Carbon (CO$_2$) Footprint Determination: An Empirical Study of Families in Port Harcourt

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Abstract: Dark soot has become a normal phenomenon in the main oil-producing city in Nigeria’s Niger Delta region called Port Harcourt – as also reported in some Chinese cities in the recent past. While many acknowledge that the emissions are hazardous to health and environment, a universal determination and analysis method for the extent of the effect of soot is yet to be agreed. Against this background, this paper determines and analyzes the carbon footprint of an average family in Port Harcourt based on energy consumption and other sources of greenhouse gases. Using the input-output approach and questionnaire, primary data were collected on driving habits, energy generation, number of persons in the household, type of cooking device, travel mode and patterns, as well as fuel usage. The sampling instrument was administered to a random selection of 261 households within Port Harcourt that were identified and enrolled (through respective engagements) for the data gathering exercise. The sample population included family sizes that ranged from 1 to 12, in addition to a wide demographic mix. Data obtained from 61% of those contacted was used to determine associated CO$_2$ emissions resulting from the family’s activities. From cooking, electricity consumption, driving and air-travel, it was evidenced, based on the estimates, that the average family in Port Harcourt emits about 5.21tons of CO$_2$e. Furthermore, it is revealed that by each person/family making minor changes to their daily routines, the cumulative effect of individual small savings will make significant impact in reducing greenhouse gas emissions and thereby climate change. Simple steps and policy actions are recommended for families to reduce their footprint.

1.0 INTRODUCTION

One of the most significant environmental challenges facing the world today is the global impact of climate change. This phenomenon often refers to major changes in temperature, rainfall, snow, or wind patterns, usually lasting for decades or even longer. Climate change can be caused by both human and natural factors. Human activities that increase the amount of greenhouse gasses in the atmosphere include burning of fossil fuels, deforestation, farmland development, and cities/roads construction. Natural causes include changes in the earth’s orbit, the sun’s intensity, the circulation of the ocean, and other atmospheric and volcanic activities among others. On the average, about 30bn tonnes of CO$_2$ emissions are released annually from human activities [1] accounting for 58.8% of greenhouse gases (GHGs) according to the World Bank [2] and confirmed by the Intergovernmental Panel on Climate Change (IPCC) in their Report [24].

Greenhouse gases, especially CO$_2$ are emitted in the combustion of hydrocarbon fuels and in other human activities, thereby resulting in greenhouse effect. As GHGs mix naturally in the atmosphere, radiations of short waves from the sun are allowed to permeate and absorb energy from the surface of the earth. [3] Actually, some GHGs are essential for life on earth because they trap atmospheric heat to ensure the planet is warm and in equilibrium. However, this natural process and the earth’s thermal equilibrium are disrupted as more GHGs are added to the atmosphere through a combination of natural and anthropogenic activities.
Consequently, a measure of human activities and their effects on the earth’s ecosystems resulting in climate change is generally referred to as carbon footprint. Carbon footprint applies to personal, group and/or sectoral activities in an economy [5],[6] & [7]. A person’s footprint is the sum CO$_2$ emitted in the production of meals, clothes, housing and transport activities consumed or engaged in by the person per time (daily, weekly, monthly or annually).

Against the above background, this paper aims to determine the full and representative carbon footprint of an average nuclear family in Port Harcourt, Rivers State in the Niger Delta region. This is an important issue given the current prevalence of dark soot in Port Harcourt. Furthermore, as climate change has gained corporate and political significance (and prominence) globally, it has become useful to compute and apply carbon footprint in policy making. In addition, they have become statutory requirements for corporate reporting in many developed countries. Given the benefits as will soon be enumerated, such policies could be introduced in Nigeria.

1.1 Case for Carbon Footprint Measurement
The benefits of the determination of carbon footprint are many. While it helps companies, persons and groups of persons to decide how to reduce their respective climate change impacts, other benefits are:

- Public report of greenhouse gas emissions per certain regional requirements
- It helps in setting target for emission reduction.
- Identification of contributory activities to carbon footprint
- Emission trend measurement and analysis, including reduction activities effectiveness monitoring.
- To understand the impacts and dimensions of carbon trading (to guide credits to be purchased in order to offset emissions).

Despite the above benefits, some pertinent questions still demand in-depth answers, especially in the Nigerian context, namely:
1. What are the specific determinants of an average family’s carbon footprint?
2. What aspects of an average family’s lifestyle have the greatest impact on climate change?
3. What can families do to minimize their contribution to climate change?

1.2 Conceptual and Literature Review on Carbon Footprint
The origin of carbon footprint can be traced to ecological footprint. Wiedmann and Minx [4] posit that carbon footprint measures the quantity of CO$_2$ emitted directly and indirectly in the cause of an activity or accumulated across the stages of a product’s life. The foregoing portends that Carbon Footprint conceptually measures how human activities result in climate change and affect the environment. It relates to the quantity of GHGs emitted in the course man’s daily routines like using hydrocarbons for heating, cooling, transportation and electricity generation for lighting.

Carbon Footprint exclusively measures the total quantity of CO$_2$ flows caused directly and indirectly by single/accumulated activities during a products’ life. [5]. It is now commonly recognized as a key index for environmental protection [4], [8], [9] & [10] which can be determined based on Global Warming Potential (GWP) of GHGs [11]. The GWP of a greenhouse gas, within a given time, indicates the capacity and extent to which that GHG contributes directly towards global warming and thereby climate change. Usually, Global Warming Potential of GHGs is commonly computed within a period of 100 years [24] and due to its intrinsic link with Carbon Footprint, related concepts like GWP Footprint[15], CO$_2$ Footprint[12], Climate Footprint[4] [11], Methane Footprint and Greenhouse gas footprint [13] [14] have been conceived.

1.3 Classifications and Methods of Computing Carbon Footprint
Natural impacts of anthropogenic activities, measured by Carbon Footprint, range from changes in the
orbit of the earth, circulation of the ocean, intensity of the sun, volcanic eruptions to other atmospheric and geological activities. As such, there are many approaches to compute carbon footprint. Notwithstanding, the universally accepted unit of measuring Carbon Footprint is “tonnes of CO₂ equivalent” while GHG emissions are measured in kg CO₂ or kg CO₂e [6], [7]. CO₂ equivalence enables the standard measurement/equalization and summation of different GHGs based on their defined GWP in relation to CO₂. In analyzing a project’s carbon footprint, it is necessary to consider all GHGs emitted directly from the activity and on the site, as well as, the indirect emissions away from the site of the project and along the relevant value chain. For instance, the carbon footprint of a piece of paper used will include GHG emissions from related transportation, electricity generation, manufacturing of the product, food and drinks consumed by the staff during the production, as well as, clothing worn by staff in the paper factory [4].

1.4 Assessment Standards of Carbon Footprint
It is notable that some standards exist for assessing and comparing carbon footprint across products and organizations – PAS 2050. Carbon footprint assessment standards, like ISO 14064, are applied in carbon emissions accounting by environment experts, national governments, and International Standard Organization. Furthermore, the application of such robust standards (like GHG Protocol) has resulted in the promotion of GHG emissions reduction among many people, organizations, governments and institutions. British Standards Institution (BSI) and World Business Council for Sustainable Development (WBCSD) have also implemented unique assessment standards. However, uniformity issues persist regarding the application of standard accounting methods in the measurement of greenhouse gases – especially CO₂. There are uncertainties regarding CO₂ emission factors and the scientific boundaries for defining them. Moreover, the Global Warming Potential of different greenhouse gases can not be the same in different climes. Herein, lies the need to for additional studies to contribute to the body of knowledge.

2.0 LITERATURE REVIEW
2.1 Theoretical Review of Literature
In its report, IPCC attributes global warming to anthropogenic Greenhouse gas (GHG) emissions. An increase of 70% of such emissions from human was recorded between 1970 and 2004. Greenhouse gas emissions from humans have increased by 70% between 1970 and 2004. Of all the greenhouse gases, carbon dioxide has been shown to be the most impactful from anthropogenic activities. Hertwich and Peters [16] adopted multi-regional input-output approach to consider the Carbon Footprint of consumption within global trade framework. The countrywide study reveals that, as a country’s income increases, its patterns of consumption changeand the Carbon Footprint per capita increasesare the most important consumption categories. Furthermore, the outcome of the study indicate that food, accommodation and transportation consumption categories are the most important. Moreover, the supply chain of these consumption categories impacts the country’s Carbon Footprint more indirectly than directly.

From a trade perspective, Druckman and Jackson [17] showed that consuming imported products involves embedded CO2 emissions. This is because of the relocation of carbon-intensive industries from developed to developed and underdeveloped countries. As a result, an increasing quantity of GHGs are emitted outside the consumption/importing countries – with significant effect on the CF of the importing countries. For instance, in the United Kingdom, “over half of the average households’ Carbon Footprint comes from embedded CO2, of which 40% took place outside UK in 2004. This proportion has been on the rise since 1990” [17].Generally, there is a broad consensus that international trade and income levels are important determinants of as country’s Carbon Footprint. In light of the above discourse, as well as, increasing relevance of indirect and embedded emissions, a
paradigm is manifesting with more focus by researchers on the consumption perspective of analyzing emissions rather than production.

Towards adopting effective climate change policies, municipal council have been applying the Carbon Footprint tool. [19] At this level, a similar paradigm has become widely acceptable such that the CF of municipal are accounted based on their consumption patterns and emissions inherent in their municipal services – rather than the production-based approached. A comparison of the Carbon Footprint of a number of Norwegian municipalities, undertaken by Larsen and Hertwich [18], shows that Carbon footprint changes significantly with size and wealth. Furthermore, it was found that 93% of the Carbon Footprint of Norwegian municipal services resulted from indirect emissions from upstream procedures, "underlying the need of introducing consumption-based indicators that take into account upstream Greenhouse Gas emissions" [18].

The measurement, analysis and application of Carbon Footprint at the municipal level are uncommon in the academic literature despite the usefulness. Carbon Footprint studies have been conducted on different scales ranging from the municipal to national levels, as well as, from specific products to a broad range of industries. This study focuses on a nuclear family within a municipal county in a developing country to highlight some peculiarities of emissions accounting.

2.2 Empirical review of Literature
Two approaches for computing carbon footprint – Environmental Input-Out (EIO) method and Process Analysis – have been proposed by Wiedmann and Minx [4]. Process Analysis, as the name indicates, is a method that accounts for emissions from the beginning of a value chain and proceeds upward. In this process the focus is on measuring a product’s direct impact from its creation to the point of consumption/destruction. However, it could also account for some secondary impacts of a product but it is essential to clearly define the scope of the analysis within which the measurement can be taken to avoid double counting. Although this method of analyzing carbon footprint is compatible and easily conducted with products, scaling it up to cover governments, industries or households is usually problematic.

Environmental Input-Output analysis is undertaken at the sectorial level, using data on environmental and economic activities within the entire economic system of a country. Once an EIOs set, it requires few resources to measure carbon footprint, however, it is ineffective at micro levels. Given the characteristics of PA and EIO approaches, a hybrid of both methods has been proposed by Wiedmann and Minx [4] to ensure that indirect and micro effects of GHG emissions can be captured.

3.0 METHODOLOGY
The determination of the full carbon footprint of any given household involves a detailed understanding of the various components of energy consumption and emission within the identified period of interest. Daily activities of households, such as driving, electricity usage, and waste generation/management, contribute immensely to GHG emissions, which in turn make up the “carbon” footprint of the household. This footprint can be determined if there is a good understanding of the “CO₂ equivalence” of the various GHG components emitted from the various household activities.

CO₂ equivalence (CO₂e) Carbon footprint is usually made up of different greenhouse gases. However, in order to express these values as a single value for comparative and other analyses, the CO₂e is used as an aggregate of these values. It can therefore be seen as “the quantity of CO₂ which would have the equivalent global warming impact as the mixture of the greenhouse gases in question” [20].
The Intergovernmental Panel on Climate Change (IPCC) [23], under the auspices of the Kyoto Protocol, provides a guide to determining the comparative weight of the impacts of these gases in Table 1 as shown below:

Table 1: Global Warming Potentials for Selected Greenhouse Gases [20]

| S/No | Greenhouse Gas                          | Global Warming Potential |
|------|----------------------------------------|--------------------------|
| 1    | Carbon Dioxide (CO₂)                   | 1                        |
| 2    | Methane (CH₄)                          | 25                       |
| 3    | Nitrous Oxide (N₂O)                    | 298                      |
| 4    | Hydroflourocarbons (HFCs)              | 124-14,800               |
| 5    | Perflourocarbons (PFCs)                | 7,500-12,200             |
| 6    | SulphurHexafluorides (SF₆)             | 22,800                   |

In order to adequately quantify the contributions of GHGs by families to global warming, an assessment of both direct and indirect emissions will be required.

3.1 Measurement Procedure and Methods

A determination of the carbon footprint of households can be approached methodically, taking into consideration both the direct and indirect components of the emissions. The direct emissions can be grouped under the following categories:

a) Emissions due to activities within the household (e.g. electricity and power generation/consumption, cooking)

b) Emissions due to travels (road, sea, and air travels by the family members as a measurement of miles travelled per period)

c) Emissions from wastes (generated directly by the family)

The indirect components, as earlier discussed, comprise contributions of third parties directly attributable to the services rendered to the particular household (e.g. goods delivery vehicle, emissions at the site of the GENCOs due to electricity generation). The ultimate method of choice for the determination of the carbon footprint for a given household depends on the reason of inquiry and data availability[4].

Process Analysis is an alternative and more advantageous method for studying the carbon footprint of small systems – like a specific process or product. However, given the simple nature of the analysis required for households, the input-output method is adopted in order to save time and man-hour resources, while not compromising on the quality of results.

3.1.1 Research Process

For the purpose of this research, the input-output methodology has been adopted. Data for households within the area of focus has been collated from three major sources, namely:

- Comprehensive Online/Hard Copy Questionnaires (Questionnaire in Appendix)
- Oral Interviews (random selection of Households)
- Additional Online Research (for complementary data sources from various relevant databases)

A random selection of 261 households within Port Harcourt were identified and enrolled (through respective engagements) for the data gathering exercise. The sample population included family sizes that ranged from 1 to 12 (including both parents), in addition to a wide demographic mix. With a full understanding of the requirements for the data to be collected, a total of 159 households (61% of identified families) returned completed questionnaires. The data for this analysis
shall therefore be based on feedback received from these 159 families, which shall be assumed to be a true representative sample population for Port Harcourt.

3.1.2 Applicable Equations
For the purpose of this research, emissions are viewed from three perspectives, namely: Household Energy, Transportation, and Waste. Information and factors determined with the questionnaire are: average driving rate, car’s mileage-per-gallon, home’s average temperature, energy sources, and waste can all have considerable impact on footprint.

GHG emissions ($GHG_{em}$) for each section are calculated based on the equations below

**Household Energy**
Emissions from electricity consumptions:

- Mains

$$GHG_{em} = \frac{12 \text{ months} \times \frac{\text{cost}}{\text{mont \ h}} \times \text{EmissionFactor}}{\text{Number of household occupants}}$$

$$= \frac{12 \times \frac{\$}{\text{mont \ h}} \times \frac{\text{kwhtons co}_2 \text{e}}{\text{kw h}}}{\text{Number of household occupants}}$$

- Household generators

$$GHG_{em} = \frac{12 \text{ months} \times \frac{\text{litres}}{\text{mont \ h}} \times \text{EnergyDensity} \times \text{EmissionFactor}}{\text{Number of household occupants}}$$

$$= \frac{12 \left( \frac{L}{\text{mont \ h}} \times \frac{MJ}{L} \times \frac{\text{tons co}_2 \text{e}}{MJ} \right)}{\text{Number of household occupants}}$$

**Emissions from other household fuels:**

- Using average mass of fuel consumed per month

$$GHG_{em} = \frac{12 \text{ months} \times \frac{\text{Number of kilograms}}{\text{mont \ h}} \times \text{EmissionFactor}}{\text{Number of household occupants}}$$

$$= \frac{12 \times \frac{\text{kg}}{\text{mont \ h}} \times \frac{\text{tons co}_2 \text{e}}{\text{kg}}}{\text{Number of household occupants}}$$

- Using average cost of fuel per month and mass of fuel

$$GHG_{em} = \frac{12 \text{ months} \times \left( \frac{\text{cost per mont h}}{\text{cost per kilogram}} \right) \times \text{EnergyDensity} \times \text{EmissionFactor}}{\text{Number of household occupants}}$$

$$= \frac{12 \left( \frac{\$}{\text{mont \ h}} \times \frac{\text{kg}}{\$} \times \frac{\text{MJ}}{\text{kg}} \times \frac{\text{tons co}_2 \text{e}}{\text{MJ}} \right)}{\text{Number of household occupants}}$$

- Using average cost of fuel per month and volume of fuel
Personal Carbon Footprint Calculator For Developing Countries

\[
\text{GHG}_{em} = \frac{12 \text{ months} \times \left( \frac{\text{cost per mont} \ h}{\text{cost per Litre}} \right) \times \text{EnergyDensity} \times \text{EmissionFactor}}{\text{Number of household occupants}}
\]

\[
= \frac{12 \left( \frac{s}{\text{mont} \ h} \right) \times \frac{L}{h} \times \frac{\text{tons co}_2 e}{\text{MJ}}}{\text{Number of household occupants}}
\]

- Transport

Using the average volume (liters) of fuel consumed in a month for a private vehicle:

\[
\text{GHG}_{em} = \frac{12 \text{ months} \times \left( \frac{\text{Litres}}{\text{mont} \ h} \right) \times \text{EnergyDensity} \times \text{EmissionFactor}}{\text{Average vehicle occupancy}}
\]

\[
= \frac{12 \left( \frac{s}{\text{mont} \ h} \right) \times \frac{L}{h} \times \frac{\text{tons co}_2 e}{\text{MJ}}}{\text{average occupancy of vehicle}}
\]

or

\[
\text{GHG}_{em} = \frac{12 \text{ months} \times \left( \frac{\text{Litres}}{\text{mont} \ h} \right) \times \text{EmissionFactor}}{\text{Average occupancy of vehicle}}
\]

Using the average cost of fuel per month for a private vehicle:

\[
\text{GHG}_{em} = \frac{12 \text{ months} \times \left( \frac{\text{cost per mont} \ h}{\text{cost per Litre}} \right) \times \text{EnergyDensity} \times \text{EmissionFactor}}{\text{Average occupancy of vehicle}}
\]

\[
= \frac{12 \left( \frac{s}{\text{mont} \ h} \right) \times \frac{L}{h} \times \frac{\text{tons co}_2 e}{\text{MJ}}}{\text{average occupancy of vehicle}}
\]

or

\[
\text{GHG}_{em} = \frac{12 \text{ months} \times \left( \frac{\text{cost per mont} \ h}{\text{cost per Litre}} \right) \times \text{EmissionFactor}}{\text{Average occupancy of vehicle}}
\]

Using average distance travelled for public transport:

\[
\text{GHG}_{em} = \frac{12 \text{ months} \times \frac{\text{Distance}}{\text{mont} \ h} \times \text{EmissionFactor}}{\text{Average occupancy}}
\]
Using number of flight per year:

\[ GH_{em} = 2 \times \text{Number of trips per year} \times \frac{\text{distance travelled}}{\text{trip}} \times \frac{\text{tons CO}_2\text{e}}{\text{passenger}} \]

\[ = 2 \times \text{No. of trips/year} \times \frac{\text{km}}{\text{year}} \times \frac{\text{tons CO}_2\text{e}}{\text{passenger}} \times \frac{\text{km}}{\text{person}} \]

- Waste

\[ GH_{em} = \frac{\text{No. of bins/week}}{\text{Average mass of waste from one bin/year}} \times \frac{\text{EmissionFactor}}{\text{Number of household occupants}} \]

Or

\[ GH_{em} = 30 \times 12 \times \frac{\text{tons CO}_2\text{e}}{\text{person} \times \text{day}} \]

3.2 Analysis – Carbon Footprint Calculation/Analysis

It has been reported that the average American emits about 18 tons of CO\(_2\) per year. This translates to about 108 tons of CO\(_2\) per year for an average family of 6. This number is a whooping 50 tons of CO\(_2\) per year per person in Qatar (about 300 tons of CO\(_2\) per year assuming a family size of 6). The average person on the planet uses about 4 tons of CO\(_2\) per year. The question is: How much CO\(_2\)e does an average family in Port Harcourt emit per year?

Using the aforementioned tools and primary data gathered the determination of the carbon footprint of an average family in Port Harcourt is computed as follows:

A) Driving

- Burning a gallon of petrol fuel produces roughly 19.64 pounds of CO\(_2\).
- The average combined fuel economy of cars and light trucks in Nigeria is 23 miles per gallon.
- The average vehicle miles traveled per year is 5,000 miles (about 8,000km):
  \[ \frac{5000}{23} = 217 \]
- Therefore, average number of gallons of fuel used per vehicle per year = 217.

Now, 217*19.64 = 4,262 pounds CO\(_2\) per year
  \[ = 1,933 \text{ kg CO}_2 \text{ per year} \]
  \[ = 1.9 \text{ tons CO}_2 \text{ per average car per year} \]

B) Home – Electricity

- Around 1.216 lbs (0.55 kg) of CO\(_2\) is produced per kilowatt-hour for electricity at its source
(power plant; EPA 2012) and 1.307 lbs CO$_2$e (0.59 kg CO2) per kilowatt-hour for delivered electricity (at home)

- The average Port Harcourt household uses 3,643 kWh per year (with an average electricity availability of 57%)

i.e. 3.643*0.59 = 2.043 kg CO$_2$e
= Around 2 tons CO$_2$ per household per year from electricity use

Assumption:
The average Port Harcourt City household has 6 people
which means, on average, 0.34 tons CO$_2$ per person per year from electricity use

C) Home - Cooking Gas
- The average home in Port Harcourt (of 6 people) burns 12.5 kg of cooking gas in 0.73 months.
- This translates to 205.5 kg of cooking gas per year.
- This is equivalent to 0.21 tons of CO$_2$e.

D) Air Travel
- A quick rule-of-thumb is that 0.1 kg CO2 is added for each passenger per kilometer travelled by air.
- Port Harcourt is about 450 km from Lagos;
- An average family takes at least two return flights to Lagos, Abuja, or a similar destination annually
- Therefore, each passenger will easily add 180 kg from air travel, giving 1,080 kg (1.1 tons of CO$_2$) for an average family of 6.

Therefore, as can be derived from the above estimates, the average family in Port Harcourt emits about 1.9 + 2 + 0.21 + 1.1 = 5.21 tons of CO$_2$e from the above few sources alone.

3.3 Calculating Household’s Carbon Footprint: Condensed Version
Table 2 provides a simple method to quickly determine a family’s carbon footprint by populating the table with inputs from various aspects of CO$_2$e generation.
You will need to specify these components, namely: annual use of electricity, annual use of natural gas (or other fuel) for heating, annual gallons of gasoline for driving, annual miles of flying, and annual output of solid waste (exclusive of what you recycle). Once these parameters are ready, enter them in Part A and follow the instructions.

Table 2: Total Carbon Footprint (in pounds of CO$_2$ per year)

| S/No | CO2 Footprint Source                  | Energy Units | Emission Factor* | Outputs of CO2 (pounds) |
|------|--------------------------------------|--------------|-----------------|------------------------|
| 1    | Electricity: Annual KWhs             | -            | 1.64            | -                      |
| 2    | Heating: Annual CCFs* of Natural Gas | -            | 12.06           | -                      |
| 3    | Driving: Annual litres of fuel used  | -            | 19.36           | -                      |
| 4    | Flying: Annual miles of flying       | -            | 1.30            | -                      |
| 5    | Solid Wastes: Annual tons of garbage discarded | - | 2.00 | - |

*CCF = 1,000 cubic feet
# Factors adopted from [www.carboncounter.org](http://www.carboncounter.org)
The concept of carbon offset is related to carbon footprint as a process whereby a person can make a payment or engage in activities that somewhat results in the reduction of CO$_2$. However, Murray and Dey [22] have argued that offsets is not a new concept.

4.0 CONCLUSION AND RECOMMENDATIONS

With a better appreciation of the impact carbon footprints can easily have on our environment, there is a dire need to take drastic measures to reduce the footprint as much as reasonably practicable. At first, this may sound like a herculean task. However, as section 4.2 reveals, a radical change in lifestyle is not needed to reduce a family’s carbon footprint. It simply involves easy and affordable new ways of living, which almost anyone can immediately implement in order to contribute to helping the environment towards becoming greener.

4.1 Recommendations – Reducing Carbon Footprint

The following simple steps are recommendations that can immediately turn things around, both for individual families and the environment. The family will gain not only by reducing overall operational costs, but also experience better health, among other things.

A. Reduce Trash Output

Landfills and other waste-dump sites emit large volumes of greenhouse gases that pollute the environment. A cursory observation of the various sites within Port Harcourt easily indicates that recycling wastes that are indecomposable will result in over 50% reduction in landfill garbage. According to Environmental Protection Agency (EPA), a family of sixpersons could achieve a 1,312.5kg reduction in its annual carbon footprint by recycling plastics, glass, and newspapers that are currently disposed of and sent to the refuse dumping sites [27].

B. Go Paperless

Although paper can be recycled, the planet will be a lot better if less paper is used. Instead of getting piles of paper mails you would never look at, choosing paperless bank and credit card statements, bills and newsletters should be preferred. The habitual use personal emails and digital devices – like tablets and smartphones – for jotting notes and sharing ideas is also recommended.

C. Reduce use of Plastic Materials

Manufacturing plastics from petroleum resources is a big drain on the finite scarce resources. This contributes significantly to increased pollution of the environment. It is recommended that households opt for greener reusable materials by reducing the amount of wasteful plastics. For instance, instead of plastic bags for grocery, cloth totes could be used. This way; overall, we can reduce the amount of plastics that need to be manufactured, in addition to the amount that could potentially end up at the dumping sites.

D. Afforestation

Tree planting is one of the ways greenhouse gases emission can be reduced. Trees and plants

The air is purified as plants and trees absorb CO$_2$ from the atmosphere. It is noted that an adult tree can absorb as much as 22 kg of CO$_2$ per year, and can reduce household cooling and heating costs by providing shade and insulation [27]. Planting tress, shrubs or a garden grown with different food crops, will reduce overall CO$_2$ footprint.

E. Use CFL or LED Light.

According to research, “spiral-shaped, energy-saving Compact Fluorescent Light bulbs cuts energy usage significantly compared to incandescent bulbs”[27]. Households are encouraged to use LED lamps to replace incandescent bulbs when the burn out. “Replacing even three 60-watt incandescent
light bulbs with 13-watt CFLs can save you some money per year and reduce carbon footprint by 83 kg (EPA)”[27].

F. Choose Energy-efficient Appliance
Household appliances like refrigerators, water heaters, computers, and dishwashers contribute immensely to the energy consumption and expenditure, as well as, carbon emissions and footprint of a household. Therefore, little eco-friendly decisions - such as using more efficient energy appliances to replace old ones is recommended.

G. Park the Car and Drive Less
Families can reduce their carbon footprint by simply driving less. The average person in Port Harcourt puts nearly 350km on their car each week. In order to minimize the carbon footprint due to driving, households are encouraged to embrace “carpooling”, biking, or riding public transport in order to impact positively on the environment. When possible and safe, families could walk or use bicycles or car-share with neighbours to reduce per capita auto mileage. Better auto-maintenance culture by families, though more expensive, will enhance combustion in cars and reduce emissions. As long as it is reasonably practicable, households are encouraged to opt for more energy-efficient cars.

In sum, it may be easy to think that the actions of an individual or a family are insignificant. But, the cumulative effect of individual small savings will make significant impact in reducing greenhouse gas emissions and environmental pollution. It therefore goes without saying that there are so many ways, both big and small, that an average family can contribute to a healthier planet by emitting less CO₂ through deliberate actions/inactions. It is now obvious that reducing families’ carbon footprint can be as easy as making a few conscious changes to daily routine and making more eco-friendly choices as a consumer. The world has seen an annual average of 4 tonnes CO₂e emissions per person with large differences across countries and/or regions [23]. However, there have been arguments towards limiting personal carbon footprint to about 2 tonnes of CO₂e emission per annum. The reduction of greenhouse gas emissions is good for the environment and especially for family budget, as well as, beneficial to family health. A unit greenhouse gas that is curtailed impacts the family and environment better than one emitted and abated.

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Appendix A

Sample Questionnaire

1. What kind of house/home does your household currently use?
   - 1 room – 1 Bedroom
   - 2 - 3 Bedroom
   - > 3 Bedroom - Duplex
   - Mansion

2. What is your current family size? (including parents, children, and every other person that lives in the household)
   - 1 to 3
   - 4 to 6
   - 7 to 10
   - 11 and Above

3. How many children under 11 years of age currently live in the household?
   - 1
   - 2
   - 3
   - 4 and Above

4. How many personal cars does your household currently use?
   - 0
   - 1
   - 2
   - 3
   - 4 and Above

5. How many electricity/power generators (including solar energy generator where applicable) does your household currently use?
   - 0
   - 1
   - 2
   - 3
   - 4 and Above

6. How many litres of fuel (petrol or diesel) does your household currently consume per day?
   - Less than 5
   - 5-10
   - 11-15
   - 16-20
   - 20 and Above

7. How many refrigerators does your household currently use?
   - 0
   - 1
   - 2
   - 3
   - 4 and Above

8. How many cookers (gas or electric) does your household currently use?
   - 0
   - 1
   - 2
   - 3
   - 4 and Above

9. How many microwave ovens does your household currently use?
10. How many water (or other) heaters does your household currently use?
   - 0
   - 1
   - 2
   - 3
   - 4 and Above

11. How many washing machines (plates and clothes) does your household currently use?
   - 0
   - 1
   - 2
   - 3
   - 4 and Above

12. How much electricity (estimated average) does your household currently consume per year (from PHCN or other GENCOs/DISCOs)?
   - Less than 50 kWh
   - 50 – 500 kWh
   - 500 – 1,000 kWh
   - 1,000 – 5,000 kWh
   - 5,000 kWh and Above