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Research Article

Ecological Footprint of Housing in Minna, Nigeria

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Abstract

Structural growth along the peri-urban fringe of Minna city along Minna-Bida road has become a major source of concern to development planners and urban administrators because of the uncoordinated and unplanned nature of these structural expansions. This study is aimed at evaluating the household ecological footprints (EF) within the residential developments in the city; and the objectives include; estimate the ecological footprint of housing by households, estimate the size of dwellings, appraise the construction materials used, determine the household energy sources and estimate the ecological footprint of Minna. This research undertaking was with the use of primary source data collected using prearranged questionnaire that enables the computation of EF and bio-capacity latent of Minna. The procedure involved the computation of the EF of Minna through the EF calculator to estimate total consumption for all the components of the EF by family units (commonly in tonnes), adaptation of the capital consumed to EF (gha) and calculating EF per capita (gha). Buildings Ecological Footprint is the largest energy flow in Minna urban metabolism (235,050,499 GJ). Electricity consumption account for 25.0% (45,770,538.75 GJ) of the total energy in the city usually demanded for lighting and cooking. An extra 12,992,086GJ of energy is used for embodied energy within the building construction and maintenance in Minna. This study therefore recommends that Housing, planning with regulation of energy efficacy budgets are prerequisite to reducing household EF in the city. Conclusively, therefore, Urbanization has become the cornerstone of globalization; cities must therefore play a greater role in determining sustainability potentials of any society.

1. Introduction

Growing human populace with urbanisation had affirmed that the changing strength to the assets usage (both natural and man-made) is in-gestation. Environment has obstinately played the role of provider of resources with absorber of the remnants produced through human activities of in- gestation[1-2]. The view that vast majority of the world's populations settles in municipal centres which persistently expand promptly. This assertion was endorsed by the United Nations Habitat report of 2008/2009 that fifty percent of the human race lives in municipal zones ever since 2007[3]. Though metropolitan zones internationally take merely 2% of the entire biosphere landmass, it has a huge implication on environment since conurbations are responsible for in gestation of more than 75.0% of the biosphere's assets usage with around 80.0% of Greenhouse Gas (GHG) release[2]. This pinpoint that development has remained a dangerous process of human activities on the vegetation and wildlife with global bio-capacity. Development has caused ecological deterioration, replacement of natural arrangement with artificial one because of over in-gestation of natural resources. Therefore, the built-up centres have to carry out a serious role in the conservation of the environs and ecology therein. It is extensively proven that the constant growth of our municipalities is causing greater and various environmental effects on the ecosystem. Growing built-up centres gulps farmland with vegetation and wildlife, reduce indigenous bio-output and bio-ability; though growing human requirement intensify the need for nature and manmade resources with extra ecological assets[4-5]. Conurbations globally depend on their surrounding area to provide input (natural reserve) and as well transmit the productivity (waste) to them[6-7]. Consequence of this action is that natural resources are actually exploited at a rapid rate that is not maintainable in relation to earth's regenerative capacity. Economic advancement has remained the utmost significant thing that is causing the un-maintainability of the biosphere. Trade and industry growth implies the manufacture and in gestation of both natural and non-natural assets that are delivered by the environs. The consumption of these resources has brought a lot of damages to ecosystem at global and national level[6-9]. The interaction between man and environment is dynamic and could transform over a period, it is this with numerous other elements that could result to ecological loss and decrease of the earth's bearing ability to sustain human life. Frequent development of our municipalities and conurbations has significant outcome on our ecosystem. Environmental consequence of development has remained subject of discussion in the aspect of sustainability. The upsurge in populace showed that there would be a greater request on natural's resources and other environmental necessities[10]. City arrangement is an incorporation of energy ingesting for transport and domestic populace size. Additionally, for significant sustainability to be achieved attention need to be set for the arrangement and role of the built-up area. Consequently, the arrangement and objective of a city growth spatially would reduce the environmental consequence that a city setting has on the ecosystem if in-gestation of resources is maintainable. Maintainable growth has to be capable of responding to diversity of troubles raised by populace upsurge, the worldwide restricted bio-ability, and social difference. In 2100, the inhabitants of the biosphere will be nearly 10 billion[3] nonetheless the worldwide natural resources is inadequate. This has resulted to man usage of resources to be on the upsurge meaningfully. Greenhouse gas emission is part of the key repercussion result of people's way of life and ingestion of resources which in turn accelerate

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international warming. Minna as a fast growing city is experiencing population influx which in turn requires the consumption of resources. Therefore the problem of consumption of arable land for construction of built-up area has been a problem because agricultural land is used for construction of houses. This brings about the danger of insufficiencies with disruption of precise natural arrangements such as shortage of drinkable water (H_2O), lack, deterioration of agrarian land, deforestation, with shortened environment damage. The insinuation of this is that the imminent development of vegetation and wildlife existence on the earth will ultimately be at danger as well as human beings. Numerous difficulties originate from the problem of sustainable development which is perquisite to this inquiry. The leading among the issues of sustainable development that relates to in gestation of assets is the level of ingesting of such resources. Concepts have showed that resources on the globe are persistent and need appropriate organization in other to be able to provide for the requirement of the current and upcoming society[11-13]. The in-gestation of nutrients and energy has remained a foremost issue in the nourishment of man in the biosphere hence; the manufacture of food has turn out to be a universal difficulty as the populace has showed to be growing further than the food manufacture14. There is increase in the consumption of resources in Minna as established by National Bureau of Statistics indicated that the extent of consumption in Minna between 1990 and 2010 increases 25 folds[15]. This research is aimed at evaluating the household ecological footprints (EF) within the residential developments in the city; the following objectives were also set; estimate the ecological footprint of housing by households, estimate the size of dwellings, appraise the construction materials used, determine the household energy sources and estimate the ecological footprint of Minna.

1.1 Study Area

Minna is positioned along leeway 9 0 37' North and longitude 60 33' East. The northeastern zone of the urban area has rock protrusions which act as physical restriction to expansion (Minna Master Plan 1980). Nevertheless the incident of development has result to the infringement of the underground base of the hill for city expansion. The metropolis of Minna has developed from a meagre resident area to a metropolitan that now doubles as the Niger State capital and the headquarters of Chanchaga Local government. Owing to growth of the metropolitan Minna has at present annexed part of Bosso Local Government. These two Local Government Areas are combined to make up the genuine borderline of Minna metropolis for this research. The present-day metropolis is extensively extent to both sideways of the key arterial dual carriage way from Maikunkele in the north to Chanchaga in the south - a trip that is approximately 20 km. There is unequal expansion of the metropolis (Little expansion at the North-East) owing to sharp slope, wearing away, and submerging and soil variety. The additional restrictions are drainage channel at the heart of the metropolis that runs South-Westward with several slight drainage networks, which caused overflowing in the metropolitan in present time. The properties that exist outside the current developed section appropriate for city expansion, particularly at the peripheries, nevertheless these needs cautious plan to retain the construction costs of drains, bridges, embankments and drainage work as rational as possible. Minna is just about 200 km from Abuja, the central headquarter of Nigeria. It covers just about 100,000 Hectares of land at the current growth. The relationship of Minna in Niger state is pointed out in Figure 1 and 2. Minna as the political headquarter of Niger state is undergoing increase proportion of development with present-day development rate of 4.8% per annum (NPC, 2011). This has improved the population of around 200,000 in 1991 to approximately 402,000 in 2012 which inevitable increase in-gestation of resources in the metropolis. This called for the evaluation of the sustainability prospect of the metropolis by measure such as EF.

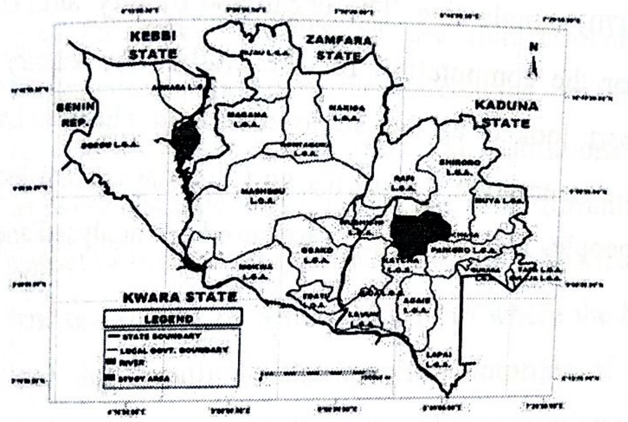

Figure 1: Niger State in the National Context

Source: Diva GIS, 2011

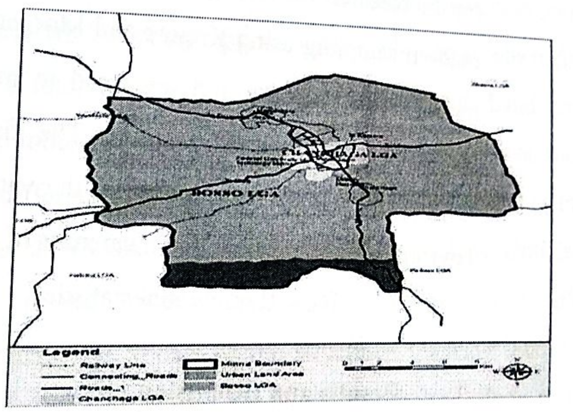

Figure 1: Minna and its Composite LGA, Niger State Source: Diva GIS, 2011

2. Methodologies

This inquiry was carried out through the method of experimental assessment that involves structured inquiry form that proved the computation of EF and bio-capacity prospect of Minna. The procedure of computing EF of Minna involves calculating the resources gulped in the city. The technique involve the calculation of the EF of Minna through the EF calculator to estimate the total consumption for all the components of the EF by family units' (usually in tonnes), Translation of the natural resources gulped to EF (gha) and computation of EF per capita (gha). The estimation of Bio-ability also include calculate approximately the summation of the entire land area of Minna land varieties (arable land, pasture land, forest land, fishing ground, developed land and energy land) and multiply it with the corresponding and produce factor of the nation (Nigeria) since there is no indigenous yield and equal factor. The Bio-ability is calculated through Consumption Land Use Matrix (CLUM). The procedure for carrying out the research involves gathering of information through organized inquiry form that recognizes the six (6) classifications

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of in gestation in EF, estimating the Bio-capacity of the city, gathering of information on environmental behaviour and socio-economic features of the people of Minna. Subsequent is transformation of consumption to divisions of EF and bio-capacity through the EF calculator and CLUM. This then established the sustainability potential of the city. SPSS software was used to analyse the perception of the people about environmental awareness and behaviour. This therefore establishes the relationship between EF and the lifestyle of the people. The city of Minna was stratified into seven strata (localities) and stratified random sampling technique was used for stress-free administration of the inquiry form. Simple random sampling was used inside every section to choose the respondents. The entity of measurement used for the research was family units'. A total number of 400 family units' were tested by means of the simple random sampling using Krejcie and Morgan (1970) sample size. The organized inquiry form comprises a multi choice response and was used to monitor the computation for the study. The inquiry form was separated into eight (8) sections. The first part looked at the socio-economic characteristics of the respondents, six sections looked at the various consumption categories and the last section looked at the environmental behaviour and awareness of the people. The information gathered are analysed and offered in both descriptive and inferential statistics.

3. Results and Discussion

3.1 Ecological Footprint Calculation for Housing by Households

This section of the research estimates for the EF of housing in Minna. This involves calculating the land enclosed by housing in addition the area that is part of the house including courtyard, garden and garage. Also the woodland part utilizes to supply construction materials and the embodied energy adopted for the construction and function of the houses. Table1 indicated the land types that make up the EF for housing in Minna:

Table 1: The Ecological Footprint Land Types used for Housing in Minna

Categories	Land Type
Floor area used up	The land covered by housing, including houses, sheds and garages.
Floor area for courtyards and kitchen garden	The land area covered by courtyards, car parks and gardens.
Forest land	The forest land used for producing construction materials for housing.
Energy	The energy used for the operation of the domestic activities - illuminating, food preparation, space and water heating
Embodied energy	The energy used for the erection, upkeep and clearance of houses.

Fieldwork, 2013

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Housing occupies land that cannot be used for other purposes, therefore it is known as "consumed land" for the aim of computing the EF. The quantity of land consumed by housing in Minna is the land that houses were built on and allied constructions like gazebos with parking garages. This part is estimated through the multiplication of the number of houses by half of the area enclosed by each house. Houses within Minna according to this research comprise distinct houses, joined-houses, row or veranda houses, suites, houses joined to shop etc. Structures may be small house, storey or multi-storey. The housing category includes the impact of residential consumption and includes all energy and natural gas consumption in residential housing as well as the quantities of land and wood utilized for housing. Residential electricity consumption uses the same process as the non-residential electricity consumption value. The final electricity consumption represents the percentage of Minna's total electricity consumption delivered. Land area includes all residential, commercial, institutional, and industrial land taken up by man-made structures, such as buildings, sidewalks, and yards. This formula is different than the other categories in this study, as the impact of built area is directly the area taken from the data without converting to CO2 emissions. Utilizing land-use figures of Minna city from where the built-up land area is calculated. While the impact of built-land should only be the specific footprints of buildings, the impact of the structures (parking lots etc) extends to the surrounding site. This overestimate of the amount of land occupied by buildings allows us to take into consideration impervious and unproductive land caused by placing buildings to any site. The impact of the wood used to construct new housing is also included in the housing impact category. The embodied energy of wood is the major element of this calculation. Using the number of housing permits issued in a given year, the embodied energy of each structure is calculated using an average number of board feet of wood per typical 2000 square foot house, assuming most residential structures use wood for their roofing. The board feet estimate must be converted into kilograms of wood. Once the mass (kg) of wood used in an average structure is calculated, this mass is multiplied by the CO_2 factor of the embodied energy it took to manufacture the wood.

3.2 Estimated Size of Dwellings in Minna

The analysis of the various houses in Minna indicated that the floor area varies between different 100 m2 and 500 m2. Approximate floor area of built houses in Minna is about 155 m2 has been assumed for the extent of the average residential unit in the city. Nonetheless, this estimate includes only the fundamental residential area, devoid of garages, verandas and storage sheds. If all these constructions are incorporated (Simpson et al., 1997), the built area enclosed by the average dwelling in Minna is raise to about 205 m2 as shown in Table 2.

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Table 2: Area Covered by Houses and Associated Buildings

Building Type	**Area (m^3)**
Dwellings	155
Garage	24
Verandah	6
Courtyard	20
Average Total Area	**205**

Fieldwork, 2013

The method of erection of houses needs the dissipation of both straight and unintended consumption f families to be set in place with the usage by the families yearly. The breakdown reflects the amount, materials, embodied energy, conveyance required; energy required for the period of erection and upkeep the structure, the land needed for building and a number of others required (Barrett et al, 2004). The EF housing here put into consideration the quantity of land required to satisfy the erection of the houses need by the family units'. The EF of diverse varieties of house has varying transformation issue. House such separate, joined-houses, domestic house, apartment building etc. is well thought-out in the research. T issues deliberate on the useful lifetime. (age of the structure), strength, face-lift, use again and upkeep. T EF of housing is compared to land taking away from bio-productive undertakings and as a result, usage the information of farmland for its computation. The building materials used for construction in Mi varies between the conventional sandcrete block (hollow bricks) and the mud houses. The former is m used because of it been a better material and easily available through expensive (as a brick prices ran between N120 and N150 for 6 and 9 inches hollow bricks). The other material for construction inclu wood, iron rods, concrete, sand, zinc, aluminium roofing sheets, large window is allowed in the buildi because of humid nature and heat generated by these roofing materials. The ranges of the building include tenement houses, flats, duplexes and terrace housing. The size of the floor area of the building varies as indicated in Table 3. Most of the household energy consumption comes from electricity (30%) 70% from other sources such as gasoline generators. Water to the households is also obtained f alternative sources such as borehole, vendors, shallow well and streams within the city. Majority of washing of clothes are carried out in the streams. The embodied energy used in the housing EF obtained from electricity, LPG, kerosene, charcoal and firewood. Diverse families dwell in dissim magnitude of structure and consequently characterized as a result. The usage of exchange factor of 3.1 universal correspondent. The improve factor is well-thought-out to be 40% that consequently make factor to be 4.42 which was used for this study. The ground base is where the structure dwells in relate entire location of the structure was also deliberated. The ground base was known by division of domestic total area inside the house by the entire figure of the populaces in the household. The calculation is summarised in Table 3.

Table 3: Estimated Direct EF of Housing Construction in Minna

Housing Components	Average Size (m²)	GER (Gj/ m²)	Total Energy (Gj)	EF (gha
Main Building	155	2.63	182,736,200	0.095
Garages	24	1.83	48,913,988	0.009
Verandah	6	0.30	2,411,551	0.005
Courtyard	20	0.58	988,760	0.008
Total	**205**		**235,050,499**	**0.117**

Fieldwork, 2013

3.3 Building Construction Materials

Several building materials were used for construction in Minna. Some of the major materials are sand making bricks and wood. The amount of wood used in constructing an average 180m² brick (sandcr house is estimated to be between 17-18 m3. Around 5 m3is needed to construct a flat. It is assumed that approximation does not include the usage of wood used for building gazebos, garages, with others. Minna around 99.0% of buildings are product of sand Crete blocks, with around 82.0% of buildi constructed using reinforce slab floor covering. The woodland area therefore required to arrange for log computed by calculating the Mean Annual Increment (MAI) of logs gathered. A medium MAI of m³/ha/yr. usages is, established on the respective MAIs of broad leaved hard wood and the assumption t for house constructed in Minna. The assumption for total forest EF of Minna per capita is. An avera yearly increase 16 m3/ha/yr for wood land use coupled with extra 20.0% of wood usage for garag gazebos, floors, etc; a projected lifespan of 99 years for buildings, A projected extra 34.0% usage of lo for maintenances, preservation, leeway. The estimated timber used for construction in Minna and the EF such wood product is 64,822 m³ and that produces 0.0011gha of EF. Furthermore, calculating the energ land imprint includes computing the quantity of energy usage for the process, building, upkeep an throwing away of housing: Procedure energy comprises the energy usage for the everyday running of th domestic homes -heating/refrigerating, illuminating, food preparation, power to keep appliances working and others; Building energy comprises the "embodied energy" which was harnessed to extract the construction resources from natural resources; Upkeep of the structure needs vitality for the lifespan of the structure, projected to be around 50 years; and the clearance of the structure and dumping of the materials would also need energy.

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3.4 Energy consumption in the Running of the family units

The continuing running of the household needs a continuous usage of energy, for illuminating, foo preparation, boiling, and hot water H2O etc. the in-gestation of energy for keeping buildings is growin Within the period of twenty (20) years from 1990 to 2010, this upsurge was from 17 to 19.6 GJ pe individual (16%), and is projected (NBS, 2011) to upsurge to 21.6 GJ per individual by 2015. Energ supposed to be Minna's main form of residential energy use but epileptic supply has reduced it. The use o fossil fuel in generating residential electricity use is on the increase, for example the use of fossil fue increased from 3254,472 GJ, or 1.84 Gj per person per annum. Kerosene in Minna indicated that abou 4.568 PJ (2.64 GJ/individual) of kerosene were aimed at local purposes mostly for space and wate warming. Fuelwood has a projection of 650,000 tonnes of logs transported annually, and an energ constituent of 13.2 Gj/tone. This gives a consumption amount of 989,000 Gj (1.99 Gj/person). Very littl quantity of natural gas is used in Minna homes because of its cost.

3.5 Embodied Energy for Building Erection, Maintenance with Renovation

The power used in the erection and maintenance of houses is known as personified energy which is the energy used to extract, produce and convey housing resources, also to build the structure. Throughout the previous 20 years, the energy strength of buildings in Minna has improved owing to modifications in design and erection. Present houses are extra classy architecturally and employ the use of building materials which includes fired clay bricks, aluminium roofing sheets and others which were not used in construction in the past. Also the magnitude of buildings is growing; the full drive used in erecting houses is increasing evidently. The quantity of personified energy in precise materials differs; therefore the option of housing materials influences the entire sum of energy used in a residence. The personified energy necessities of the constituents of a building, stated as the Gross Energy Requirements (GER), calculated in Mj/ m2, are summed to offer an estimation of the entire GER for the buildings. The GER is the quantity of all the energy that has gone into the construction, as well as energy for: mining, processing and conveying the natural materials, building the machine which was mined and treated the natural materials, producing the housing constituents, aid services and convey to the construction site and Erection of the structure, together with means of transport. The entire GER could differ immensely, dependent on the resources used to erect the structure. Computing the personified energy in Minna building comprises: determining the quantity and extent of building with the varieties of building materials used; calculating the GER of the several structure constituents; and adding up the constituent GERs to get the entire personified energy needed. Gross Energy Requirement (GER) of building constituents comprise of the structure shell, which comprises the foundation, levels, walls, roofs and other physical constituents, and the fit-out, that comprises the interio finishing with furniture, interior cabinets and watercolour, vapour with electrical fixtures, hygienic fixtures, dividing walls, and others. The Table 4 shows the embodied energy for the housing fit-out.

Table 4: GER of Housing Fit out Components

Building Fit out	Embodied Energy MJ/m²
Carpet	800
Ceramic tiles	630
Vinyl	840
Logs parquetry	640
Stud Partition Walls	200
Built in cabinets/closets	180
Hygienic fittings	300
Electrical fittings	280
Vapor fittings	180

Source: Estimates based on Lawson (1995)

3.6 Embodied Energy in Minna Buildings

Using the GER projections for several housing constituents, the projected embodied energy in the average houses and related buildings in Minna is shown Table 5. The projections, the entire personified energy in constituents for erection of houses in Minna is represented in Table 5. Upkeep with repair of building also requires embodied energy, which has been estimated that the magnitudes of embodied energy usage in structures maintenance and repair are highlighted:

i. 60.0% for mining, major and secondary production with fitting of structure materials on the construction site;
ii. 34.0% for maintenance, renovation and change during a 50 year lifetime of the structure;
iii. 6.0% for conveyance and dumping of materials.

Table 5 indicates the projected quantity of energy usage, with the entire and for every capita EF for energy in building maintenance in Minna. These numbers are estimated permitting: A projected lifespan of 99 years for structures; a inhabitants of 402,706; and, a projection of 100 GJ per 1 ha of land.

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Table 5: Estimated Total Embodied Energy of Housing in Minna

Embodied Energy Use	**Total Energy (Gj/a/*capita*)**	**Energy (Gj)**	**EF Minna (ha)**	**EF/*capita* (gha)**
Construction	10,982,821	2.47	17,828.21	0.065
Maintenance	1,010,265	1.03	10,102.65	0.034
Total	**12,992,086**	**3.50**	**29,713.68**	**0.069**

Fieldwork, 2013

3.7 Total EF of Housing in Minna

Table 6 indicated the estimated EF of housing in Minna. The aggregation of both the direct EF and the embodied energy of construction and maintenance indicated the per capita EF of housing in Minna.

Table 6: Estimated EF/capita of Housing in Minna

	Consumed Land	**Garden Land**	**Forest Land**	**Energy Land**	**Total EF**
Housing EF	0.063	0.020	0.011	0.023	0.117
Embodied Energy				0.069	0.069
Total Housing	**0.063**	**0.020**	**0.0011**	**0.092**	**0.186**

Fieldwork, 2013

The calculation of the EF of housing was carried out based on the response of the households the per capita EF of housing was obtained for each type of household housing consumptions. Therefore, the average EF of housing in Minna is 0.186 with households having average 205 m2. Some family units' also have extra or small floor extent. This consequently might be (+/¬- 0.0011) dependent on the floor extent of the building for the family units'. The calculation of embodied energy of housing include those of building materials, transportation of the materials to the site of construction, the energy used per households for heating, fossil fuel usage and built-up land. This is represented in Table 5.

3.8 Housing and Sustainability of Minna

Buildings EF is the largest energy flow in Minna urban metabolism (235,050,499 GJ). Electricity consumption account for 25.0% (45,770,538.75 GJ) of the total energy in the city that is usually demanded for lighting and cooking. Extra 12,992,086GJof energy is used for embodied energy within the building construction and maintenance in Minna. Residential buildings account for 50% of electricity demand and land area for construction in the city. The total CO_2 discharges from structure running energy using electricity are 217,412.71tonnes; larger percentage is associated with residential dwelling operations. The amalgamation of CO_2 discharges connected with the personified energy of the dwellings in Minna compared to lifespan of the buildings indicated that the total CO_2 emission of the houses construction materials increases annually. There might remain no doubt that great density are usually originate at the metropolis centre of Minna, uncertain with small spaces among residences at the urban centre, and intense form of structures remain the greatest promising for reduce per capita family unit's environmental footmark in Minna. Numerous issues account for this; dense conurbation has been substantiated to be a unique technique to lessen EF. Populated with strong building growth has been used to decrease EF since huge number of persons is exhausting a little piece of land. The conflicting view is the facilities inside the building that might be over used. This might require diverse consequence on ecological awareness. Obstinately, lightly inhabited extents at the city peripheral of Minna have a much higher percentage of single-family (detached) buildings over a large piece of land. Persons' dwelling in single-family building have a broadly greater energy in-gestation as well as H_2O, remains gasoline owing to usage of both secluded and profitable cars for conveyance over a extended distance to urban centre of Minna, and other building in-gestation than inhabitants in all other kinds of buildings. In addition, the structures are commonly big in extent in metropolitan peripheries, which once extra impact consumption methods with way of life significantly. Likewise, the quantity of family units with access to a private vehicle is much in city peripheries compare to metropolitan centre of Minna. Access to personal vehicles is additional factor that influences a family units' movement energy usage. The inquiry showed that family units' in the city peripheries have extra access to personal vehicles than the persons' at the central area of the conurbation, this allow them to travel lengthy distance to their working place. Likewise family units' residing at central area of the metropolis and older conurbation of the municipality centre have a propensity to reside in multi-family housing or smaller structures with lesser floor extent devoid of courtyard and have a reduced access to personal vehicles than family units' dwelling in the fresher conurbation and city peripheries. Additionally, categories of residence also have influence on EF in Minna; the single-family (small house and duplexes) building is a manufacturer of greater EF and meagre substitute. On characteristic building kind, the family in distinct family buildings has greater environmental footmark per family member that is nearly 20% greater than family units' that are dwelling in extra intense types of building, for instance, semi-detached or apartment structures and multi-family inhabited structures (blocks of flats). Figure 2 indicated various EF measurement and special characteristics of the inhabitant of Minna. The residential land-use is simply divided into the densely populated area of the city which comprises the inner city and the older suburb, this shoes that the EF is lower compared to sparsely populated area which comprises of the urban fringe and the newer suburb. This is due to high distance covered on daily basis as the distance to city centre also indicated that moderate distance has higher EF than the nearer places to the city centre. Furthermore, the type of dwelling also indicated that households with single family house (usually at the

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fringes) has higher EF than the households living in the other types of housing such as tenement, terrace, block of flats and row building.

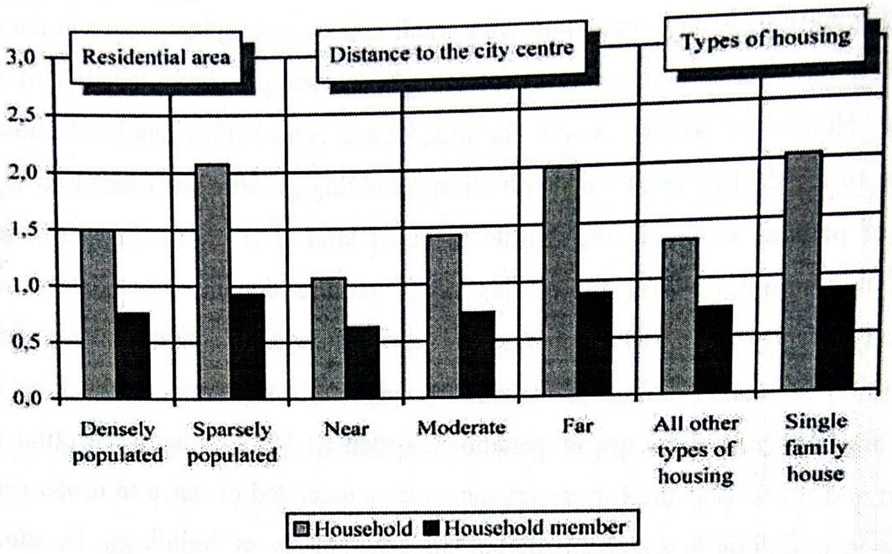

Figure 2: Average EF per family and family member in Minna.

Table 7: Housing energy usage

Housing	The usage of bring in construction material is preferred more than the indigenous construction materials. About 60% of the materials are imported (NBRRI 2004) There is insufficient or no provision of infrastructure in the buildings such as water, kitchen, toilet facilities etc. There is reduced level of upkeep and the usage of recycled product is not preferred. Most of the development in the metropolis is small house which permit huge area development of land. The extent of Minna in 1980 has been multiplied within 32 years thereby producing sprawl and insufficient infrastructure.	The usage of indigenously source construction materials ought to be fortified so as to lessen the EF of conveying of such produces for building. The use Building Code for Maintainable Households is vital since imposing high standards of infrastructure will have benefits in future. It is completely essential that these households are constructed to the maximum standards to avert the footmark growing further. There must be sufficient maintenance of houses and face-lift by home owners rather than permitting it to deteriorate. The growth of the metropolis has to be compressed so as to lessen the distance and lessens the EF of Minna. The usage of tall building ought to be fortified so as to decrease the consequence of loss of arable land to building purposes.

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3.9 Scenario of Housing and Energy EF reduction in Minna

The delivery of building with the manner families live in their homes places a burden on the environment, not simply for land and building resources, but likewise energy usage inside the building. Building accounts for 17.0% of the EF of Minna. Consequently, the inquiry is prearranged around three sets of situations that model the alteration in the housing footmark. The emphasis of these situations is on energy needs in the household and the variety of choices existing to the individuals to lessen the EF. Housing, planning and control of energy efficacy funds are all compulsory. This grants a number of choices which can be used to lessen the housing footmark and which are analysed in the following situations:

i. Increasing the supply of contemporary, energy efficient homes
ii. Improving the values of current homes
iii. Substituting lowly quality housing standard
iv. Aiming energy usage by families

Table 7 indicated the energy usage at present and assumption of reduction in both housing and energy EF in Minna. Household energy usage of non-conventional source in Minna has both health and environmental consequences. Therefore if 25.0% of charcoal and firewood are reduced and better conventional sources such as electricity and natural gas is used, there will be reduction of 0.056 gha reduction in the EF of Minna (final EF will be 1.040 gha). Domestic energy usage adds to greenhouse gas discharges, contamination and ecological unit deterioration. This might be reduced through the usage of renewable energy (e.g. solar power production) or green electrical energy (mains power resulting from renewable sources). Housing choices account for almost 17.0% of EF of Minna. It's an amazing fact that while the number of people living together in Minna families is progressively reducing (8 people per household in 1991 and 5.2 in 2006), the average floor area and size of building in Mina is on the increase. The typical extent of new buildings rose from 115 m2 in the 1980's, to 205 m2 1990, reaching 327 m2 in 2012 (MLS&TP, 2012). Over the same period the number of household in a compound has declined from 6.4 household per dwelling in 1983, down to 4.7 in 1990, and 3.6 in 2000 (Minna master plan, 2000). The request for larger houses pushes the demolition of still functional older residences, but necessitating extra resources and energy to construct. The amount of persons per household and the extent of building have the following EF in Minna based on Barrette (2004) estimate, this is shown in Table 8.

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Table 8: Household size, Plot size and EF of Minna

No of people/household	Plot size/Capita (m^2)	EF (gha)	Floor area (m^2)	House type
1-5	1.8	+0.01	50-100	Tenement
6-10	1.2	0.02	101-200	Tenement
11-15	0.8	0.03	201-300	Small Flats
16-60	0.5	0.04	301-400	Large Flats
21-25	0.4	0.05	401-500	Duplex
25+	0.3	0.06	500+	Large Duplex

Fieldwork, 2013

The use of both solar inert household design with the little environmental influence resources (e.g. reprocessed logs, openings etc, and renewable or remaining resources such as straw bale or tires) significantly cut the ecological impact houses on the environment. If a house is green designed or built, it takes off 0.06 gha of housing EF. The EF situations for this inquiry were founded on base-line EF figures obtained. The scenarios are thus single pointer of the prospective footmark diminutions related with the diverse situations. Nevertheless, they do provide an overall understanding into possible influences, and make known individual behaviours and way of life have a huge influence on the general footmark of a city.

4. Conclusion

Urbanization has become the cornerstone of globalization; cities must therefore play a greater role in determining sustainability potentials of any society. This research initiates a detailed measurement of micro EF in developing countries. Urban metabolism and EF analysis for an African country is examined. Explanation of component approach in the methodology for local EF analysis based local consumption. The use of component method for estimating the sustainability potential of low income countries more effectively is favoured to address local capabilities and benefits within sustainability potentials of the people. Cities are the leading form of human habitat in the 21st century, and nearly 75.0% of the global resources are either directly or indirectly consumed within the cities. The research has proved that within cities, income is highly correlated to consumption, but urban morphology and management policies adopted by the government at all level also perform a significant role in the process of resources consumption. A two way method need to focus on urban sustainability that try to reduce overall consumption (EF) and the decent and ethical obligation of great revenue users to decrease their individual in-gestation, is evolving in the city sustainability works. However, as one of the low income city in the world, Nigerian metropolises have been relaxed to accept EF that checkmates city consumption with existing bio-capacity. The EF of Minna footprint in 2013 is 1.096 gha. Minna city dwellers have an average EF that is lower than national averge of 1.44 gha/ca in Nigeria and nearly three times lower than the world average bio-capacity need,

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projected at 2.70 gha/ca. the analysis of the bio-capacity of Minna indicated that its bio-capacity is lower than the universal per capita bio-capacity supply, projected at 1.8 gha/ca[1]. In additional words, if everybody in the world used up at the rate proportionate to that of a normal inhabitant of Minna, the world will be sustainable because it will take 14 months to consume the resources of the world and sequestrate the CO_2 so produced and will definitely support a lifestyle. The use of direct component method of estimating EF limits comparison with national level because compound method is usually used to estimate the national EF. The delivery of buildings and the manner families live in their houses mounts burden on the environment, not simply for land and building resources, but likewise energy usage inside the house. Structures accounts for 17.0% of the EF of Minna. Housing, planning and control of energy efficiency budgets are all required. This offers a quantity of choices which might be used to lessen the housing footmark and which are analysed in the subsequent situations:

i. Increasing the supply of modern, energy efficient homes
ii. Improving the values of current households
iii. Substituting lowly quality building stock
iv. Aiming energy usage by families

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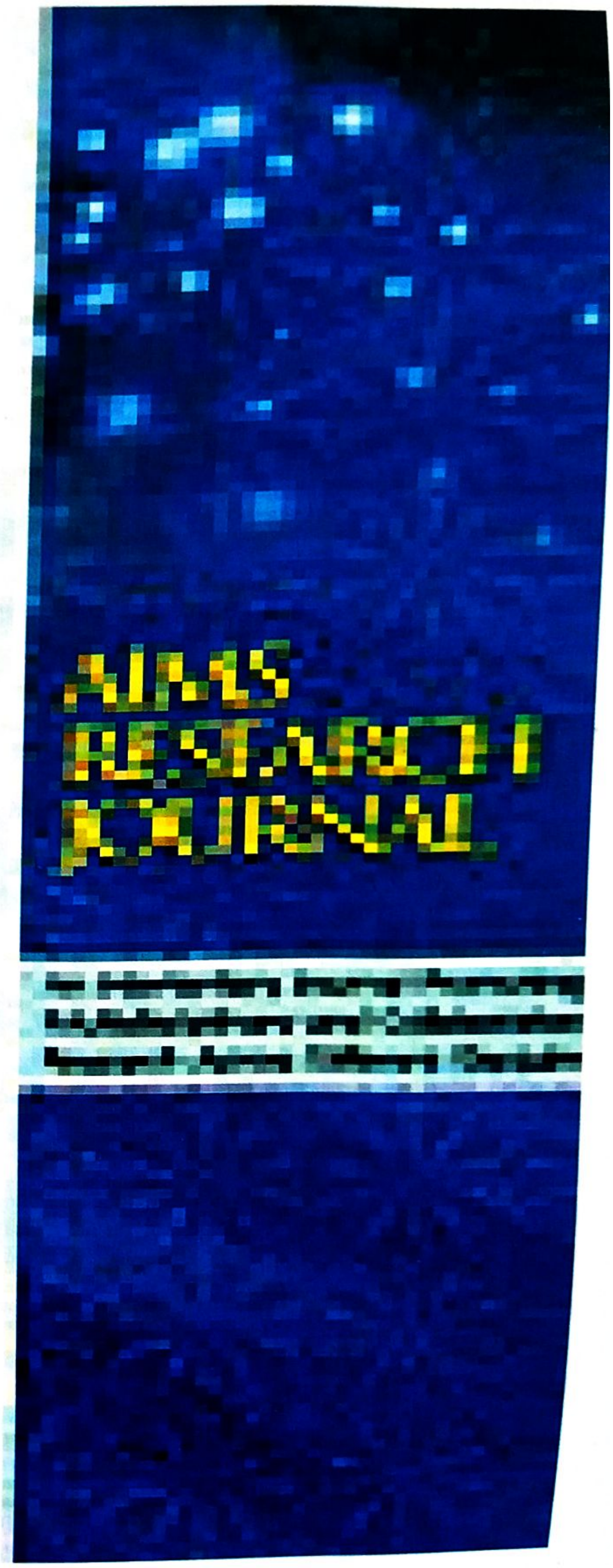

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