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ECOLOGICAL FOOTPRINT EVALUATION FOR ENVIRONMENTAL SUSTAINABILITY IN IJEBU ODE, OGUN STATE, NIGERIA

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ABSTRACT

The aim of this study was to evaluate the Ecological Footprint (EF) for Environmental Sustainability in Ijebu Ode. The study adopted a descriptive cross-sectional study design and the objectives were, to assess the average EF of Ijebu Ode. Both primary and secondary data were employed, and the primary data for this study was collected from four hundred (400) systemically sampled households through structured questionnaires, and analysed descriptively using the Statistical Package for Social Sciences (version 20.0). The findings revealed the average ecological footprint of the Ijebu Ode to be 0.3gha per capita, with the footprint of water as the highest contributor to the EF, with 0.9gha (86.5%) of the total footprint. Thus, the study concluded that, the average EF of Ijebu Ode is 0.3 gha and therefore sustainable. However, it was recommended that, sustainable consumption must be encouraged, implemented and demonstrated to sustain the current EF of Ijebu Ode and public campaigns should be encouraged and implemented adequately in light of increasing awareness of the adverse environmental impacts of unsustainable consumption.

Contribution/Originality: This study will prove very useful in identifying gaps in knowledge of Ecological Footprint in Nigeria, and also inform policy decisions on environmental development and sustainability.

1. INTRODUCTION

Of recent, there have been many discussions on the planet's global resources and the attention is primarily on the declining of the non-renewable assets. However, it is becoming more and more evident that the earth's renewable capital, and the environmental services it provides, are at serious or even greater risk [1, 2]. From 1961 to 2010, Ecological Footprint account shows that man's demand for renewable resources and environmental services rose by nearly 140% (i.e., from 7.6 to 18.1 billion global hectares), reaching a point where the earth's bio-productive area (increased from 9.9 to 12 billion global hectares) is no longer adequate to support the competing demands. In 2010, humanity demanded the equivalent of approximately 1.54 Earths' worth of provisioning and regulatory services [3].

Latest and on-going studies have shown that humanity's demands on nature's natural resources are increasing, conceivably beyond sustainable levels [4, 5]. This advocates the necessity for careful analysis and evaluations, which can measure and compare the competing demands on the earth's ecological resources, and according to the Global Footprint Network. [6], "Ecological Footprint is the only metric that measures how much nature we have and how much nature we use". This by implications gives rise to Ecological Footprint; a concept recently developed and

pioneered by Wackernagel. and Rees [7], but which has since become an established and vital environmental indicator of environmental sustainability.

EF measures the amount of biologically productive land and water area required to produce all the resources an individual, population, or activity consumes and absorb the waste they generate, given prevailing technology and resource management practices. This area can then be compared with biological capacity (bio-capacity), which is the amount of productive area that is available to generate these resources and to absorb the waste [8]. The footprint x-rays a picture that is a crucial measure of humanity's demand for nature's resources against nature's supply, and it is fast becoming progressively crucial at all levels - global, regional, national, as well as local, as a measure of environmental sustainability.

Thus, it gives an ideologically simple, instinctively interesting approach to integrating sustainability aims into the planning and development process. Even though, the EF does not denote social or economic well-being, it does mirror ecological welfare and provides a signal as to whether or not; the present-day consumption and production patterns are probable to be sustainable or not [9]. As a result, the ecological pressure of human activities is assessed as the area of biologically productive land and water area needed to generate the natural resources consumed and to absorb the wastes generated within the prevailing management and production practises for a given population, Wackernagel, et al. [5]. It does not only evaluate the sustainability of present-day activities by man, but also, proves very useful in creating general population awareness and supporting decision-making [9]. It is a measure of the amount of load placed by a defined population on nature [7].

The fight between the slow formation rate of natural resources and the rise in demand for these resources by man is the core concern of regional and world sustainable development. According to the World Wildlife Fund [3], human beings need at least 1.5 times the amount of Earth's resource regeneration capacity to provide for the total world consumption of environmental services, such as water pollution and desertification, meaning that human beings face serious and lifelong challenges. It is a fact that the most harm to the environment at the moment is not production but rather consumption of environmental and natural resources. The present-day paradigm shift is that environmental issues have moved from production to consumption [10]. It has been demonstrated that production is a function of consumption, and consumption determines human actions because it is dependent on the lifestyle pattern embraced by individual households. Thus, this needs a change from sustainable development to sustainable consumption [10].

As environmental issues are fast becoming a global and national concern, several investigations have been reported to assess the sustainability of cities, regions, and the world by estimating their average ecological footprint. For example, Humphrey [11] "in the recent Africa EF report documented that, "in 2008, the total productive area, or biocapacity, of the planet was 12.0 billion global hectares (gha) or 1.8 gha per capita. Humanity had an Ecological Footprint of 18.2 billion gha, equivalent to 2.7 gha per capita. This overshoot of approximately 50 per cent means that in 2008 we used the equivalent of 1.5 Earths to support our consumption, or in other words, it would have taken the Earth approximately a year and a half to regenerate the resources used by humanity in that year. This means that in order to sustain humanity's current pattern of lifestyles, we are drawing on resources at a faster rate than they can be renewed, eating into our ecological reserves". Similarly, a previous investigation by Kissinger, et al. [12] reported that, the global human population is using nature's assets more rapidly than the earth can regenerate. Moreover, several previous studies have demonstrated that per capita EF is negatively associated with numerous environmental consequences, such as pollution, among others [13-15]. Therefore, humanity's unsustainable consumption and production have been noted as the main factors in the sustained degradation of the environment [16] and, therefore, to institute a deviation from the existing trend in the consumption pattern of ecological assets and waste generation signifies a significant task [17]. From the Nigerian perspective, the degree of development has risen from 42.59% in 2009 to 51.16% in 2019 [18]. Increase in urban areas have triggered the growth of national economies and are certain to be accompanied by unparalleled consumption and loss of environmental resources [19]. Thus, measures to utilise

the growth opportunities presented by urbanisation and to facilitate Nigeria's urban assets and environmental resources for sustainable development must be given the much-needed research priority in light of the increasing concern and impact of EF on the sustainability of our natural resources.

However, though several researches have been conducted to investigate EF as a measure of environmental sustainability, there are very few previous studies that have addressed EF of households in Nigeria. This study would, therefore, prove very useful in identifying gaps in knowledge of EF in Nigeria, and it is envisaged that findings from this study would inform policy decisions on environmental development and sustainability.

Therefore, the main purpose and objective of this investigation is to evaluate the average Ecological Footprint Ijebu Ode, Ogun State, Nigeria.

2. MATERIALS AND METHODS

2.1. Study Area

The evaluation of the EF was conducted for the City of Ijebu Ode, which is located some 60 kilometres north-west of Lagos. The City of Ijebu Ode is the second largest in Ogun State, Nigeria, with a land area of 192 km² and an estimated population of 154,032 according to the 2006 national census See, Figure 1.

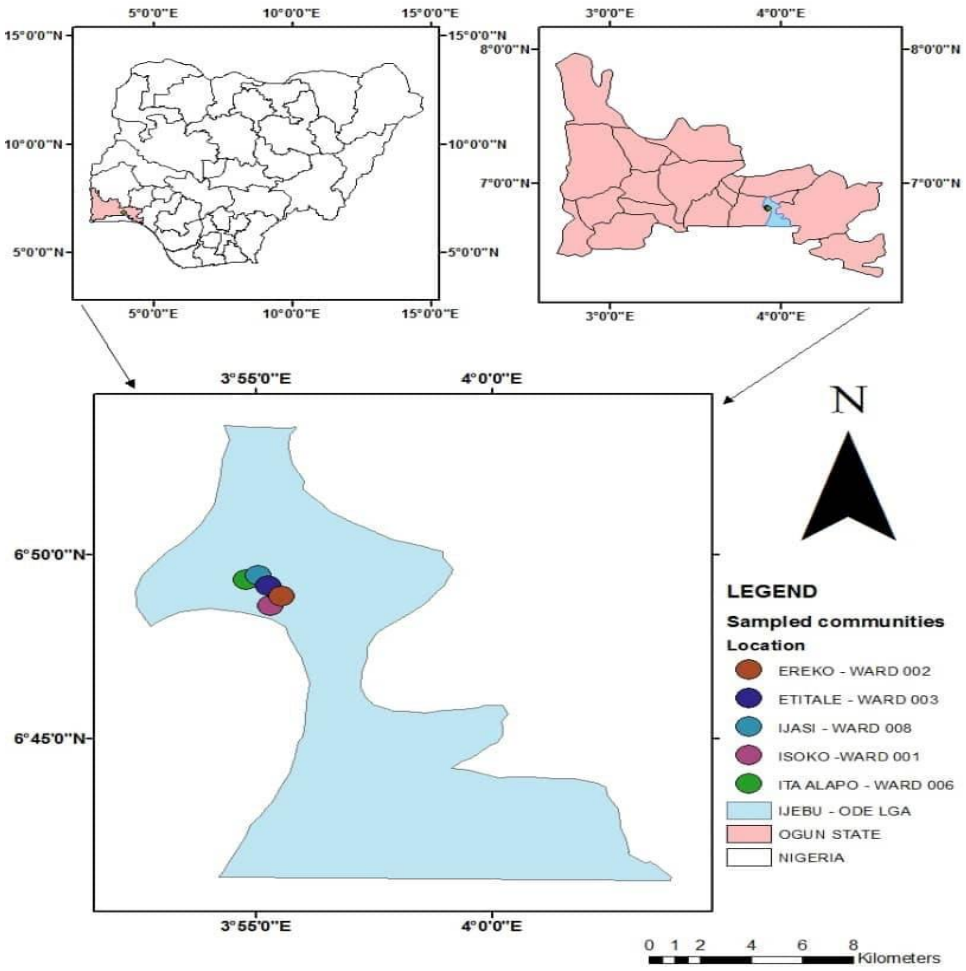

Figure-1. Spatial Map of Ijebu ode showing the sampling locations.

2.2. Sample and Sampling Techniques

A sample size of four hundred (400) respondents was selected for the study and was determined using Slovin's formula for sample size determination (see Equation 1), at error margin of 0.05 and a 95% confidence level;

$$n = \frac{N}{1 + e^2} \quad (1)$$

Sciencing.com [20].

Where;

n = sample size.

N = population size.

e = margin of error.

The sampling was achieved using simple random sampling in selecting five (5) wards out of the eleven (11) wards in Ijebu Ode, with eighty (80) respondents sampled from each ward, therefore, making up the required four hundred samples, while a systematic random sampling technique was later used in the selection of residential households in each of the selected wards at an interval of every fifth house.

2.3. Data Collection Procedure

Primary data for this study were obtained by means of structured questionnaire administered on a systematic sample size of four hundred (400) households. The primary data includes four hundred (400) household questionnaires; this was used to elicit information on the ecological footprint of food, water, energy consumption, and waste generation (see Table 1) from respondents of the study area in the selected five wards of Isoku/Ososa, Odo/Esa, Itantebo/Ita Ogbin, porogun I, and Ijasi/Idepo of ijebu ode LGA. The questionnaires were administered with the help of some of the 400 level students offering Environmental Health Technology. The secondary data was also collected from organisations such as Global Footprint Network, Food and Agricultural Organization, National Bureau of Statistics (Nigeria), National Population Commission, Nigerian Electricity Regulatory Commission (NERC), and other web-based publications (see Table 2).

2.4. Method of Data Analysis

Data collected for this study was analysed both descriptively using Statistical Package for Social Sciences (version 20.0) and through inferential statistics using mathematical models for Ecological Footprint calculations and the results presented using the pictorial variable such as histogram and pie-chart.

Table 1. Considered components for the derivation of EF.

Food	Grains	Beverages	Fish	Fruits	Meat	Turkey/chicken	Egg	Vegetables
Water	Laundry	Bathing	Kitchen	WC	Drinking	-	-	-
Energy	Electricity	Gas	Kerosene	Firewood	Charcoal	Generator	-	-
Waste	-	-	-	-	-	-	-	-

Table 2. EF data requirements and sources.

S/N	Data	Source
1	Demographic Data	Field Survey
2	Population (Ijebu Ode)	NPC [21]
3	Footprint Consumption Data	Field Survey
4	Electricity Tariff/Kwh	NERC [22]
5	Yield Factors	GFN [23]
8	Equivalence Factors	GFN [23]

2.5. Determination of EF

The EF of Ijebu Ode was estimated based on the footprints of the consumption of food, water, housing, energy, and waste generation, and the analysis shown below.

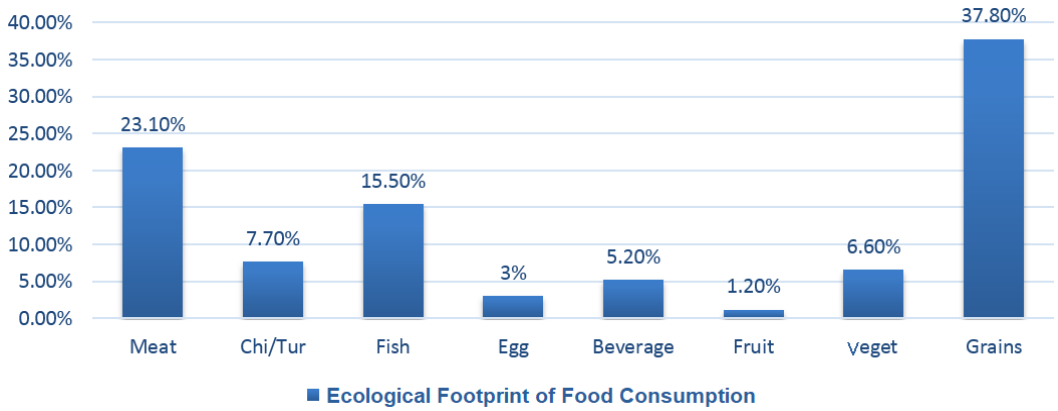

Figure 2. Footprint of food consumption.

2.5.1. Determination of the EF of Food Consumption

The footprint of some major food categories consumed in Ijebu Ode, includes Grains, Beverages, Fruit, Meat, Fish, vegetables and chicken/Turkey was determined (see Figure 2). The total amount of annual food consumed was determined from the empirical survey. This value was converted to consumption in kilogrammmes by dividing the annual cost of consumption with the average amount of 1 kg of food from the market survey, which is in this case, 420 naira (Field survey, 2021). The consumption per kilogramme was also converted to consumption per tonne by dividing it by1000. The footprint in global hectare was thereafter obtained by dividing the consumption in tonnes with the yield factor of forest land (0.88) also by multiplying the resulting value with the national equivalence factor (2.52) and embodied energy of the food consumption in tonnes [23]. The EF per capita was therefore computed by dividing the global hectare footprint with the population of 154,032 [21], living within Ijebu Ode [24]. This gives the footprint in global hectare per capita as expressed in Equation 2:

$$EF_f = \sum_1^8 \frac{C}{Y_c} \times E_f \times EE \quad (2)$$

[24].

Where;

EF_f = EF of food (gha/capita).

C = food consumption in tons.

EE = embodied energy (MJ/kg).

Y_f and E_f = yield and equivalence factor.

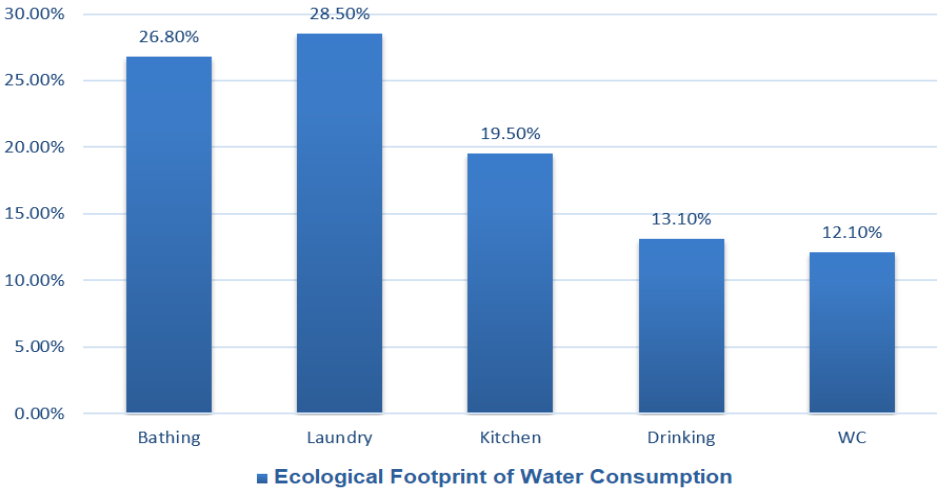

Figure 3. Footprint of water consumption.

Figure 3, indicates the various water consumption with laundry as the highest with 28.5%, bathing 26.8%, followed by kitchen activities with 19.50%, drinking and sanitation with 13.10% and 12.1% respectively.

2.5.2. Determination of the EF of Water Consumption

The annual amount of water consumption in litres used per household was determined from the empirical survey. The embodied energy for water reported was 2000 kWh/mg [25], which was later converted to mega joule per kilogramme (MJ/Kg) by dividing 2000 kWh/mg with 0.2778 kWh (equivalent to 1 MJ) and 1000 mg (equivalent to 1 Kg) [4]. The energy value in kWh was thereafter obtained by multiplying the embodied energy with the annual litres of water consumption, 16,244,280 L from the empirical survey. The resulting value in kWh was converted to MJ by dividing it by 0.2778kWh. The carbon dioxide (CO_2) emission in Kg/MJ was also obtained by multiplying the CO_2 emission in kilogram with the embodied energy in MJ/Kg and 0.2778 kWh [25]. The EF in global hectare was thereafter obtained by dividing the energy value in MJ with the national yield factor for inland water (0.38), also multiplying the resulting value with the equivalence factor (0.38) [24], and CO_2 emission in Kg/MJ [23]. The EF per capita was therefore computed by dividing the footprint in global hectares with the population of 154,032 [21] as expressed in Equation 3:

$$EF_w = \sum_1^5 \frac{EV}{Y_f} \times E_f \times CO_2\ gas\ emmission\ \left(\frac{kg}{MJ}\right), \quad (3)$$

Fadeyibi, et al. [24].

Where;

EF_w = EF for water consumption.

EV = energy value.

Y_f and E_f = yield and equivalence factor.

$CO_2\ emission$ = carbon dioxide emission.

3. RESULTS AND DISCUSSIONS

3.1. EF of Food Consumption

The footprint analysis of food revealed that, the EF of food in Ijebu Ode is 0.05 gha per capita, the third lowest with 4.8% of the different EF components, as shown in Table 3. The probable reason may be unconnected to the unprecedented rise in the price of food and food items and the current economic hardship in the country. Similarly, according to the National Bureau of Statistics [26], 60% of the population of Nigeria depends on locally grown food items, whereas, the high income group consumes more imported food, which is highly processed and packaged, and has a greater impact on the EF of the country. More so, an increasing population means an increase in household demand and consumption of resources, which influences the EF and Ijebu Ode has a relatively low population of 154,032 according to Census 2006 [21]. This result agrees with a recent work by Fadeyibi, et al. [24] on Ecological Footprint for Environmental Sustainability in the Ilorin Metropolis of Kwara State, which reported the EF of food to be 0.02gha with 5% of the various footprint components.

Table 3. Ecological footprint summary.

S/N	Footprint	EF (gha)	%
1	Food	0.05	4.8
2	Energy	0.07	6.7
3	Water	0.9	86.5
4	Waste	0.02	2.0
Total		1.04	100

A similar study on household level consumption and ecological stress in urban area by Shakil and Muhammed [27] revealed the EF of food to be similarly low, with 17% of the different footprint components. However, in contrast, Ojo and Razck [28] on Appraisal of Resource Consumption Pattern on The Ecological Footprint of Bida, revealed the EF of food to be the highest, with a footprint of 0.38 gha making up 57.25% of the whole footprint of Bida. According to Konstantina [29], the waste caused by the food industry threatens biodiversity, topsoil, the marine environment, and the climate itself. The carrying capacity of the planet is running out. Food production uses 34% of arable land and 69% of purified water. The devastating environmental consequences, however, are not limited to this. Standardized products accounts for 24-30% of greenhouse gas emissions, contributing to global warming and extreme weather events.

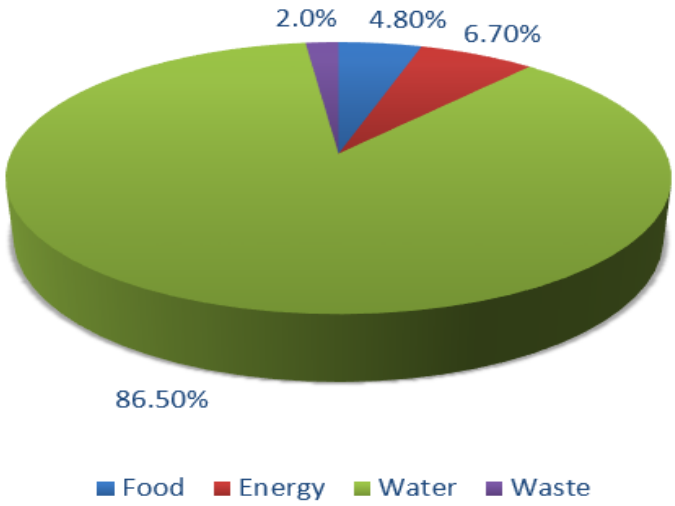

Figure 4. EF summary of Ijebu Ode.

3.2. EF of Water Consumption

Further analysis of the EF of water consumption in Ijebu Ode revealed the per capita EF of water to be 0.9 gha, and the highest of the footprints with 86.5% (see Figure 4 and Table 3). A possible explanation for this might be the availability and accessibility of water in the study area, as the majority of households have boreholes or wells, and there is provision of water collection points to cater for households with no water sources, which translates into more water consumption due to availability. This result is in agreement with the result of Fadeyibi, et al. [24] on Ecological Footprint for Environmental Sustainability in the Ilorin Metropolis of Kwara State, which reported the EF of water to be 0.108gha per capita. However, in contrast, is the finding of Ojo and Razck [28], on the Appraisal of Resource Consumption Pattern on The Ecological Footprint of Bida, which revealed the EF of water to be 0.002 gha the lowest of the footprint categories at 0.3%, a result which, according to the author, is because public water supply in Bida is regarded as the borehole sunk for the community or water supply delivered to households by tankers.

3.3. Ecological Footprint of Ijebu Ode

The ecological footprint has been reported to be the best metric for measuring sustainability at an individual, household, community, and country level. This has made it a utility tool for environmental sustainability. The Ecological Footprint of Ijebu Ode presents the different categories of consumption across the components of the footprint measurement. The footprint analysis shows the ranking of the components of the footprint according to their consumption rate (see Figure 4). The water footprint accounts for 86.5% of the entire footprint of Ijebu Ode. This is an indication that water is available and consumption is high. It also shows the importance of water as a means of hygiene and survival in the study area and above others as it is relatively free and available for usage, and thus the high demand placed on water consumption vis-a-vis the high percentage of the footprint towards water. The food

footprint is the third highest of the EFs of Ijebu Ode, with 4.8%. This is an indication of the current economic situation and the rise in the price of food items, which automatically influences the rate of consumption, and thus the position of the EF of food in Ijebu Ode.

However, the present study further showed that the average EF of the study area was 0.3 gha per capita. It is therefore encouraging to compare this figure to the average EF of Nigeria, which is 1.0 gha per capita [6], which is indicative that Ijebu Ode is an Ecological Reserve.

4. CONCLUSIONS

In conclusion, the EF analysis revealed the average ecological footprint of the study area to be 0.3gha per capita, with water consumption as the highest contributor to the EF at 0.9gha (86.5% of the total footprint). The study therefore concludes that, the EF of Ijebu Ode is 0.3 gha, and therefore sustainable. However, though it is lower than the global average, there must not be room for complacency as failure to sustain and/or reduce consumption can lead to unsustainability in the future. Therefore, it is recommended that sustainable consumption must be encouraged, implemented and demonstrated to sustain the current EF of Ijebu Ode, and public campaigns should be encouraged and implemented adequately in light of increasing awareness of the adverse environmental effects of unsustainable consumption.

However, the present evaluation of the *EF* is majorly focused at the household level and there are very few investigations into the EF of cities, especially in Nigeria, and this is an important issue for future investigation.

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Authors' Contributions: All authors contributed equally to the conception and design of the study.

REFERENCES

[1] UN Environment Programme, *Global environment outlook 4: Environment for development.* Valletta, Malta: Progress Press Ltd, 2007.

[2] UN Development Programme, "Human development report 2007/2008 fighting climate change: Human solidarity in a divided world. http://hdr.undp.org/en/reports/global/hdr2007-2008/chapters/ [Accessed Date February 2010]," 2008.

[3] World Wildlife Fund, "Living planet report 2014: Species and spaces, people and places. Retrieved from www.panda.org. [Accessed Date October, 2021]," 2014.

[4] J. Rockström, W. Steffen, K. Noone, Å. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, M. Scheffer, C. Folke, and H. J. Schellnhuber, "A safe operating space for humanity," *Nature*, vol. 461, pp. 472-475, 2009.

[5] M. Wackernagel, N. B. Schulz, D. Deumling, A. C. Linares, M. Jenkins, V. Kapos, C. Monfreda, J. Loh, N. Myers, and R. Norgaard, "Tracking the ecological overshoot of the human economy," *Proceedings of the national Academy of Sciences*, vol. 99, pp. 9266-9271, 2002.Available at: https://doi.org/10.1073/pnas.142033699.

[6] Global Footprint Network., "Data and methodology. Retrieved from: http://www.footprintnetwork.org. [Accessed Date October, 2021]," 2021.

[7] M. Wackernagel. and W. E. Rees, "Our ecological footprint – reducing human impact on the Earth," ed Gabriola Island, B.C., Canada: New Society Publishers, 1996, p. 160.

[8] B. Ewing, A. Reed, A. Galli, J. Kitzes, and M. Wackernagel, *Calculation methodology for the national footprint accounts.* Oakland: Global Footprint Network, 2010.

[9] R. A. Begum and J. J. Pereira, "Holistic ecological footprint for Malaysia," *Journal of Applied Sciences Research*, vol. 8, pp. 4783-4787, 2012.

[10] E. Holden, "Ecological footprints and sustainable urban form," *Journal of Housing and the Built Environment*, vol. 19, pp. 91-109, 2004.Available at: https://doi.org/10.1023/b:joho.0000017708.98013.cb.

[11] S. Humphrey, "Africa ecological footprint report: Green infrastructure for Africa's security," ed Tunisia: WWF International; African Development Bank, 2012, pp. 1-71.

[12] M. Kissinger, C. Sussman, J. Moore, and W. E. Rees, "Accounting for the ecological footprint of materials in consumer goods at the urban scale," *Sustainability*, vol. 5, pp. 1960-1973, 2013.Available at: https://doi.org/10.3390/su5051960.

[13] A. Bergesen and T. Bartley, "World-system and ecosystem," *J World Syst Res*, vol. 3, pp. 364-368, 2000.

[14] T. Burns, B. Davis, and e. a. Jorgenson AK, "Assessing the short- and long-term impacts of environmental degradation on social and economic outcomes. Presented at the annual meetings of the American sociological association, august," ed Anaheim: CA,. Press, 2001, pp. 155-176.

[15] R. Tucker, "Environmentally damaging consumption: The impact of American markets on tropical ecosystems in the twentieth century. In confronting consumption, Princen T, Maniates MF and Conca, K (Eds.)," ed Cambridge, MA: MIT Press, 2022, pp. 177-196.

[16] R. Simpson, A. Petroeschevsky, and I. Lowe, "An ecological footprint analysis of Australia," *Journal of Environmental Management*, vol. 7, pp. 11-18, 2000.

[17] J. Barrett and A. Scott, *An ecological footprint of liverpool: Developing sustainable scenarios*. York: Stockholm Institute, 2001.

[18] Statista, "Urbanization in Nigeria. Retrieved from: www.statistica.com. [Accessed date October, 2021]," 2020.

[19] H. Suzuki, A. Dastur, S. Moffatt, and N. Yabuki, *World Bank eco cities*. Canberra, Australia: World Bank, Australian Agency for International Development (AusAid), 2009.

[20] Sciencing.com, "Sciencing.com. Retrieved from: www.sciencing.com [Accessed Date on Nov. 6th, 2021 at 11.02am]," 2021.

[21] NPC, "National Population Commission. Retrieved from: www.nationalpopulation.gov.ng. [Accessed Date Oct. 2021]," 2006.

[22] NERC, "National Electricity Regulatory Commission. Retrieved from: www.nerc.gov.ng. [Accessed Date Oct. 2021]," 2021.

[23] GFN, "National footprint accounts. Retrieved from: http://data.footprintnetwork.org. [Accessed Date October, 2021]," 2019.

[24] M. Fadeyibi, H. O. Sawyerr, and G. Salako, "Ecological footprint for environmental sustainability in ilorin metropolis, Kwara State, Nigeria," *International Journal of Low-Carbon Technologies*, vol. 00, pp. 1–8, 2020.

[25] EPA, "Greenhouse gases equivalencies calculator. Guidelines for national footprint inventories," ed Washington: U. S: Environmental Protection Agency, 2017, p. 201.

[26] National Bureau of Statistics, *National manpower stock and employment generation survey (Households and micro enterprises: Informal sector)*. Nigeria: NBS Publications, 2010.

[27] M. Shakil and S. Muhammed, "Household level consumption and ecological stress in an urban area," *Journal of Urban Sciences*, vol. 2, pp. 9-32, 2018.

[28] O. Ojo and N. Razck, "Measuring the sustainability: Appraisal of ecological footprint of Bida, Niger state, Nigeria," *J Res Gate*, vol. 6, pp. 6-12, 2018.

[29] R. Konstantina, "The ecological footprint of nutrition," *International Journal of Scientific Research and Engineering Development*, vol. 3, p. 1380-1382, 2020.