Journal of Technology Innovations and Energy ISSN: 2957-8809
https://doi.org/10.56556/jtie.v2i1.428

RESEARCH ARTICLE

Ecological Footprint of Energy Consumption In Ijebu Ode, Nigeria

Henry Sawyerr[1], Afolabi Opasola[1], Edet Otto[2]*, Nsikak Akpan[3]

[1]Department of Environmental Health, Kwara State University, Kwara State, Nigeria
*[2]Department of Environmental Health, Ajayi Crowther University, Oyo, Nigeria
[3]Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria

Corresponding Author: Edet Otto, Email: e.otto@acu.edu.ng
Received: 31 December, 2022, Accepted: 18 March, 2023, Published: 20 March, 2023

Abstract

Notwithstanding overwhelming evidence that shows how unsustainable energy consumption contributes to our already rising ecological footprint (EF), the situation is mostly unchanged worldwide, especially in developing countries with poor equipment for efficient energy generation, with a growing threat of global warming due to unsustainable energy consumption and its disastrous environmental effects. Therefore, this study sought to analyze the ecological footprint of energy consumption in Ijebu Ode. A descriptive cross-sectional method was employed, and primary data were sourced from systemically sampled 400 households using structured questionnaires, analyzed descriptively using Microsoft Excel, and inferentially using the ecological footprint mathematical model. Findings revealed the overall EF of energy consumption in Ijebu Ode at 0.07 gha/capita, constituting about 6.7% of the city EF share, with electricity having the major share (0.04 gha; 51.9%), followed by gas with a footprint of 0.02 gha (26%). The lowest of the energy footprints were kerosine, charcoal, and firewood, with 0.003 gha (3.9%), 0.002 gha (2.6%), and 0.001 gha (1.3%), respectively. Thus, we conclude that Ijebu Ode has sustainable energy consumption, and therefore calls for practical policy directives aimed at improving our natural gas distribution potential to facilitate household availability and affordability in light of our reputation as the highest natural gas reserve holder in Africa.

Keywords: Ecological footprint; Energy consumption; Environmental Sustainability; Renewable energy; Sustainable energy

Introduction

Presently, rethinking energy consumption and environmental sustainability remains on the front burner of academic and scientific discourse, particularly with increasing energy utilization and fossil fuel-based energy systems generating huge environmental concerns. Studies have identified unsustainable consumption and the diminishing planet's ecological capital as one of many of the main causes of environmental degradation and climate change (Ahmed & Wang, 2019; Ahmed et al., 2020; Omojolaibi & Nathaniel, 2020). This is most concerning for fossil fuel utilization because of its high carbon emissions and overall impact on environmental degradation, as evident from continued global warming.

It has been documented by the Global Footprint Network (GFN) (2018) that around 80 percent of the world's populace resides in countries with substantial environmental concerns, and almost all emerging countries are experiencing ecological deficits, including Nigeria, with an ecological deficit of -0.4 gha (GFN, 2022). The ecological footprint (EF), which estimates the bio-productive surface required to support a population, was first introduced by Rees and Wackernagel in 1992 (Wakernagel & Rees, 1996). The ecological resources that a defined population needs to generate the resources it uses and absorb the waste generated, particularly carbon emissions, are regarded as the EF demand (Bello et al., 2018; Kassouri & Altntaş, 2020; Long et al., 2020). It is an accounting tool for regulating and determining the natural resources used in a community (GFN, 2018) and has roots in the sustainability principle, which asserts that our consumption of renewable assets should not exceed their potential to reproduce (Daly, 1990). Studies have proven the influence of energy consumption on EFs, notably fossil fuel sources known for their large carbon emissions, which are worsened by the fact that human growth depends on energy at the cost of sustainability. For example, fossil fuels have been shown to reduce the value of the environment by increasing the carbon and ecological footprint (Ahmed et al., 2019). In a related study, Nathaniel (2020) stated that excessive energy usage increases Indonesia's EF statistics over the long and short term. In another pertinent study, Khan and Hou (2020) discovered a positive association between energy consumption per person and EF levels. Ahmed et al. (2020) highlighted comparable findings for the Group of Seven nations. Thus, the influence of energy consumption on the EF is clear from the studies cited above.

Nevertheless, despite increasing evidence showing how unsustainable energy consumption contributes to our already rising EF, the situation remains mostly unchanged worldwide, particularly in developing countries with poor equipment for efficient energy generation. Developing countries have been found to consume more non-renewable energy than renewable energy because of insufficient investment in the sustainable energy sector (Hu et al., 2018), which is expected to account for 65 percent of global energy consumption by 2040 (Energy Information Administration (EIA), 2013). Global warming concerns will only grow because of continued, unsustainable energy use and its disastrous environmental effects.

However, little research has been conducted on household EF in Nigeria, with most concentrating on a specific region of the nation (Ojo & Abd'Razack, 2018; Fadeyibi et al., 2020). As a result, our study fills this gap by analyzing the EF of energy in Ijebu Ode, southwest of the nation, and aims to offer empirically based knowledge that will guide future policies for clean energy and environmental sustainability in Nigeria. This study is structured into five sections: introduction, literature review, materials and methods, results and discussions. Each section examines a different part of the study on ecological footprint of energy consumption in Ijebu Ode.

Literature Review

Energy Consumption and the EF Nexus

The production and use of energy have been shown to play a significant role in environmental sustainability as well as economic growth and development. Numerous studies have examined how energy use affects EF levels. For instance, Khan and Hou (2020) in a recent study reported a positive correlation between per capita energy usage and EF levels in 38 International Energy Agency (IEA) countries. In a further related study by Nathaniel (2020), it was demonstrated that the long- and short-term EF of Indonesia increased as a result of high energy consumption. Similar conclusions have been documented in the Group of Seven (G7) nations (Ahmed et al., 2020) and France (Ang, 2007).

In an attempt to promote sustainability in economic development, several nations have turned their attention to clean and renewable energy sources because of the impact of nonrenewable energy on carbon emissions (Zaidi et al., 2018). Hence, numerous studies have examined the relationship between the consumption of renewable energy and EF, in line with the concept that adding more renewable energy sources to a country's energy grid will ensure environmental sustainability. The use of renewable energy has been demonstrated to reduce the EF of several Organization for Economic Cooperation and Development (OECD) nations (Destek & Sinha, 2020). Similar findings were found in emerging nations from Asia (Sharma et al., 2020) and 16 European Union countries (Alola et al., 2019). Similarly, Naqvi et al. (2020) showed statistical support for increased renewable energy use to lower EF in the context of high- and upper-middle-income nations. However, no statistically significant effects of renewable energy use on EF were found in lower-middle- and low-income countries.. In contrast, notable studies have highlighted dissimilar results regarding the impact of energy consumption on EF. According to Nathaniel and Khan (2020), the utilization of renewable energy has little impact on the EFs of a few Association of Southeast Asian Nations (ASEAN) member countries. Moreover, the cause of the increasing levels of EFs was found to be higher non-renewable energy usage. Equally notable findings revealed that the use of renewable energy is harmful to the sustainability of the environment in a recent study of 15 economies with the largest carbon emissions (Usman et al., 2020). The authors further claimed that the increased use of renewable and non-renewable energy increased EFs. However, the marginal effects of renewable energy consumption on EFs were shown to be relatively less significant when compared to non-renewable energy; thus, achieving environmental sustainability through renewable energy is a relatively better strategy (Usman et al., 2020).

In addition, although it has been demonstrated that high utilization of non-renewable energy leads to high levels of EF, data for individual countries showed that renewable energy had little impact on EF. For instance, a link between nonrenewable energy usage and positive outcomes was found in Thailand, Vietnam, and Malaysia (Nathaniel et al., 2020), while higher consumption of renewable energy was associated with lower EF levels, but only in the cases of Israel and Jordan (Nathaniel et al., 2020). Thus, the authors concluded that the use of renewable energy did not have an impact on the EFs of Middle East and North African (MENA) countries. In contrast, it was discovered that nonrenewable energy increased the EFs of MENA nations as a whole, as well as for Algeria, Yemen, Iran, Tunisia, Oman, and the United Arab Emirates (Nathaniel et al., 2020). Thus, the use of renewable energy does not ensure a decrease in the EF, as suggested by the ambiguous results reported in the aforementioned studies. Hence, there is a need to examine the links between many countries.

Overall, there is no denying that renewable energy consumption has hitherto increased environmental pollution (Bulut, 2017). Nevertheless, compared to non-renewable energy, the overall effect of renewable energy on climate change is less significant and less expensive (Sinha et al., 2018; Chen et al., 2019). In this sense, empirical evidence from China shows that coal (a nonrenewable energy source) significantly increases the level of pollution in the country. Similarly, research has suggested that renewable energy use is more environmentally friendly in the long term (Dogan &

Seker, 2016; Bhattacharya et al., 2017; Inglesi-Lotz & Dogan, 2018).

Energy situation in Nigeria

As an energy giant, Nigeria is Africa's most productive oil-producing nation, which, together with Libya, accounts for about two-thirds of the continent's crude reserves (Oyedepo, 2012) and ranks second only to Algeria in natural gas production (Sambo, 2015). Among the various energy consumption sectors, the household sector accounts for the major share of energy consumption, accounting for approximately 60% of the overall share (Energy Commission of Nigeria, 2003). According to Dayo et al. (2004), the household domain has consistently accounted for over half of the country's domestic energy consumption, varying between 55 percent and 61 percent. Among the main energy-consuming activities in households are cooking (91%) and lighting (6%), and the remaining 3% can be linked to the utilization of electrical appliances (Energy Commission of Nigeria, 2005).

Several studies have also highlighted the major energy sources among Nigerian households, which include both renewable and non-renewable sources. Nigeria, although blessed with abundant renewable energy sources, is limited by its technological capacity to utilize the full potential of these sources. In support of this, Abiodun (2003) reported that the majority of Nigerian households rely on kerosine for cooking, while relatively few use gas or electricity. Similarly, a detailed distribution of Nigeria's household cooking energy indicates electricity (0.45%), liquefied natural gas (LPG) (0.74%), natural gas (1.26%), biogas (0.23%), kerosene (19.8%), charcoal (3.13%), and firewood (72.18%) (Buba et al., 2017). Further evidence suggests that Nigeria's household energy consumption comprises of electricity (4%), kerosene (13%), gas (1%), and firewood. (82%; Etege & Alabi, 2011). These have continued to pose a serious threat to environmental sustainability and therefore call for an energy-transformative approach to ensure an evidence-based shift to cleaner and more sustainable energy consumption..

Materials And Methods

Study Area

The study was conducted at Ijebu Ode, which is about 60 km northwest of Lagos and the second-largest city in Ogun State, southwest Nigeria, with a land mass of 192 km2 and 154,032 population (National Bureau of Statistics (NBS), 2007) (see figure 1). The city of Ijebu Ode is known for its fast-growing and widely distributed suburban zone, with an estimated current population of 367,749 and a population growth rate of 3.36 percent, according to the World Population Review (2022).

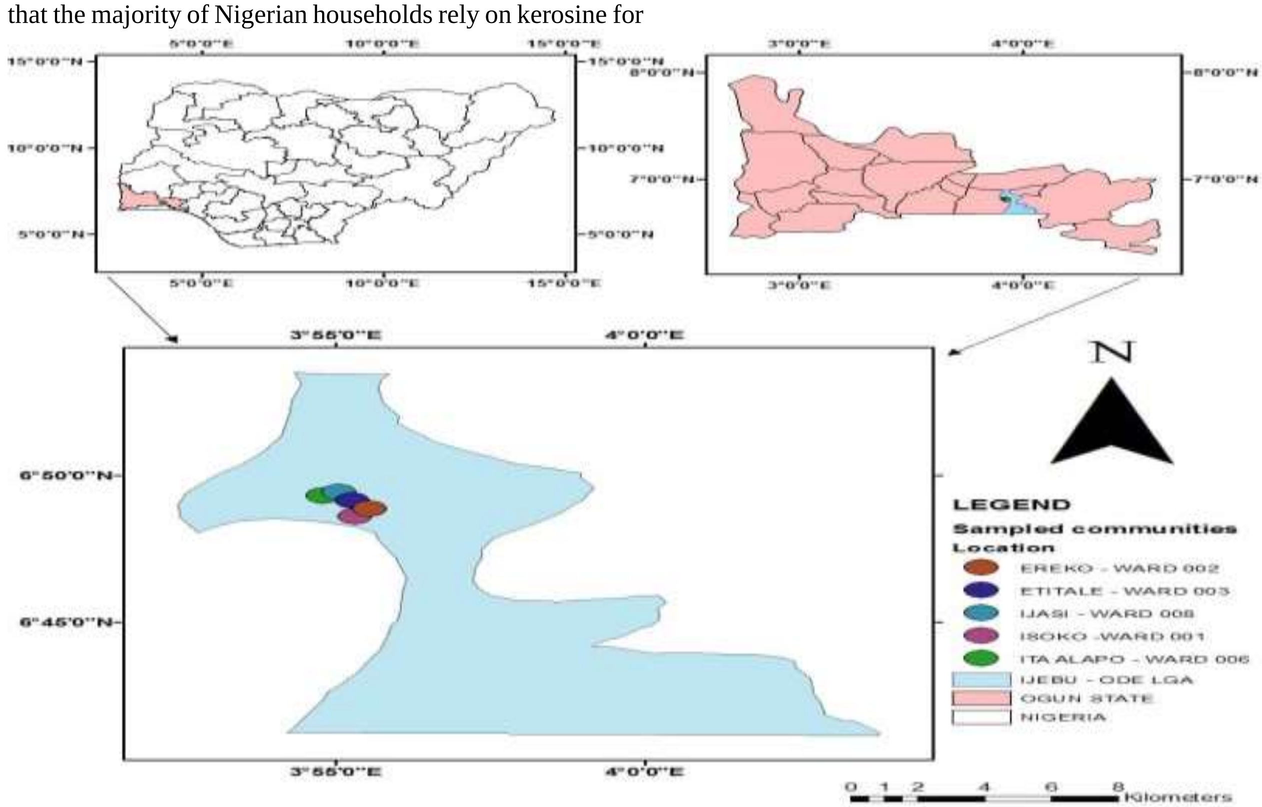

Figure 1: Ijebu Ode spatial map of the sampling locations (Otto et al., 2022)

Sample and Sampling Techniques

To create the required 400 samples, five (5) wards were selected at random from a total of eleven (11) wards of the city, and eighty (80) participants were selected from each ward to create the samples. Residential homes were chosen at intervals of every fifth home in each of the chosen wards using a systematic random sampling technique. An aggregate sample of 400 participants was estimated using Slovin's sample size determination method (Eq. 1), with an error margin of 0.05, and a 95% confidence level.

$$n = \frac{N}{1 + Ne^2} \quad \text{Eq. 1}$$

(Ellen, 2020).

Where;

n = sample size
N = population size
e = margin of error

Data Collection Procedure

The primary data for this study were provided by a structured questionnaire distributed to a systematically selected sample of 400 households. The primary dataset consisted of 400 household questionnaires used to collect information about energy consumption and expenditure from respondents in the five Ijebu Ode wards of Itantebo/Ita, Porogun I, Odo/Esa, Ogbin, Ijasi/Idepo, and Isoku/Ososa. Additional sources of secondary data included the Global Footprint Network, Food and Agriculture Organization, National Bureau of Statistics (NBS), Nigerian Electricity Regulatory Commission (NERC), and other web-based publications (Table 1). To ensure the presentation of a geographical analysis of EF in Ijebu Ode, the sampling locations were recorded using a global positioning system (GIS) to build a GIS database.

Table 1: EF Data Needs and Sources

S/n	Data	Source
1	Socio-demographic Data	Author's Survey
2	Ijebu Ode's Population	NBS (2007)
3	Energy Consumption	Author's Survey
4	Tariff/Kwh of Electricity	NERC (2015)
5	Yield Factor	GFN (2019)
6	Equivalence Factor	GFN (2019)

Data Analysis Approach

Inferential statistics were employed to analyze the data collected for this study using mathematical models to calculate the ecological footprint (see Eq. 2), and the results were visualized using pictorial variables such as histograms and pie charts. Descriptive analysis was performed using distribution tables with simple percentages in Microsoft Excel.

Determination of EF of Energy

According to Shakil & Muhammed (2018), as cited by Fadeyibi et al. (2020), the greenhouse gas (GHG) conversion standard (2010) was adopted to evaluate the EF of energy consumption using six categories of energy sources, including electricity, generators, gas, kerosene, charcoal, and firewood. The amount of energy gathered during the field survey was measured in kWh. Because 1 kWh is valued at the N27.40 Nigerian Naira (Nigerian Electricity Regulatory Commission (NERC), 2015), the overall amount of energy from each source was converted to an energy value in kWh by dividing the amount by the N27.40 naira, while the energy value for electricity was determined in MJ by dividing the energy value in kWh by 0.2778 kWh. Additionally, the updated GHG emissions of various fuels for 2019 were used to calculate the embodied energy in MJ per kg and CO_2 emissions in kg/MJ. Subsequently, the footprint was calculated and expressed in "global hectares" (gha) by dividing the energy value in MJ by the national yield factor for forest land (0.26) (GFN, 2019), and multiplying the result by the equivalency factor (1.29) (GFN, 2019), CO2 emissions (kg/MJ), and the resulting value divided by the total population value of Ijebu Ode (NBS, 2007), to give the EF of energy consumption in gha/capita (see Eq. 2).

$$\boldsymbol{EF_e = \sum_1^6 \frac{EV}{Y_f} \times E_f \times CO_2\, gas\, emmission\, \frac{kg}{MJ}} \quad \text{Eq. (2)}$$

(Fadeyibi *et al*., 2020):

Where;
EFe = EF for energy by energy usage mode (gha/capita),
EV = Energy Value (MJ/kg)
CO_2 *Emission* = carbon dioxide emission (kg/MJ) and
Y_f and E_f = yield and equivalence factor

Results

The various energy types utilized by the household surveys were categorized into the following categories: electricity, gas, kerosene, charcoal, firewood, and generator (Figure 2). The footprint analysis of the different energy categories reveals that electricity has an EF of 0.04 gha (51.9%), and the largest of the EF shares was followed by gas with 0.02 gha (26%), and generators with 0.011 gha (14.3%) (Figure 3). Also, the EF of kerosine consumption is 0.003 gha (3.9%), charcoal is 0.002 gha (2.6%), and firewood is 0.001 gha (1.3%), according to the analysis (figure 3). However, the overall EF of energy consumption was shown as 0.07 gha per capita.

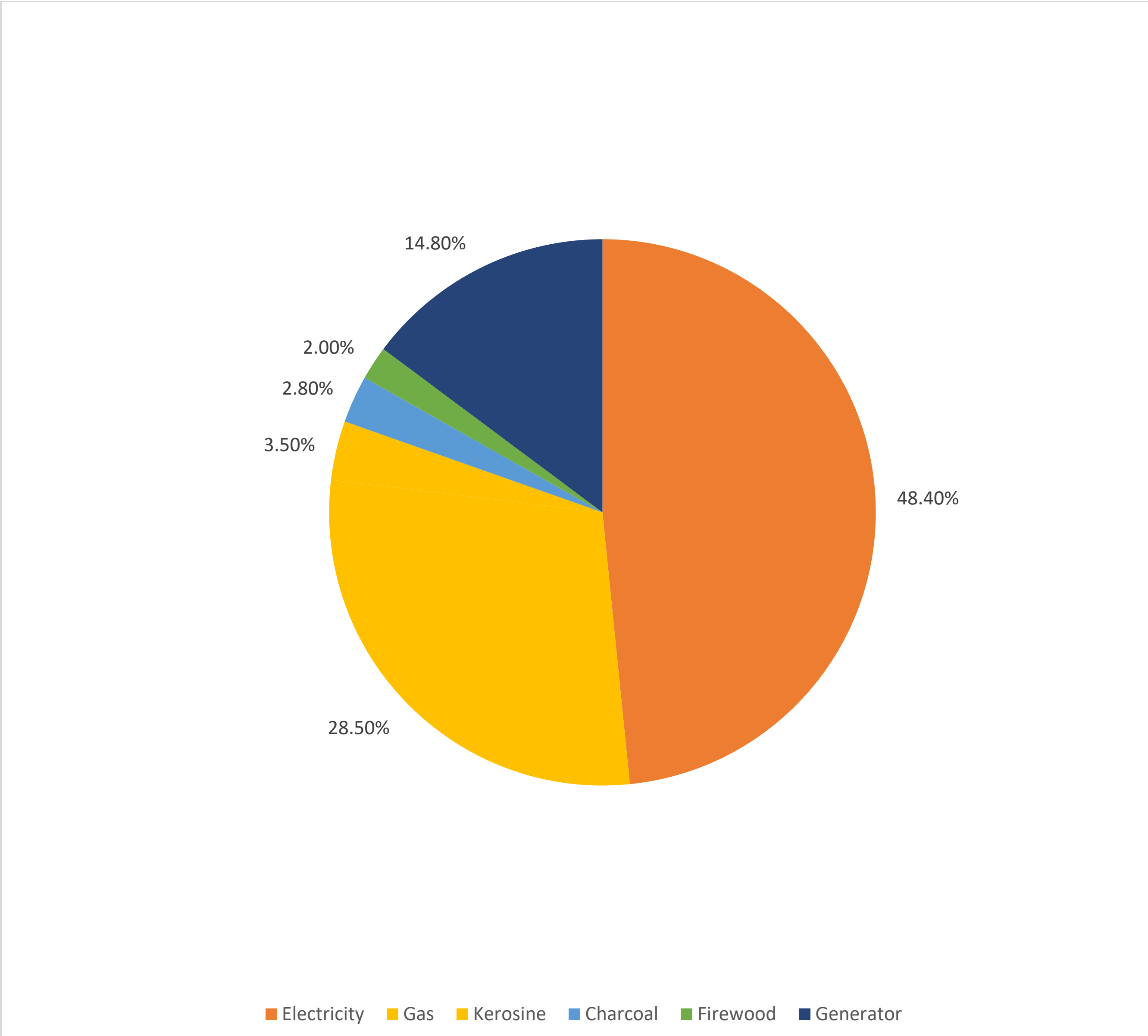

Figure 2. Percentage distribution of annual energy consumption by categories

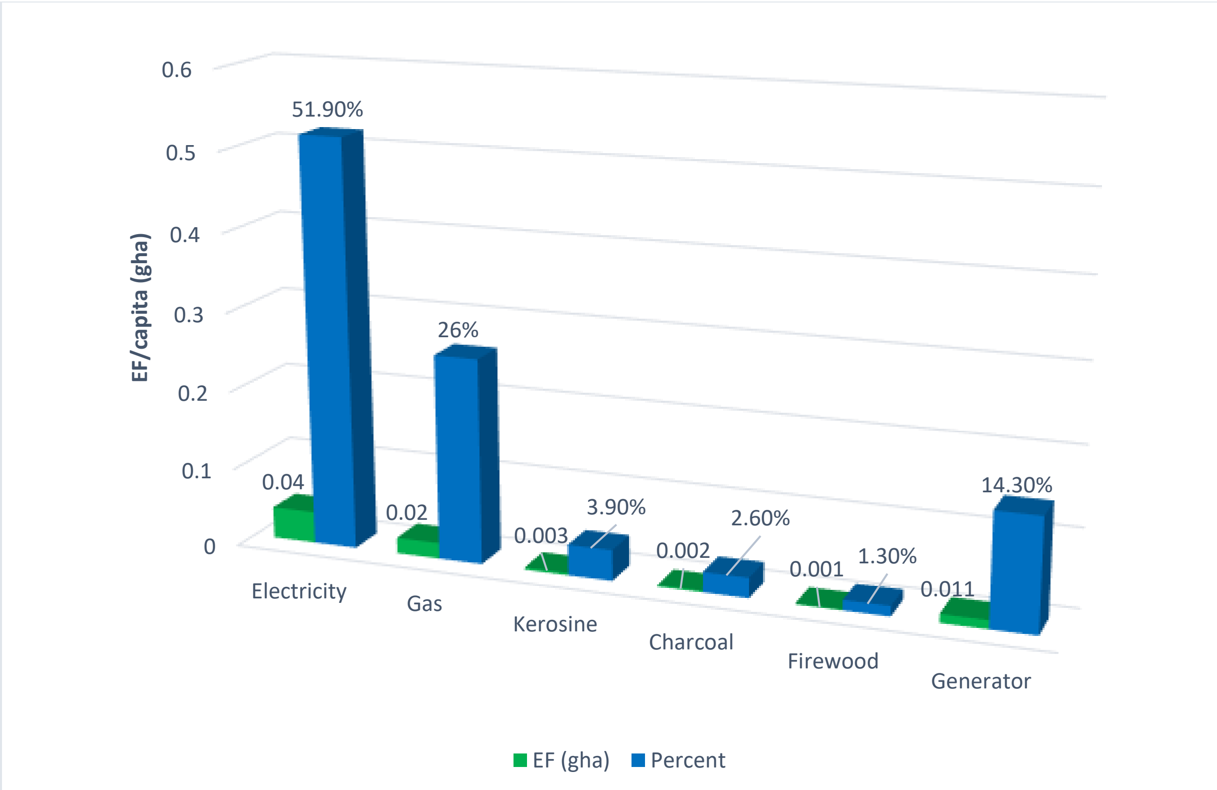

Figure 3. EFs of various energy categories and their percentage distribution

Discussions

The present study was initiated to evaluate the EF of energy consumption in Ijebu Ode. The findings suggested that the EF of energy in Ijebu Ode was shown to be 0.07 gha per capita, contributing to approximately 6.7% of the total EF share of Ijebu Ode (figure 3). This finding suggests that Ijebu Ode's energy usage is sustainable, as any footprint calculation of more than 1.0 gha per capita denotes unsustainable resource use, according to Razack and Ludin (2014). Moreover, the result may have been caused by modern and sustainable energy (electricity and gas) utilization by the residents, as opposed to biomass and traditional energy sources (kerosine and firewood), which have been scarcely utilized (figure 2). A study suggested that modern energy for Nigerian household cooking has shifted to electricity and "liquefied petroleum gas" (LPG) (Nnaji et al., 2021). Moreover, researchers have found that the continuous use of clean energy significantly reduces the EF (Sharif et al., 2020; Sharma et al., 2021; Xue et al., 2021). Similarly, studies have shown that using traditional energy sources such as fossil fuels and wood as energy sources significantly increases CO_2 emissions (Shahbaz et al., 2013; Anser, 2019; Chen et al., 2019), and the ecological footprint has been found to be significantly related to CO_2 emissions (Abbas et al., 2021). Therefore, the current results corroborate those of Ojo and Abd (2018) and Khan and Uddin (2018). However, this is in contrast with Fadeyibi et al. (2020) and Begum and Pereira (2012), who in their respective studies reported that energy is the largest contributor to the EF share in Ilorin (44%) and Malaysia (53%), respectively. A possible explanation for this disparity may be the variation in the utilization and affordability of the major energy sources. In the former case, the high energy utilization was attributed to the high usage of generators that use fossil fuels (gasoline and diesel), which are known for their high CO_2 emissions, while the latter is linked to the subsidization of energy, which increases consumption owing to its affordability. It has been noted that having access to energy sources that are more efficient indicates greater levels of energy consumption (Pachauri and Spreng, 2004). Consequently, studies have found that extensive use of energy increases carbon dioxide emissions and the ecological footprint (Tiba & Omri, 2017), while fossil fuels are known to increase CO_2 emissions (Anser, 2019) and the ecological footprint (Szigeti et al., 2017).

Further analysis revealed that electricity consumption has an EF of 0.04 gha (51.9%), which constitutes the major share of the energy footprint, compared to the footprint of generator usage with 0.011 gha (14.3%), which is the third largest share of the energy footprint (figure 3).However, they are unconnected with a relatively steady supply of electricity in the area. For example, Ogun State has been reported to be one of the first four states in Nigeria, with the highest electricity supply as a result of its huge industrial activity (Power, 2019). In addition, the result may be explained by the record of huge estimated bills (that do not depend on the actual energy consumed) paid by unmitigated or non-prepaid residents who do not have access to a smart prepaid electricity meter. An empirical study found that non-prepaid or unmetered customers are often highly overbilled (Ohajianya, 2021), and about 80% of consumer complaints received by the NERC are about estimated and excessive bills (Arimoro et al., 2019). Similarly, the continuous skyrocketing of fuel prices over the years has made it practically and economically difficult for households to sustain the use of generators as an alternative source of power, except for commercial and energy-dependent outfits, and a few well-to-do families. However, our result is a confirmation of the findings of Ojo & Abd'Razack (2018), who established that electricity has the highest energy footprint in Bida with 0.06 gha (64%) of the entire energy share. In addition, a study assessing household energy consumption in major Nigerian cities (Warri, Port Harcourt, and Calabar) by Okuma et al. (2021) revealed that electricity has the highest consumption, with 67.7% of all energy sources, second only to kerosene.

By contrast, Fadeyibi et al. (2020) demonstrated that electricity has the lowest footprint of the total energy footprint share in Ilorin, which, according to the authors, is due to the low supply of electricity. Nonetheless, the disparity may also be due to the fact that unlike Ijebu Ode, Ilorin, as a metropolitan city, has many of its electricity consumers using prepaid meters, which overrules the chances of excessive bills that come with estimated billings. Our findings show that, despite intermittent power supply, most residents continue to rely heavily on electricity owing to the high economic cost of using generators, which can only be sustained by a relatively small number of economically stable individuals and commercial or business outfits. Several studies have reported that electricity usage has a low impact on EF because of its low-carbon emissions (Borisade et al., 2020; Sharif et al., 2020). These results have policy implications and call for realistic policy decisions on the need to revamp the national grid to ensure a steady supply of electricity for sustainable energy consumption, as well as reduced EF.

In addition, the results further revealed that the EF of gas consumption is 0.02 gha (26%), which is second only to electricity in the energy consumption footprint (figure 3). The withdrawal of a government subsidy on the price of kerosene by the Nigerian government in 2016 may not be unrelated to the rise in the consumption of this contemporary cooking fuel, which, according to the National Population Commission (2019), witnessed an increase in LPG to 15% as the preferred cooking fuel in homes. Accordingly, Eleri (2021) opined that household cooking accounts for a large percentage of Nigeria's energy consumption, translating into a significant latent demand for LPG. Similarly, the NBS report of 2020 indicated that clean-cooking access has moved from a very low level of less than 5% to about 10% due to new efforts to promote LPG (NBS, 2020), which is a sustainable cooking fuel because of its lower carbon emissions compared to other fuel types (Borisade et al., 2020). Other studies have also reported a high utilization of LPG as a household energy source (Okuma et al., 2015; Okuma et al., 2021).

The present finding is in agreement with a similar report by Ojo and Abd'Razack (2018), who demonstrated the EF of gas consumption to be 0.01 gha (9%) of the energy footprint of Bida, but disagrees with Fadeyibi et al. (2020). This disagreement may be a result of the regional imbalance in the consumption of LPG, with 65% estimated modern fuel use for cooking in most of Nigeria's southern states (Nnaji et al., 2021). By implication, it is advisable to note that cooking activities account for the high energy consumption in households (Borisade et al., 2020). Hence, LPG utilization, especially among households, should be encouraged through resource availability and affordability owing to its low carbon emissions, which have been documented (Xue et al., 2021), to reduce ecological footprints. Similarly, households can embrace and use biogas produced from domestic garbage, which is a sustainable but less expensive source of clean energy. According to empirical studies on the importance of biogas, animal and agricultural wastes are used to produce a large amount of biogas (Abubakar et al., 2022), notably in nations such as India, Greece, China, and Ukraine (Talevi et al., 2022; Aravani et al., 2022; Kucher et al., 2022). A recent study by Ahmed et al. (2022) indicated that placentas have the same biogas potential as other organic wastes in renewable energy production.

Additionally, the EF of kerosine consumption was shown to be 0.003 gha (3.9%), charcoal 0.002 gha (2.6%), and firewood 0.001 gha (1.3%), which were the lowest footprint shares, according to the analysis (figure 3). These results are consistent with the studies of Ojo and Abd'Razack (2018) and Fadeyibi et al. (2020). Nonetheless, the results may be unrelated to the rising cost of kerosine, which was the main source of energy in most households, but following subsidy withdrawal for kerosene in 2016, there was a dip in the use of over 40% between 2013 and 2018, as evidenced by the use statistics dropping from 26% to 15% (Nnaji et al., 2021). Similarly, while there is widespread usage of fuelwood for cooking across the country, there is a significant regional disparity. For instance, very few households that primarily cook with wood have been documented in the states of Ogun and Lagos, which is not unconnected to the fact that the distribution systems of LPG are more robust and household incomes are higher in the wealthier southern states (Eleri, 2021). Moreover, Maina et al. (2020) reported that a dwindling pattern had been documented in the past years, with fuelwood fetch declining, while the other fuel sources increased, with a significant increase in LPG usage. This is in further support of our finding earlier reported (figure 3). However, it is instructive to note that, aside from its significant impact on carbon emissions and EF upsurge (Chen et al., 2019; Abbas et al., 2021), it has been estimated that around 45,000 hectares of forest are lost annually to illegal felling of trees and shrubs for domestic biomass and charcoal production (Adegoke & Lawal, 1999), and if the trend continues, the implication is that the forest resources will have been greatly depleted (Sambo, 2006).

By implication, this study proves essential in establishing the literature on the EF of energy consumption in Ijebu Ode, with crucial policy implications on the need to adjust the nation's energy portfolio and institute a paradigm shift toward clean and sustainable energy sources. However, the authors were not ignorant of some of the observable limitations of the study, which involved delimiting it to the household level. Therefore, evaluation of the EF of energy consumption at the city or regional level in the country is recommended.

Conclusion

This study aims to evaluate the EF of energy consumption in Ijebu Ode for environmental sustainability. Findings revealed that the energy consumption in Ijebu Ode has a per capita EF of 0.07 gha, which represents 6.7% of the total EF of Ijebu Ode. The main contributor to the energy footprint was electricity (0.04 gha; 51.9%), followed by gas (0.02 gha; 26%). The smallest contributors to the energy footprint were kerosine, charcoal, and firewood (0.003 gha; 3.9%, 0.002 gha; 2.6%, and 0.001 gha; 1.3%, respectively). We infer that Ijebu Ode has a sustainable pattern of energy consumption that supports its environmental sustainability. We suggest policy actions to increase the availability and affordability of renewable and clean energy sources to improve and ensure sustainable energy consumption.

Acknowledgments

The authors appreciate all the final-year Environmental Health Technology students who served as trained assistants.

Competing Interest

There are no opposing issues disclosed by the authors.

Funding

The authors funded the research themselves.

References

Abbas, S., Kousar, S., & Pervaiz, A. (2021). Effects of energy consumption and ecological footprint on CO2 emissions: An empirical evidence from Pakistan. Environment, Development and Sustainability, 23(9), 13364–13381. https://doi.org/10.1007/s10668-020-01216-9

Abiodun, R: Fuel price hike spells doom for Nigeria's forest (2003). http:www.islamonline.net/English/index.shtml. Accessed 18 June 2011

Abubakar, A. M., Silas, K., & Aji, M. M. (2022). An elaborate breakdown of the essentials of biogas Production. Journal of Engineering Research and Sciences, 1(4), 93–118. https://doi.org/10.55708/js0104013

Abubakar, A. M., Silas, K., & Aji, M. M. (2022). An elaborate breakdown of the essentials of biogas production. Journal of Engineering Research and Sciences, 1(4), 93–118. https://doi.org/10.55708/js0104013

Adegoke, C. O., & Lawal, G. T. (1999). Preliminary investigation of sawdust as high grade solid fuel. *Journal of renewal energy*, 7(1&2); 102-107.

Ahmed, Z., & Wang, Z. (2019). Investigating the impact of human capital on the ecological footprint in India: An empirical analysis. Environmental Science and Pollution Research, 26(26), 26782–26796. https://doi.org/10.1007/s11356-019-05911-7

Ahmed, Z., Wang, Z., & Ali, S. (2019). Investigating the non-linear relationship between urbanization and CO2 emissions: An empirical analysis. Air Quality, Atmosphere & Health, 12(8), 945–953. https://doi.org/10.1007/s11869-019-00711-x

Ahmed, Z., Zafar, M. W., Ali, S., & Danish. (2020). Linking urbanization, human capital, and the ecological footprint in G7 countries: An empirical analysis. Sustainable Cities and Society, 55, 102064, https://doi.org/10.1016/j.scs.2020.102064

Ahmed, Z.; Zafar, M.W.; Ali, S. (2020). Linking urbanization, human capital, and the ecological footprint in G7 countries: An empirical analysis. Sustain. Cities Soc. 55, 102064.

Ahmed, Z.D., Abubakar, A.M, Batool, K., Sabo, M.J, & Taki, B.M. (2022). Prospects of alternative energy harvest from placenta degradation. https://doi.org/10.5281/ZENODO.7300296

Alola, A.A.; Bekun, F.V. (2019). Sarkodie, S.A. Dynamic impact of trade policy, economic growth, fertility rate, renewable and nonrenewable energy consumption on ecological footprint in Europe. Sci. Total Environ. 685, 702–709.

Ang (2007) in his country-specific study highlighted that increased domestic production and energy consumption significantly intensified the carbon emissions in France.

Anser, M. K. (2019). Impact of energy consumption and human activities on carbon emissions in Pakistan: Application of STIRPAT model. *Environmental*

Science and Pollution Research, 26(13),13453–13463.

Aravani V. P. et al., (2022). Agricultural and livestock sector's residues in Greece & China: comparative qualitative and quantitative characterization for assessing their potential for biogas production," Renewable and Sustainable Energy Reviews, vol. 154, no. 111821, pp. 1–10, doi:https://doi.org/10.1016/j.rser.2021.111821

Arimoro, T. A., Oyetunji, A. K. & Odugboye, O. E. (2019). Analysis of electricity billing system in corporate buildings in Lagos, Nigeria," *J. Manag. Econ. Stud.*, vol. **1**, no. 6, pp. 10–20, doi:10.26677/TR1010.2019.150

Begum, R. A. & Pereira J.J. (2012). Holistic ecological footprint for Malaysia. Journal of Applied Sciences Research, 8(9): 4783-4787, 2012 ISSN 1819-544X

Bello, M.O, Solarin, S.A, Yen YY (2018) The impact of electricity consumption on CO2 emission, carbon footprint, water footprint and ecological footprint: the role of hydropower in an emerging economy.J Environ Manag 219:218–230. https://doi.org/10.1016/j.jenvman.2018.04.101

Bhattacharya, M., Churchill, S., Paramati, S., (2017). The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. Renewable Energy 111, 157-167.

Borisade, E., Stanley, A. M., Dadu, D. W., Sani, L. F., & Abah, A. M. (2020). An appraisal of household cooking fuel consumption and their carbon related emission in Zaria Metropolis, Nigeria. FUTY Journal of the Environment, 14(1), 50–59.

Buba, A., Abdu, M., Adamu, I., Jibir, A., & Usman, Y. I. (2017). Socioeconomic determinants of households fuel consumption in Nigeria. International Journal of Research²Granthaalayah, 5(10), 348±360. https://doi.org/10.5281/zenodo.1046324

Bulut, U. (2017). The impacts of non-renewable and renewable energy on CO2 emissions in Turkey. Environmental Science and Pollution Research 24 (18), 15416-15426.

Chen, S., Saud, S., Saleem, N., & Bari, M. W. (2019). Nexus between financial development, energy consumption, income level, and ecological footprint in CEE countries: Do human capital and biocapacity matter? *Environmental Science and Pollution Research, 26*(31), 31856–31872.

Chen, Y., Wang, Z., Zhong, Z., (2019). CO2 emissions, economic growth, renewable and nonrenewable energy production and foreign trade in China. Renewable Energy 131, 208216.

Daly, H.E., (1990). Toward some operational principles of sustainable development. Ecol. Econ. 2, 1–6. https://doi.org/10.1016/0921-8009(90)90010-R

Dayo, FB, Adegbulugbe, AO, Ibitoye, F, Adenikinju, A, Voss, A (2004). Estimating the economic benefits of kyoto protocol to the Nigerian economy. UNIDO (Economy, Environment, Employment), Vienna

Destek, M.A.; Sinha, A. (2020). Renewable, nonrenewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organization for economic co-operation and development countries. J. Clean. Prod. 242, 118537.

Dogan, E., & Seker, F., (2016). Determinants of CO2 emissions in the European Union: the role of renewable and non-renewable energy. Renewable Energy 94 (August), 429-439.

Eleri, A. I. (2021). Expanding demand for clean-cooking in Nigeria. international centre for energy, Environment and Development, 4–22.

Ellen, S. (2020). Slovin's formula sampling technique. Slovin's Formula Sampling Techniques (sciencing.com). December 14. Accessed March, 25, 2022.

Energy Commission of Nigeria (2003). National Energy Policy. Federal Republic of Nigeria, Abuja.

Energy Commission of Nigeria and United Nations Development Programme (2005). Renewable energy master plan: final draft report. http://www.iceednigeria.org/REMP%20Final%20Report.pdf

Energy Information Administration (2013) Future world energy demand driven by trends in developing countries. Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=14011

Enete, C.I, & Alabi, M.O. (2011). Potential impacts of global climate change on power and energy generation. Journal of Knowledge Management, Economics and Information, Technology 6,1–14

Fadeyibi, M. Sawyerr, H. O. & Salako G. (2020). Ecological footprint for environmental sustainability in Ilorin Metropolis, Kwara State, Nigeria. International Journal of Low-Carbon Technologies, 16(2), 376–383. https://doi.org/10.1093/ijlct/ctaa072

GFN. (2022). Ecological Footprint Explorer. Open Data Platform (footprintnetwork.org). accessed July 25th, 2022

Global Footprint Network (2018) National footprint accounts. http://data.footprintnetwork.org/#/countryTrends?cn=351&type=BCpc,EFCpc. Accessed 18 Nov 2020

Global Footprint Network (2019). National footprint accounts. Retrieved from http://data.footprintnetwork.org. Accessed October, 2021

Hu H, Xie N, Fang D, Zhang X (2018) The role of renewable energy consumption and commercial services trade in carbon dioxide reduction: evidence from 25 developing countries. Appl Energy 211:1229–1244. https://doi.org/10.1016/j.apenergy.2017.12.019

Inglesi-Lotz, R., Dogan, E., (2018). The role of renewable versus non-renewable energy to the level of CO2 emissions a panel analysis of sub- Saharan Africa's Big 10 electricity generators. Renewable Energy 123, 36-43.

Kassouri Y, & Altıntaş H. (2020). Human well-being versus ecological footprint in MENA countries: a trade-off? J Environ Manag 263(10):110405. https://doi.org/10.1016/j.jenvman.2020.110405

Khan, I. & Hou, F. (2020**).** The dynamic links among energy consumption, tourism growth, and the ecological footprint: The role of environmental quality in 38 IEA countries. Environ. Sci. Pollut. Res. 28, 1–14.

Khan, Md., & Uddin, M. (2018). Household level consumption and ecological stress in an urban area. urban science, 2(3), 56. https://doi.org/10.3390/urbansci2030056

Kucher O. et al., (2022). Energy potential of biogas production in Ukraine," Energies, vol. 15, no. 5, pp. 1–22, 2022, doi:https://doi.org/10.3390/en15051710

Long X, Yu H, Sun M, Wang XC, Klemeš JJ, Xie W, Wang C, Li W, Wang Y (2020) Sustainability evaluation based on the three dimensional ecological footprint and human development index: a case study on the four island regions in China. J Environ Manag 265(4):110509. https://doi.org/10.1016/j.jenvman.2020.110509

Maina, Y. B., Umar, N. K., & Egbedimame, A. B. (2020). An empirical analysis of the impact of household fuel wood consumption on the environment in Nigeria. FUTY Journal of the Environment, 14(3), 35–46.

Naqvi, S.A.A.; Shah, S.A.R.; Mehdi, M.A. (2020). Revealing empirical association among ecological footprints, renewable energy consumption, real income, and financial development: A global perspective. Environ. Sci. Pollut. Res. 27, 42830–42849.

Nathaniel, S.; Anyanwu, O.; Shah, M. (2020). Renewable energy, urbanization, and ecological footprint in the Middle East and North Africa region. Environ. Sci. Pollut. Res. 27, 1–13.

Nathaniel, S.; Khan, S.A.R. (2020). The nexus between urbanization, renewable energy, trade, and ecological footprint in ASEAN countries. J. Clean. Prod. 272, 122709.

Nathaniel, S.P. (2020**).** Ecological footprint, energy use, trade, and urbanization linkage in Indonesia. Geo Journal, 1–14.

National Bureau of Statistics 2006 (2007). Population census. National Bureau of Statistics, Federal Republic of Nigeria. NBS Publications; Nigeria, Available at http://www.nigerianstat.gov.ng/Connections/Pop2006.pdf. Accessed 27th February, 2015.

National Bureau of Statistics. (2020). 2019 Poverty and inequality in Nigeria: executive summary. Abuja: National Bureau of Statistics.

National Population Commission (NPC) and ICF (2019). Nigeria demographic and health survey, 2018. Abuja, Nigeria, and Rockville, Maryland, USA: NPC and ICF International

Nextier Power. (September 10, 2019). States with highest supply of electricity in Nigeria. States with The Highest Supply of Electricity in Nigeria | Nigeria Electricity Hub. Accessed June, 18th, 2022

Nigerian Electricity Regulatory Commission (2015). Ibadan Disco Tariffs-N/Kwh. NIGERIAN ELECTRICITY REGULATORY COMMISSION TCN AND DISCOS TARIFFS MYTO 2015 December 18, 2015 (nerc.gov.ng). Accessed October, 26, 2022.

Nnaji, M., Eze, A. A., Uzoma, C. C., & Nnaji, C. E. (2021). Addressing household cooking fuel options in Nigeria iop conference series: Earth and Environmental Science, 730(1), 012038. https://doi.org/10.1088/1755-1315/730/1/012038

Ohajianya, A. C. (2021). Estimated billing system is the bane of grid electric power supply and development in Nigeria: An empirical analysis. Journal of Advances in Science and Engineering, 5(1), 1–10. https://doi.org/10.37121/jase.v5i1.157

Ojo O.J. & Abd'Razack. N. (2018). Measuring the sustainability: appraisal of ecological footprint of Bida, Niger state, Nigeria. *J Res Gate*;**6**:6–12.

Okuma, S., Orhorhoro, E., & Idowu, A. (2021). Evaluation of domestic energy preference in Nigeria cities: A case study of Warri Benin Port Harcourt and Calabar. Journal of Applied Research on Industrial Engineering, 8(1). https://doi.org/10.22105/jarie.2021.269276.1241

Omojolaibi, J. A., & Nathaniel, S. P. (2020). Assessing the potency of environmental regulation in maintaining environmental sustainability in MENA countries: An advanced panel data estimation. Journal of Public Affairs. https://doi.org/10.1002/pa.2526

Otto, E., Sawyerr, H. & Opasola, O. (2022). Ecological footprint evaluation for environmental sustainability in Ijebu Ode, Ogun State, Nigeria . *International Journal of Natural Sciences Research*, 10(1), 21–29. https://doi.org/10.18488/63.v10i1.2979

Oyedepo, S. (2012). Efficient energy utilization as a tool for sustainable development in Nigeria. International

Journal of Energy and Environmental Engineering, 3(1), 11. https://doi.org/10.1186/2251-6832-3-11

Pachuari, S. and Spreng, D. (2004). Energy use and energy access in relation to poverty. *Economic and Political Weekly*, 39(3), 271-278.

Razack, N. T. A. A., & Ludin, A. N. M. (2014). Ecological footprint and food consumption in Minna, Nigeria. IOP Conference Series: Earth and Environmental Science, 18, 012179. https://doi.org/10.1088/1755-1315/18/1/012179

Sambo AS (2008) Matching Electricity Supply with Demand in Nigeria. International Association of Energy Economics 4:32–36

Sambo, A.S. (2006). Renewable energy electricity in Nigeria: the way forward. Paper presented at the renewable electricity policy conference held at Shehu Musa Yarádua Centre. Abuja.

Shahbaz, M., Khan, S., & Tahir, M. I. (2013). The dynamic links between energy consumption, economic growth, financial development and trade in China: Fresh evidence from multivariate framework analysis. *Energy Economics, 40*, 8–21.

Shakil M.K, & Muhammed SU. (2018). Household level consumption and ecological stress in an urban area. *J Urban Sci*;**2**:9–32.

Sharif, A., Baris-Tuzemen, O., Uzuner, G., Ozturk, I., & Sinha, A. (2020). Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. Sustainable Cities and Society, 57, 102138. https://doi.org/10.1016/j.scs.2020.102138

Sharma, R., Sinha, A., & Kautish, P. (2021). Does renewable energy consumption reduce ecological footprint? Evidence from eight developing countries of Asia. Journal of Cleaner Production, 285, 124867. https://doi.org/10.1016/j.jclepro.2020.124867

Sinha, A., Shahbaz, M., Sengupta, T., (2018). Renewable energy policies and contradictions in causality: A case of Next 11 countries. Journal of Cleaner Production, 197, 73-84.

Szigeti, C., Toth, G., & Szabo, D. R. (2017). Decoupling–shifts in ecological footprint intensity of nations in the last decade. *Ecological Indicators*, *72*, 111–117.

Talevi M. et al., (2022). Speaking from experience: Preferences for cooking with biogas in rural India," Energy Economics, vol. 107, no. 105796, pp. 1–10, doi:https://doi.org/10.1016/j.eneco.2021.105796

Tiba, S., & Omri, A. (2017). Literature survey on the relationships between energy, environment and economic growth. *Renewable and sustainable energy reviews, 69*, 1129–1146.

Usman, M., Makhdum, M.S.A., & Kousar, R. (2020). Does financial inclusion, renewable and nonrenewable energy utilization accelerate ecological footprints and economic growth? Fresh evidence from 15 highest emitting countries. Sustain. Cities Soc. 65, 102590.

Wakernagel M., Rees W.E. (1996). Our ecological footprint: reducing human impact on the earth. New Society Publishers; Gabriola Island, Canberra, Australia: 1996. pp. 30–100. [Google Scholar]

World Population Review (2022). Ijebu Ode Population. Ijebu-Ode Population 2022 (Demographics, Maps, Graphs) (worldpopulationreview.com). 2022. Accessed June 20, 2022.

Xue, L., Haseeb, M., Mahmood, H., Alkhateeb, T. T. Y., & Murshed, M. (2021). Renewable energy use and ecological footprints mitigation: evidence from selected South Asian Economies. Sustainability, 13(4), 1613. https://doi.org/10.3390/su13041613

Zaidi, S., Danish, Hou, F., Mirza, F., (2018). The role of renewable and non-renewable energy consumption in CO2 emissions: a disaggregate analysis of Pakistan. Environmental Science and Pollution Research 25 (31), 31616-31629.

Zaku S, Abdallah A., Olayande, .J. Kabir, A., & Tukur, A. (2015). comparative studies of household energy use in nigeria: a case study of Gwagwalada and Gwako in Gwagwalada Area Council of Abuja-FCT" swift Journal of Economics and International Finance Vol 1(1) pp.005-009.