce when households are driverless, explore alternative transport options like bicycles for shorter distances, and use a single car for daily activities throughout the week. According to data collected, some families use 2 to 3 cars simultaneously every day of the week, which increases carbon emissions per year per household. The Government can also encourage, develop the public transport system, and make it safer, more convenient, and affordable for all to use. The WHO (2008) also suggests that Speeding uses more petrol and emits more CO₂, therefore households should be encouraged and enlightened on how speeding emits CO₂. Driving at higher speeds generally reduces vehicle fuel economy because of increased aerodynamic resistance. According to the U.S. Department of Energy, fuel economy typically decreases rapidly at speeds above approximately 50 mph (80 km/h), while a study of 74 light-duty vehicles found that fuel economy was about 27% lower at 80 mph than at 60 mph. The Department of Energy also notes that optimum fuel economy is typically achieved at the lowest speed at which a vehicle can operate smoothly in its highest gear. Therefore, households should be encouraged to adopt moderate and consistent driving speeds and use the highest appropriate gear for the prevailing road and traffic conditions.

In Summary, actions based on CO₂ emission reduction are also beneficial to health; CO₂ emitted by industries in residential areas can be reduced using Carbon taxes. Yue, et al, (2020) affirms that CO₂ emission will be significantly reduced reaching the peak value during 2030-2040 in china's power industry, with the use of medium Tax level (TAX-2) which they employed in their research. This can meet the requirements of both CO₂ emission reduction effect and cost in the power industry, which will on the long run impact on their economy, because of this effective economic policy tool.

The subject of CO₂ emission reduction is everyone's responsibility, good for the environment, excellent for the economy, and good for the family budget.

REFERENCES

- [1] WHO. (2008). REDUCING YOUR CARBON FOOTPRINT CAN BE GOOD FOR YOUR HEALTH. London:
- [2] European Commission.
- [3] Adeyemi A. Ogundipe*, C. O. (2019). CO₂ Emissions and Environmental Implications in Nigeria.
- [4] International Journal of Energy Economics and Policy, 2020, 10(3), 317-324, 317.
- [5] AKHATOR, E., OBANOR, A., & EZEMONYE, L. (Sept, 2016). Electricity Generation in Nigeria from Municipal Solid Waste using the Swedish Waste-to-Energy Model . J. Appl. Sci. Environ. Manage, Vol. 20 (3) 635 - 643.
- [6] Alimi, T. O.-H. (2016). Predicting potential ranges of primary malaria vectors in South America based on projected changes in climate, land cover and human populations . Parasite Vectors , 431.
- [7] American Forest . (2021, June 07). American Forest . Retrieved from American Forest 1875: <https://www.americanforests.org/about-us/mission/>
- [8] Azubuike, S. I., Gershon, O., & Asekomeh, A. (2022). Introduction: Decarbonising African Cities in a Carbon-Constrained World. Spring Link, 1-11. doi:https://doi.org/10.1007/978-3-031-14006-8_1
- [9] Balogh, J. M., & Jámor, A. (2017). Determinants of CO₂ Emission: A Global Evidence. International Journal of Energy Economics and Policy, 7(5), 217-226.
- [10] Center for Sustainable Systems . (2020). Carbon Footprint Factsheet . Michigan : University of Michigan, Pub. No. CSS09-05.
- [11] Consumer Report . (2021, June 06). Consumer Report Inc. Retrieved from Consumer Report : <https://www.consumerreports.org/cro/2012/03/the-natural-gas-alternative/index.htm>
- [12] Dunne, D. (2020, August 21). Carbon Brief Limited . Retrieved from Carbonbrief .org : <https://www.carbonbrief.org/contact-us>
- [13] EIA. (2021, June 04). Independent Statistics and Analysis. Retrieved from U.S Energy Information Administration: <https://www.eia.gov/tools/faqs/faq.php?id=74&t=11>
- [14] EPA. (2021, May 14). United State Environmental Protection Agency . Retrieved from United State Government : <https://www.epa.gov/transportation-air-pollution-and-climate-change/carbon-pollution-transportation>
- [15] EPA. (2021, May 29). United States Environmental Protection Agency. Retrieved from United State Government : <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>



- [16] Ezenwa, N., Nwatu, V., & Gershon, O. (2020). Renewable Energy Consumption Shocks on CO₂ Emissions and Economic Growth of Nigeria. IOP conference Series. 665, pp. 23-25. IOP Publishing Ltd. doi:10.1088/1755-1315/665/1/012013
- [17] Fubara, S. A., Iledare, O. O., Gershon, O., & Ejemeyovwi, J. (2019). Natural Resource Extraction and Economic Performance of the Niger Delta Region in Nigeria. IJEEP, 188-193. doi:<https://doi.org/10.32479/ijeeep.7716>
- [18] Gershon, O., & Patricia, O. (2019). Carbon (CO₂) Footprint Determination: An Empirical Study of Families in Port Harcourt. 3rd International Conference on Science and Sustainable Development (ICSSD 2019) (pp. doi:10.1088/1742-6596/1299/1/012019). Journal of Physics: IOP Publishing.
- [19] Gershon, O., & Asaolu, K. (2020). Evaporative quality of Nigeria's gasoline truck loading perspective.
- [20] Springer (ISSN 2363-7692).
- [21] Gershon, O., & Mbajekwe, C. (2020). Investigating the Nexus of Climate Change and Agricultural Production in Nigeria. IJEEP(2146-4553), 1-8. doi:<https://doi.org/10.32479/ijeeep.9843>
- [22] Gershon, O., Azubuike, S. I., & Asekomeh, A. (2022). Conclusion: Towards a Decarbonisation Framework for African Cities. Springer Link, 175-185.
- [23] Gershon, O., Ezenwa, N. E., & Osabohieh, R. (2019). Implications of oil price shocks on net oil- importing African countries. Elsevier. doi:<https://doi.org/10.1016/j.heliyon.2019.e02208>
- [24] Get.Invest . (2021, May 14). Get.Invest Mobilising energy renewable investment . Retrieved from Get-Invest.eu: <https://www.get-invest.eu>
- [25] IPCC. (2014). Climate Change 2014, Mitigation of Climate Change. New York : Cambridge University Press .
- [26] IPCC. (2007). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. Switzerland : Intergovernmental Panel on Climate Change.
- [27] Jenny, c., & Sara, s. (2016). Is there a relationship between economic growth and carbon dioxide emissions? stockholm: Södertörns University | Institution of Social Sciences.
- [28] Jeremiah Ejemeyovwi, G. O. (2018). Carbon Dioxide Emissions and Crop Production: Finding A Sustainable Balance. International Journal of Energy Economics and Policy, 303-309.
- [29] P, D., G, O., O, M., O, I., & J, E. (2021). Carbon Emission And Population Growth: Evidence From The Magna Cum Laude Oil Producing African Countries. IOP science, 665. doi:10.1088/1755- 1315/665/1/012038
- [30] Pieprzyk, B; Kortluke, N; Hiljie, P R;. (2009). The Impact of Fossil Fuels:Greenhouse gas emission, Environmental Consequences and Socio-economic effect. Energy Research Architecture, Avialable from: <http://www.@ ebb-en.org/EBB press release/ERA>.
- [31] Reuter, T. (2021, March 13). Nigeria says no increase in pump prices after regulator sparks confusion. Lagos , Lagos, Nigeria .
- [32] Rezai, A. F. (2012). Global warming and economic externalities. Econ. Theory, 49, 329-351.
- [33] The Nature Conservancy . (2021, May 07). The Nature Conservancy . Retrieved from nature.org/tnchelpline: <tps://www.nature.org/en-us/about-us/who-we-are/>
- [34] U. S. Environmental Protection Agency. (May 2014). Greenhouse Gas Emissions from a typical passenger vehicle . Michigan : Office of Transportation and Air Quality.
- [35] UN. (2015). Adoption of the Paris Agreement. United Nations Framework Convention on Climate Change Conference of the Parties. Paris: https://unfccc.int/sites/default/files/english_paris_agreement.pdf.
- [36] UNDP. (2010). Human Development Report. New York: United Nation Development Program . Yue, Y., Zhi-xin , J., Ji-zu, L., & Li, J. (2020). Research on the Impact of Carbon Tax on CO₂ Emissions of
- [37] China's Power Industry. Hindawi, Journal of Chemistry, Article ID 3182928, 12 pages.
- [38] Yung, W., Muthu, S. S., & Subramanian, K. (2018). Carbon Footprint Analysis of Personal Electronic Product— Induction Cooker. Science Direct, 113-114.