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Sustainability of Fuel Wood Harvesting from Afaka Forest Reserve, Kaduna State, Nigeria

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Abstract

This study examined the sustainability of fuel wood harvesting from Afaka Forest Reserve in Kaduna, Nigeria. The methods adopted for data collection involved field observation, physical measurement of harvested wood diameters, photographing reporting and farmers' interviews. The collected data was analyzed, by means of descriptive statistics in order to estimate the quantity of wood harvested per day, week, month and year; as well as the sizes of harvested trees and the harvesting method. The results indicated that a daily average of 91.9 tons of wood is harvested from the forest and transported into Kaduna through various classes of vehicles. In figures, about 15% of the harvested wood has a diameter of less than 5cm, 40% (5.1–10 cm), 14% (10.1–15 cm), 16% (15.1–20 cm) and 15% (> 20 cm). No specific scientific method of harvesting is in place and the rate of regeneration and/or replacement planting is far below the rate of harvesting. Taking into consideration the demand for fuel wood, poverty level, the harvesting cost, and availability of alternatives to fuel wood, the rate of wood harvesting is expected to increase and in no time, the Afaka forest may disappear with enormous consequences on the environment, considering the sizes of wood harvested daily. To avoid this, the Government at all levels, NGO, CBO will have to expand the forest and at the same time put in place a sustainable method of harvesting, such as putting a limit to the quantity of wood harvested per time and providing of alternative supply of affordable energy to the population.

Keywords: environment, forest, fuel wood, land degradation, sustainability

1. Introduction

There are many studies on forestry which cut across many spheres of research. Some focused on agriculture, forest ecosystem, climate change, economic benefits, human security, and wildlife, among others. However, emphasis recently is on environmental degradation and climate change for obvious reasons, namely, changes in climate pattern and intensity, and massive socio-economic consequences like floods, tsunami, hurricane, land slide, extinction wildfire, coastal flooding, typhoon and desertification, which in one way or the other have spread across worldwide. The recent International Summit on climate change, held in Poland on November, 2013, has not succeeded in building a general consensus that could enable all the countries to find a final solution to this crisis.

The significance of forestry ecosystems and their management is enormous to any society and at any scale. They provide non-timber forest products from a wide range of species, both flora and fauna, which are very useful to the human (Cavendish, 2001). Chomitz and Kumari (1996) revealed that forest products are exploited for food, fuel wood and pharmaceutical uses. Moreover, Bolaji-Olutunji and Osadebe (2010) gave a breakdown of some of the benefits to include economic values in form of financial benefits from the sales of plant leaves/vegetables, plant root, honey, fruits, seeds, fire wood, bush meat, mushrooms, and snails, among many other products. Uncontrolled exploitation of these benefits without a plan for sustainable development could lead to the forest land cover reducing to barely 5% of the former size in Nigeria (Popoola, 2006).

Particularly, Adekunle and Ige (2006) revealed that the rate of deforestation in Nigeria is increasing due to the rapid growth in human population to be fed, accommodated in expanding settlements, as well as engaging in the commercialization of agriculture. The FAO (2005) reported that Nigeria lost 55.7% of its primary forest to

logging, subsistence agriculture, and firewood collection between 2000 and 2005. This rate has positioned Nigeria as one of the countries on top of the chart with the highest rate of deforestation.

One of the main reasons for the depletion of Nigerian forests resources is the uncontrolled wood harvesting and forest fire which, according to Hanagam (2013), has led to the recruitment of forest guards by the Niger State public Administration to protect these natural resources. Another reason for the depletion is the people's low patronage of other sources of energy in Nigeria. For instance, Adeshina (2013) reported that Nigeria with a population of about 160 million people is expected to utilize only 300,000 tons of Liquefied Petroleum Gas-LPG in 2012; this level of usage is clearly considered too low. In the case of the electricity, its generation is still very low in the country (below 4,000 MW on average), erratic and expensive (9 US cents per kWh outside of fixed charges and Value Added Tax-VAT). Moreover, the electricity price is still increasing and unaffordable for more than 70% of Nigerian who are living below poverty line. Finally, kerosene which should have been a better alternative for energy generation, is also embroiled in price racketeering and scarcity in the country, leaving fuel wood as the only option for domestic cooking and energy supply to the majority of the citizens. Consequently, the forests and woodlands in the country bear the burden and are the worst for it.

Indeed, the dependence on fuel wood as a source of energy reduces carbon storage and sequestration, increasing the cases of environmental degradation as consequences of the deforestation rate in Nigeria. Therefore it is necessary to find an alternative to fuel wood in order to conserve the available forest resources against further human destruction. To this end, the Nigerian Government signed an afforestation loan with the World Bank for stabilizing wood products outputs, establishing forest reserves, and safeguarding forest resources from indiscriminate exploitation, as well as, meeting the demand for poles, energy and food in a sustainable management in 1989 (CBN, 2001). However, there is still a progressive depletion of forest resources especially non-timber forest products in the northern parts of Nigeria despite this public intervention.

Hence, the continuous reduction of national forest resources is a key factor to analyze at Nigeria scale. In this sense, the present study tries to examine the harvesting rate of fuel wood in a Nigerian particular area in order to visualize the forest sustainability in the short and long terms. Thus, the objectives of the study were disaggregated as follows:

a) To estimate the quantity of wood removed on a daily basis and compare it with forest replacement rate;

b) To determine the sizes of wood harvested and to estimate the value/cost of the fuel wood harvested and compare it with the cost of other source(s) of energy, namely: gas, electricity and kerosene.

The study results will provide an useful information for policy makers in the areas of energy supply planning and environmental management in Nigeria. This study will also provide the basis for other studies on natural sustainability in relation to the exploitation of forest resources.

2. Description of the Study Area

The study is limited to the Afaka Forest Reserve in Igabi Local Government Area, Kaduna State located within latitude 10°33′06″N - 10°37′44″N and longitude 7°14′33″E - 7°22′08″E (Figure 1). The forest reserve has an area of 6,103.99 ha and perimeter of 41,767.95 m. The elevation varies across the forest region but it is generally a plain land with an average of 610 m above mean sea level. The forest reserve has a tropical continental climate, which is characterized by two clearly distinct seasons of dry and wet, the dry season lasts from October to early April while the remaining months constitute the dry season. The forest temperature is high throughout the year with mean minimum and maximum temperatures 23 °C and 34 °C respectively; the diurnal range of temperature is sometimes as high as 12 °C, which is good climatic indicator for crop and forest yields throughout the year. The annual average rainfall is 1250 mm with a rainfall peak between July and August (Adewuyi et al., 2010).

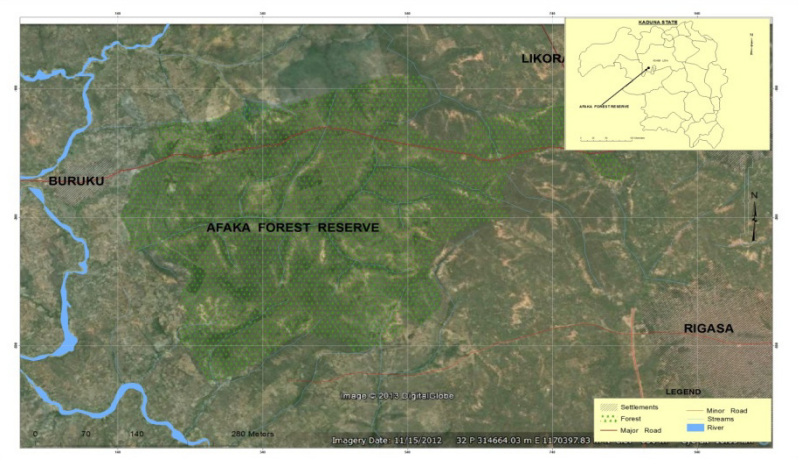


Figure 1. Location of the study area

The Afaka Forest Reserve is drained by two of the tributaries of Kaduna River and its vegetation is diverse because it is a combination of plantation and natural forests. In this area, the main indigenous forest species are *Pakia biglobolsa* (Dorawa), *Ceiba petandra* (Silk Cotton), and *Andasonia digitata* (Kuka) while the exotic forest species include *Azadiracta indica* (Neem), *Tectona grandis* (Teak), *Eucalyptus* spp., *Gmelina* spp., and *Pinus caribea* (pine). Table 1 illustrates the main characteristics of forest species in the Afaka Forest Reserve.

Table 1. Arrangement, spacing and height of the forest trees

Transect	Specie	Pattern of arrangement	Average spacing (m)	Average height (m)
A	Exotic	In rows	3.0	14.0
B	Indigenous	Haphazardly	4.5	12.7
C	Mixed	Semi-arranged	3.2	13.6
D	Exotic	In rows	3.7	14.0

The immediate human settlements around the study forest area are Old Afaka, Mando, Rubu, Sabo Gidan, Sabo Fili, Buruku, Rigasa and Likora while the peri-urban area of Kaduna metropolis is about two kilometers away. The population within and around the forest reserve is very sparse, and these forest inhabitants are mainly farmers, hunters, traders, and artisans. However the main forest pressure comes from Kaduna metropolis whose population is estimated at about a minimum of 2 million people.

3. Materials and Methods

This study involves both biophysical and socio-economic measurements and the use of satellite images for field survey as well as including first-hand information and documentary data collection. The first-hand information was collected through field observation and, measurements and farmers' interviews after a preliminary survey. This checkup survey was carried out in order to determine the forest size and, the forest management and to plan for detailed field measurement such as determining the number and dimensions of required. This was carried out to provide the basis for determining the process sustainability.

The field investigation was carried out in 2013, between July and December, and particularly the observations and measurements were daily carried out between 6.30 am and 4.00 pm. On the one hand; the mode of wood transportation, the number of vehicles engaged in bringing fuel wood to the city, the category and capacity of the vehicles and purpose of transporting wood (business or personal uses) were gathered at the metropolis surroundings on the route from the forest area. On the other hand, the method employed in wood harvesting as well as the forest replacement were moreover observed and inquired within the forest area. For this purpose, the forest reserve was divided into four sections and; a quadrant of 50 × 100 m^2 was randomly demarcated in each section with the aim of embracing the total representation of the forest study area. The data collection finally considered tree measurements in the forest area, *i.e.*, the type of harvested forest species, the average height of

the trees, the size of the harvested wood, the part of the harvested tree, the arrangement pattern of the tree stands, and the distance between tree stands.

A recording sheet was designed for the observation and field measurements gathered on field and lately analyzing statistically using Pearson correlation method. A digital camera was also employed to capture some of the photographic observations and measurements. Finally, availability sampling method was used to select 20 farmers who were interviewed to obtain their views on fuel wood harvest in the forest area.

4. Results

4.1 Mode of Transport and Quantity of Fuel Wood Harvested from the Forest

Table 2 indicates the typologies of land vehicles used in transporting fuel wood from the forest reserve to the final destination (Images I-VI), methods function of the fuel wood volume to transport. The main methods of wood transport in the study area were by means of trailers, tankers, semi-trailers (Gongoro), buses (Peugeot J5 and Ford buses) and open-roof vans (Pick-up). Other vehicles of transporting fuel wood to the metropolis included: private cars, motor cycles, bicycles, wheel barrows, animals (donkeys) and human means (heads portage). These vehicles and modes carry various volumes of fuel wood as displayed in Table 2.

Table 2. Summary of mode and capacity of vehicle used for fuel wood harvest from Afaka Forest Reserve

Type of vehicle	Average vehicle capacity (Tn)	Mean no. of vehicles that enters the metro	Average weight (Tn)	% of total harvest	Remark
Semi trailer (Gongoro)	2.50	20	50.00	46.23	
Buses (J5 & Ford)	1.00	17	17.00	15.72	
Open roof van (pick-up)	0.80	28	22.40	20.71	
Top of truck trailer	0.75	25	18.75	17.34	
			Total 108.15		

Numerous farmers harvest wood using their bicycle, motor cycle and animals from time to time for commercial and private use.

Thus a close examination during the field investigation showed that there is an important variation in the quantity of fuel wood harvested and transported by individuals using motor cycles, bicycles, animals, and human means and, moreover these people categories harvested fuel wood throughout the day and sometimes used foot paths which could not be covered in this study. Consequently, fuel wood transported to the metropolis by these means was exempted in this study's analysis, particularly because the quantity carried by these people was very small compared with other transportation means and the wood involved consisted mainly of the branches which did not have much effect on the forest according to their easy and fast regeneration.

However, based on the fuel wood harvested and transported through the highway, the semi-trailer was used to carry over 50 Tn per day of fuel wood about 46% of total wood harvested. This figure is followed by the open roof van popularly called pick-up, which daily carried about 22.4 Tn of wood, that is the 20.71% of total wood harvested, and finally, the top of trucks/tankers and buses with 18.75 and 17 Tn/day, respectively (17.34% and 15.72% of total wood harvested, respectively). The total volume of fuel wood transported by these types of vehicles was about 108.15 Tn per day of fuel wood into the metropolis. Furthermore, Table 2 shows that the motive for wood transporting into the city on a large scale, was commercial, especially for those using semi-trailer, buses and pick-ups, as well as they were also fully engaged in it as a full-time business. Conversely, those who utilized the top of trucks/trailers, usually on a smaller scale, did so for both commercial and private use by the family members. The most frequent vehicle for transporting fuel wood to the city was the open- roof van (pick-ups) which records 28 times per day, whereas that the least frequent mean of transport, recording 17 times per day, was the bus. On average, 107 vehicles daily transported fuel wood into the city from the forest reserve. Using the Pearson correlation to established the relationship that exist between the average vehicle capacity and the average numbers of vehicles that enters the metropolis, the result was $r = -0.44$, indicating a negative relationship, which means, the higher the capacity of the vehicle the lesser the rate at which they carry the fuel wood to the metropolis. While, the relationship between the average vehicle capacity and average weight of fuel wood carried into the metropolis was $r = +0.52$, a positive relationship. Consequently, the higher the capacity of the vehicle the higher the quantity of fuel wood they will carry into the metropolis per trip.

4.2 Sizes of Wood Harvested

Table 3 illustrates the sizes of the wood harvested in the study forest area, which were grouped into five categories, coded A to E (Images VII-XI). This categorization was based on the average diameter, circumference and weight of the log. These three parameters linked to the wood harvested size, were used together because the length for each piece of wood was almost the same for all the categories (about 73cm, on average). According to Table 3, 40% of the wood harvested belonged to category B, with diameter ranging 5−10 cm, an average circumference of 17cm, and an average weight of 1kg. The other size categories, that is, A, C, D and E contributed 15, 14, 16 and 15% respectively, of the total wood harvested. It is very important to indicate that C, D and E categories were mainly stems and roots of trees, with only a few branches; they collectively contributed 45% of the fuel wood harvested.

Table 3 also reveals that A, B and C categories were basically branches and stems of trees, they constituted 69% of the total wood harvest from the study forest; in the D and E categories stems or roots constituted 31%. The remark column reveals that most of the wood harvested was stem, probably associated to the wood merchants no longer systematically harvested only matured trees, rather they also search every type and size of wood on their way, from shrubs to very big trees. It is relevant to point out that a large percentage of D and E categories, which constituted 31%, consisted of a very large proportion of tree roots, while branches of trees constituted the remaining categories. In general, these descriptive statistics indicated that most of the wood harvested in the forest area was more of stems followed by branches, then root. This is an unusual situation in modern day forest management, where trees are mostly trimmed and not completely uprooted thereby not just removing the vegetation, but also exposing the soil to all manners of degradation, such as erosion.

I. Animals (donkey)

II. Pick up van

III. Top of tank trailer

IV. Human transport (Head portage)

V. Wheel barrow

VI. Semi-trailer (Gongoro)

Figure 2. Images I–VI: Different transportation means used in carrying fuel wood from forest into Kaduna metropolis

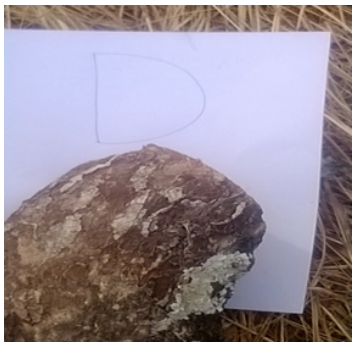
Table 3. Analysis of sizes of fuel wood harvested in the study area

Code	Diameters (cm)	Minimum average perimeter (cm)	Average weight (kg)	% of total wood harvested	Remarks
A	≤ 5	11	0.5	15	Branches/stem
B	5.1 – 10	17	1	40	“
C	10.1 – 15	40	3	14	“
D	15.1 – 20	49	10	16	Stem/root
E	≥20.1	65	30	15	“

VII. A (≤ 5.0 cm)

VIII. B (5.1-10.0 cm)

IX. C (10.1-15.0 cm)



X. D (15.1-20.0 cm)

XI. E (≥ 20.1 cm)

Figure 3. Images VII–XI: Classification of sizes of fuel wood harvested based on diameter (A-E categories)

4.3 Comparative Analysis of Economic Value of Energy Sources

The price of energy from the present study is displayed in Table 4, where it is appreciated that fuel wood is the cheapest among the various sources of energy used by the people in the city. This was arrived at by estimating the amount of energy generated from the quantity of wood, liter of kerosene, volume of gas or kilowatt of electricity and there price. The previous fact is attributed to regular availability and the fact that it does not require any capital investment to use it beside three big stones or in some instances an iron stand, while to utilize other sources, most average citizens have some challenges. For example, electricity is also cheap, but this source is hardly available regularly and, therefore its reliability for prompt domestic use is poor. Gas is ready available most of the time but its price is a big challenge that makes it out of reach for most citizens and it also requires a capital investment to buy a cooker, further, many are still afraid of it in terms of safety. Finally, kerosene, which would have been the automatic alternative, is very scarce to get at the official price which is cheap (₦50 or 35 US cents) but sold exorbitantly at up to ₦150 or 1 US dollar per liter in the black market, thereby compounding the problem the more. As a result, other sources of energy are not utilized by the majority of the people, making fuel wood very popular in its effect on the human health and the environmental conservation.

Table 4. Analysis of price of energy

Source of energy	Rate in ₦ (US Dollars)	Remarks
Electricity	17(10 cents) /Kilowatts/Hour	Regular power outage
Kerosene	160 (1 Dollar/Liter)	Always scarce to get at official rate
Fuel wood	Varies but average of 150 (1 Dollar)/10 Pieces	Always available
Gas	3,300 (20 Dollars)/12,5Kg	Very expensive for average Nigerians

5. Discussion

5.1 Implication for the Environment

The rate of fuel wood harvesting from Afaka Forest Reserve has diverse effects on the forest ecosystem. For instance, the field study of the forest area showed that there was now an increase in the spacing between trees in many areas, and consequently there was no continuous canopy of trees in many parts of the forest (Image XIII). The wider spaces have given room for farming activities by some farmers within the forest (Image XIII). The effects of the increase in spacing between trees also exposed the soil to the direct effect of rainfall and other interaction such as track/path now used by heavy vehicles to collect fuel wood have led to soil compaction, this effect, which may not be visible now, but would sooner or later, begin to manifest in the form of environmental degradation such as flooding, soil erosion, destruction of wild life habitat and decrease in plant and animal diversity in the area. This finding supports some of the positions taken by Adewuyi (2011) and Adewuyi and Baduku (2012) in their studies in the areas adjacent to the study forest.

XII: A whole large tree harvested

XIII: A forested area cleared for agriculture

Figure 4. Images XII–XIII

The implication can also be viewed from the perspective of distortion in the land use and land cover distribution for the area. Mortimore (1989), WRI (1997), Xue and Fennessy (2002), and Adewuyi and Olofin (2014) have shown that deforestation can contribute to changes in the micro climate at local scale and global warming which is already a big issue that is taking a lot of attention and available resources to mitigate.

Another implication is the pollution and reduction of underground water in the area. As a result of the increase in space between trees, vehicular movement in the forest occurs; there is reduction in tree canopies and farming activities. It is expected that surface run-off will increase, which will generally facilitate erosion but, more importantly, it will also reduce the capacity of the forested area to serve as area to recharge underground water, which is a very important source of water in the dry season for the ecological zone. The little that is recharged stands the chance of polluting the ground water due to the effects of chemical of fertilizers and pesticides applied by farmers and the pollution from heavy duties truck through their combustion, as well as the burning of the wood, thereby increasing the carbon-dioxide and monoxide in the atmosphere.

5.2 Socio-Economic Implication

This study identifies that there are both positive and negative socio-economic implications of wood fuel harvesting at the Afaka Forest Reserve. The farmers' interview and the personal field observations revealed that,

the use of fuel wood provided the following benefits to its users, among others:

a) It was the main source of energy for domestic needs;

b) Its cost in domestic cooking was lower in comparison with other energy sources;

c) It improved the cash-flow and wealth creation for farmers and sellers involved in the business;

d) It created rural employment such as drivers, wholesalers, retailers, and labourers for the teeming youth.

Consequently, these are some of the reasons why there is always a market for fuel wood, thereby making market the driving force for the continuous increase in the volume of trees harvested from the forest and making exploitation out-pace the rate for natural regeneration or planting of new trees.

With a substantial proportion of Nigerians depending on fuel wood for domestic energy, the results of this study portends great socioeconomic and environmental problems for the country. As gathered from several sources, the population of Nigeria is currently estimated to be 173.6 millions (Population Reference Bureau, 2013), *i.e.*, to 189 inhabitants/km^2 and growing at an annual rate 2.8% Nigeria is the 7th most populated nation in the world. Indeed, it is estimated that the population of Nigeria would rise to 400million in 2050.

Meanwhile, forest areas are not increasing in Nigeria and the rate of fuel wood exploitation would increase, not only in the Afaka Forest Reserve, but also in all the forests in the country. Increased rate of fuel wood harvesting in the face of reducing forest quality is not sustainable. Consequently, a holistic environmental audit, as well as a management plan, is required as quickly as possible in order to save the fragile environmental resources of the country.

6. Conclusion

This study has examined the sustainability of the rate of fuel wood harvesting in Afaka Forest Reserve in Kaduna State, Nigeria. It reveals that 108.15 Tn of wood is daily transported, on the average, from the forest to the town by major vehicles, besides the ones being carried on donkeys, human head, bicycle, motor cycle, wheel barrow, and private cars. It was discovered that the larger the vehicle, the higher the capacity and the quantity of fuel wood they carried to the metropolis per trip but the lesser the frequency of trip. The method of harvesting does not follow any known system, as a result, in most cases, stems and roots constitute a significant proportion of wood harvested. This study further reveals that, increasingly, the forest area is giving way to agricultural activities thereby making the forest to have no continuous canopy and exposing the area to drivers of environmental degradation because of the inherent deforestation. It is also discovered that many people (male, female, single, married, young, old, poor and rich) are involved in the chain of activities involving fuel wood harvesting and sales as a result, many families livelihood depend on the fuel wood harvesting activities.

Consequently, eradicating fuel wood harvesting or reducing its intensity will create other socio-economic problems like loss of jobs, increase in crime and many more. Therefore, the best approach to solving this problem is to embrace afforestation and social forestry which will solve both the environmental as well as the socio-economic problems since it will generate more jobs and it will allow many to diversify their sources of income. The second recommendation is to make other sources of energy readily available and cheap so as to discourage patronage of fuel wood as energy source which will also reduce the rate of harvest eventually. Finally, Government at all levels, NGO, CBO will have to expand the forest and at the same time put in place a sustainable method of harvesting, such as putting a limit to the quantity of wood harvested per time and provision of alternative supply of affordable energy to the population.

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