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## **Assessment of Commercial Charcoal Production Effect on Savannah Woodland of Nasarawa State, Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration between both the authors. Author ASE conducted the study, collected and analysed the data and author EHM managed the literature searchers. Both the authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/JGEESI/2020/v24i230204

Editor(s):

(1) Azza Moustafa Abdel-Aty, National Research Center, Egypt.

Reviewers:

(1) Dione Richer Momolli, Federal University of Lavras, Brazil.

(2) Marcos Antônio Souza dos Santos, Federal Rural University, Brazil.

(3) Junir Antonio Lutinski, Universidade Comunitária da Região de Chapecó, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/55890>

**Original Research Article**

**Received 02 February 2020**

**Accepted 09 April 2020**

**Published 16 April 2020**

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### **ABSTRACT**

Charcoal is used as fuel in cooking for household, large food consumption and also in some industries especially those involved in casting bronze and other metals. It can be produced year round which involves woodland exploitation that contributes to deforestation with various negative consequences like loss of valuable resources and environment, drives climate change through the release of greenhouse gases, it also reduces the bio-productivity of ecosystems by disrupting the habitats of thousands of species, transforms forest lands into barren deserts and exposes bare surfaces which are susceptible to soil erosion, thus making the entire ecosystem unstable.

These are among the major threats to forest reserves and contributes highly to deforestation with 0.038 hectare of savanna woodland depleted for production of a single 15 kg capacity bag of charcoal in the study area and this had led to forest degradation which 96.2% of the respondents attested. The study was to determine the impacts of charcoal production to the forest reserves and also the public perceptions of the environmental effect of unplanned cutting of tree for Charcoal Production and it recommended awareness, prudent forest management and getting involve the private sectors, combined with proactive actions and policies.

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*Keywords: Charcoal; deforestation; biodiversity; greenhouse gas.*

## 1. INTRODUCTION

Charcoal has remained a source of energy for several purposes in both rural and urban centers globally [1] and now an export commodity in Africa, with a large market in the Europe, USA and Asia with price range from \$170 -\$300/ton depending on the packaging. Tropical Africa accounts for 70% of the exports and the market is all year round with a slight drop between July and September Awoyemi et al. [2]. According to Food and Agricultural Organization FAO, [3], of the United Nations, over 40 million metric tonnes of charcoal are consumed globally and approximately 2.4 billion people rely on wood and charcoal for domestic consumption. Charcoal provides 82% of urban and 34% of rural household energy in Kenya and the industry employs over 700,000 people directly who support over 2 million dependant Muchiri, [4]. In Tanzania income generated from sale of charcoal was found to be above the minimum wage paid by government and private sectors employees Mndeme, [5] and business of trading of charcoal has now become a very lucrative venture in Nigeria also William et al. [6], with Nigeria currently ranks second to Brazil in the production of charcoal and the western countries particularly prefer Nigeria's charcoal, as the country is rich in tropical hardwood, which burns slower and heats faster with Nigeria now exports 380,000 metric tonnes of charcoal annually Dayo, [7]. Charcoal is used as fuel in cooking for household and large food consumption and also in some industries' especially those involved in casting bronze and other metals and can be produced year round with production and export been done during the dry season from November to May, reason because production and export of charcoal during the raining season could be rejected by buyers due to high moisture content more than 10% that usually characterized the charcoal produced during this period. In Europe, the sales season starts from May to August because this is their summer time and their order starts coming from September to May, but some big time importers in Europe buy all year round. Charcoal production involves woodland exploitation which contributes to deforestation and deforestation is associated with various negative consequences: the loss of valuable resources and dangerous interference with the environment Martin et al. [8]. Consequently, by impoverishing our natural environments, in the long run deforestation affects our lives and

economy negatively and sustainable management of forest resources has been of primary concern due to potential impact on biological diversity and importance in maintaining global ecological functions. There are some effects of deforestation on our ecosystem contributed by this charcoal production like; Biodiversity/Environmental impact, Climate Change, Socioeconomic and Health.

### 1.1 Biodiversity and Environmental Impact

Charcoal making involves cutting down of trees and also removal of vegetation cover that contributes to the loss of biodiversity. In terms of species diversity, tree removal results in alteration of plant community structures, distribution of different species and plant density [9]. Possible disruption of essential ecological processes is associated with accelerated and irreplaceable depletion of genes, populations, species and ecosystems [10]. Biodiversity is the basis of ecosystem health and of the provision of ecosystem services [11], there exist species inter-dependence in an ecosystem therefore decline or loss of a species population impacts on the life cycle of other species and the ecosystem at large [12]. Constant cutting down of trees for charcoal purposes results in simplification of those habitat with connection to thinning of woodlands, for instance a tree species can support many plant and animal species on an obligatory basis and one fruit tree can provide food for many birds and mammals [13]. Charcoal industry if unsustainable may lead to deforestation and environmental degradation therefore disrupting the rich biodiversity ecosystem [14]. Nearly all charcoal consumed in Kenya and elsewhere in sub-Saharan Africa is made from local indigenous tree species [15]. Forestry or trees are endowed with important ecological benefits including soil erosion control, catchment protection and wildlife conservation [16].

According to Bailis et al. [17], unsustainable charcoal production activities could lead to.

- Reduced biodiversity as a result of deforestation and forest degradation. When forest cover is removed, wildlife is deprived of habitat and becomes more vulnerable to hunting.
- Disrupted water cycles as a result of deforestation, trees no longer evaporate

groundwater, which can cause the local climate to be much drier.

- Increased soil erosion as deforestation accelerates the rate of soil erosion, by increasing runoff and reducing the protection of the soil from tree litter.

## 1.2 Climate Change Impact

Climate change is a change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Charcoal production as a human activity contributes to the causes of climate change through the harvesting, production and use of charcoal, unsustainable harvesting of trees and combustion of charcoal contributes to global climate change since both activities result in emission of greenhouse gas [18,19], further more, the harvesting of trees reduces the carbon sequestration ability or potential of forests or woodlands. Greenhouse gas are the gaseous constituents of the atmosphere that absorb and re-emit infrared radiation *UNFCCC,1992*. Therefore, the impacts of charcoal production on climate change starts with the felling of trees and continues to the carbonization of the wood and the final use of charcoal and felling of trees is recognized as the second largest contributor of carbon dioxide to post-industrial atmospheric CO<sub>2</sub> increase globally [20]. In the carbonization of woody biomass into charcoal, carbon is emitted to the atmosphere in the form of CO<sub>2</sub>, CO and CH<sub>4</sub>, while complete burning of one tonne of dry wood emits 1833 kg of CO<sub>2</sub> equivalent [19]. CO<sub>2</sub> is an important GHG with atmospheric residence time of approximately 100 years, the time it takes CO<sub>2</sub> to be recycled via the carbon cycle and the concentration of CO<sub>2</sub>, together with its long residence time in the atmosphere are the most relevant factors for global warming, highlighting the prominence of CO<sub>2</sub> among the GHG in climate change mitigation strategies [21]. These Charcoal production contributes to GHG emissions in three processes: land use change processes induced by wood harvest, carbonization of the woody biomass and the combustion of the charcoal itself by end-users [22]. This charcoal production influences GHG emissions depending on how the tree harvesting is done sustainable or unsustainable [19]. They opined that the resulting influence on climate change depends on the difference between rate of harvest and rate of regeneration. When the former continuously

exceeds the latter for long periods, charcoal production results in a net emission of CO<sub>2</sub> to the atmosphere [19]. It means that areas where demand is high, aggressive charcoal producers often harvest trees at a rate that often outweighs the rate of regeneration. The effects of excessive harvesting of trees is further aggravated by the fact that regeneration rates in savanna woodlands is not high enough to support the increasing number of producers and intensity of current productions for any extended period of time [23].

## 1.3 Socioeconomic Impacts

Disruption of livelihoods as millions of people relies directly on forests, through small scale agriculture, hunting and gathering and by harvesting forest products such as rubber. Deforestation continues to pose severe social problems, sometimes leading to violent conflict. The global wood production in 2000 reached approximately 3.9 billion m<sup>3</sup> whereby 2.3 billion m<sup>3</sup> was used as woodfuels implying that approximately 60% of world's total wood removals from forest and trees are used for energy purpose [24]. The global projection of consumption of woodfuel by 2010 ranged from 1.5 billion m<sup>3</sup> to 4.25 billion m<sup>3</sup> [25]. In Africa over 90% of the wood taken from forest is woodfuel. The majority is of wood is consumed as fuelwood, however, a varying but significant amount is transformed into charcoal. A study of charcoal production impact on the sustainable development of Asa Local Government Area of Kwara State revealed significant negative impact of charcoal production on the ecology of the study are high proportion of the respondents 67% agreed that tree felling for charcoal production is affecting their environment negatively [26].

## 1.4 Health Impact

Emission of greenhouse gases from charcoal production in tropical ecosystem in 2019 are estimated at 71.2 million t of carbon dioxide and 1.3 million t for methane [27]. All this emissions burns and smokes inhalation leads to a decline in physical health that can lead to mental health also, same time it contributes to climate change that has some health effects, according to U.S. global change research program 2016, Climate change effects human health in two ways;

- Changing the severity or frequency of health problems that are already affected by climate or weather.

- Creating unprecedented or unanticipated health problems or health threats in places or time of the year where they have not previously occurred.

Also many trees inside forest reserves serves as source of local herbs for the fringe community, which they use to take care of their health issues. According to the local homeopathic medicine dealers, deforestation has made them to lose many trees that they use for treatment and some are on extinction.

## 2. MATERIALS AND METHODOLOGY

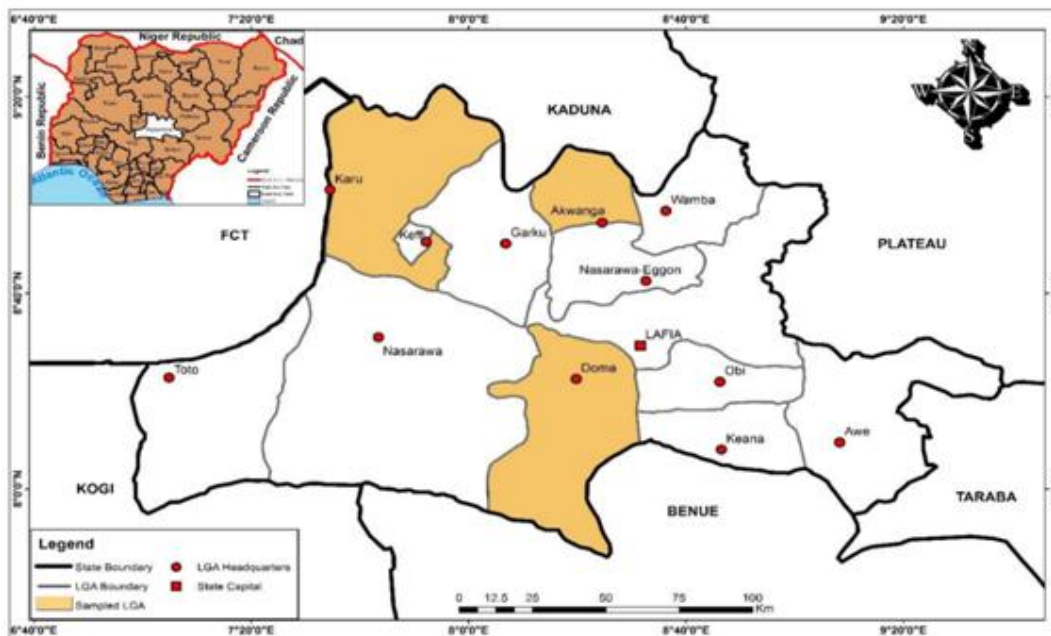
The study was conducted in Nasarawa state in North Central of Nigeria with land area of 27,117 km<sup>2</sup> and lies between latitude 7°45' and 9°25'N of the equator and longitude of 7° and 9°37' of green wich meridian, surrounded by Kaduna in the north, west by Abuja federal capital territory, south by Kogi and Benue state and east by Taraba and Plateau state.

Commercial charcoal production businesses around the state is among the major threat to forest reserves and contributes highly to deforestation and this paper was to determine

the impacts of this charcoal production to the forest reserves and also the public perceptions of environmental effect of unplanned cutting of tree for Charcoal Production. Three locations with highest production capacity was used for the study, quantitative and qualitative mode of inquiries was used to explore the contributions of commercial charcoal production on deforestation in this selected areas namely; Karu, Akwanga and Doma.

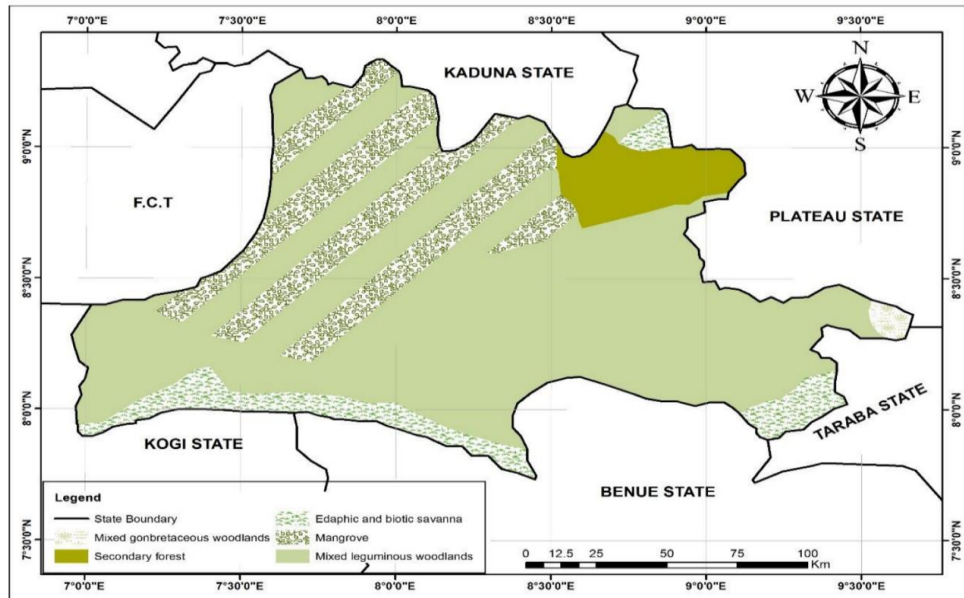
Primary and secondary source through in-depth interviews and discussion with selected 450 respondents from all the locations, comprising charcoal producers, traders, buyers, village heads and indigenous people of the study areas, in - house survey questionnaire was employed and physical aspects relevant to the study were observed, measured and recorded using GPS. Information's was also accessed through review of relevant texts, journals, newspapers, official publications, magazines and internet which served as tangible source of insight into charcoal production and deforestation.

Fig. 1 shows the state with boundaries and the three locations used for the study namely; Karu, Akwanga and Doma, while Fig. 2 shows the vegetation of the state.



**Fig. 1. Nasarawa State with 3 study areas**

Source: Geography Department, Nasarawa State University, Keffi



**Fig. 2. Vegetation of Nasarawa State**

Source: Geography Department, Nasarawa State University, Keffi

### 3. RESULTS AND DISCUSSION

Information on average duration for one complete cycle of charcoal burning/production, mass of charcoal yield per production, the mass of wood used and tree density were used to determine the impact of woodland depletion due to charcoal production in the three study area used.

Table 1 shows that 0.038 hectare of savanna woodland are depleted for the production of a single 15 kg capacity bag of charcoal in the study area. This means that the monthly production alone is responsible for the loss of 133.93 hectares out of which 64.3% occurred in the surrounding forest woodlands as indicated by the sources of wood used for production, while 1607.16 hectares of the savanna woodland is depleted annually due to commercial charcoal production, 64.3% (1033.4 hectares) of which occurred in forest reserves. According to the Ministry of Agriculture and Natural Resources, Lafia, Nasarawa State, there are 41 forest reserves in the State, totalling 150,765.26 hectares which constitutes 5.6% of the State's total land area, out of these 41 reserves, 37 are gazetted while 4 remains ungazetted [28].

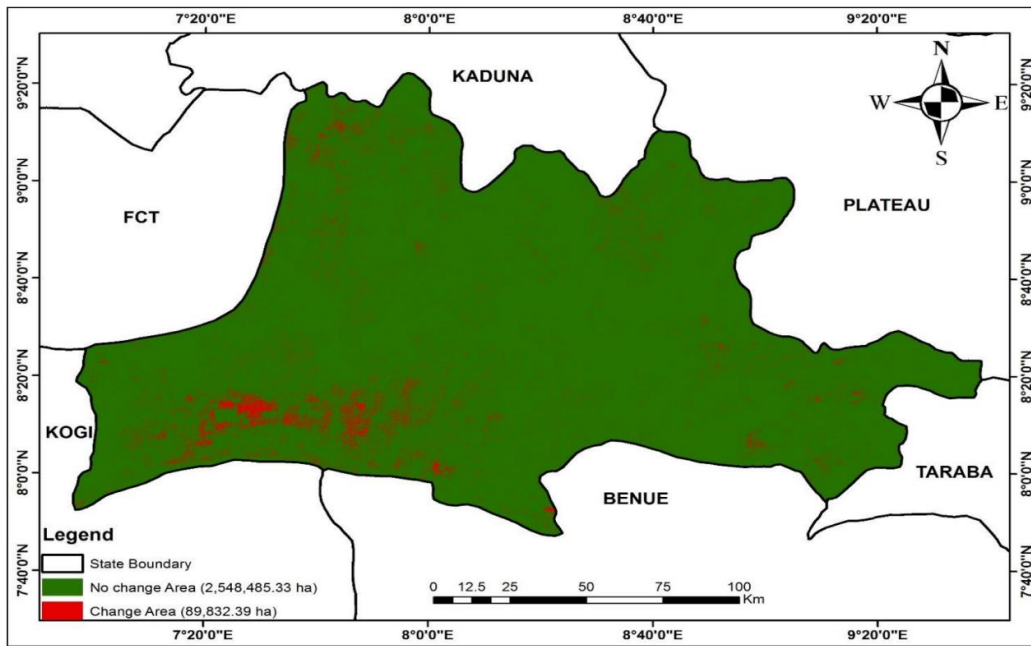
These reserves are not protected and have been threatened by other environmentally unfriendly

attitudes like illegal felling, farming, encroachment and de-reservation. Given an annual depletion of 1033.4 hectares of forest woodland in the State, 18601.2 hectares of forests was estimated to have been depleted over the period of 18 years (2001 – 2018) covered in the study. This represents 12.34% of the forest reserves in the State. This finding corroborates the claim by Vuyiya et al. [29], that human activities particularly charcoal production and use constitute a tangible threat to tree species and forests cover depletion. Furthermore, the Global Forest Change map [30] of the University of Maryland shows that a total of 89,832.39 hectares of the entire Nasarawa State had experienced tree cover changes between 2001 and 2018 and within the same period, contributing to depletion of 28,928.88 hectares of tree cover. This implies that commercial charcoal production in the State was responsible for 32.20% tree cover degradation within the period. This level of degradation is considerably high and do not support the Nigerian Government policy of maintaining 20–25% of the land area under forest cover for the well-being of the national, regional and global environment.

Fig. 3 shows the area of forest cover changes for the whole Nasarawa state according to Hensen et al. 2013.

**Table 1. Depletion of woodland due to commercial charcoal production**

Measured variables	Akwanga	Doma	Karu	Average
Depleted area of woodland due to charcoal production (ha/15k bag)	0.014	0.007	0.017	0.013
Depleted area of woodland due to charcoal production (ha/month)	55.94	10.39	94.96	133.93
Depleted area of woodland due to charcoal production (ha/year)	679.28	124.68	1139.54	1607.16
Depleted area of woodland due to charcoal production (ha/18 years)	12083.04	2244.24	20511.72	28928.88



**Fig. 3. Areas of forest cover changes**

Source: Clipped from Global Forest Change Map, version 1.6

**Table 2. Environmental effect of unplanned cutting of tree for charcoal production multiple response**

Effect	Akwanga		Doma		Karu		Total	
	N	%	N	%	N	%	N	%
Biodiversity loss	123	87.9	92	76.0	160	84.7	375	83.3
Forest degradation	139	99.3	105	86.8	189	100	433	96.2
Soil Erosion	10	9.1	6	5.0	11	5.8	27	6.0
Flash flood	5	3.6	0	0	10	5.3	15	3.3
Number of respondents	140		121		189		450	

In comparison of the three production areas, it was found that Karu production area had the most tree depletion with estimated value of 0.017 hectares depleted for the production of one bag (15 kg) of charcoal, 94.96 hectares per month, 1139.54 hectares per year and 20511.72 in the 18 years period. This was followed by Akwanga

production area in the same order with 0.014 hectares, 55.94 hectares, 671.28 hectares and 12083.04 hectares. The least depletion was observed in Doma production area where 0.007 hectares of tree cover was depleted to produce one bag of charcoal, 10.39 hectares depleted for monthly production, 124.68 hectares

for annual production and 2244.24 hectares for the 18 years period.

Commercial Charcoal Production contributes highly to forest degradation in the study area. About 96.2% the respondents attested to this. Another high proportion 83.3% of the respondents identified plant diversity loss as another striking effect of unsustainable charcoal production in the study area. It appeared that most of the producers were unaware of the indirect effects of their activities in the study area as only 6% and 3.3% identified soil erosion and flash flood respectively, as some of the effects of unsustainable charcoal production in the study area. Although the awareness pattern was generally the same across the three sampled LGAs, it appeared that producers in Akwanga and Karu were more aware of the situation that those located in the production area of Doma LGA. The finding on deforestation confirmed identified charcoal production as one of the earliest major causes of deforestation in Europe especially in Britain during the middle Ages [31]. Account of charcoal production in many parts of the world especially in developing countries such as Nigeria, Brazil, Tanzania, Senegal, Somalia, Ghana and many others today paints a gloomy picture of unsustainable use of forest and savanna woodland resources [32,33,31]. Forest/woodland degradation is the more probable direct outcome of commercial charcoal production [34]. Deforestation and degradation of woodlands are among the major environmental problems consequent to commercial charcoal production globally and in 2009 estimates on deforestation resulting from charcoal production in various parts of the world puts Oceania at 5.40 km<sup>2</sup>, Central America 390 km<sup>2</sup>, South America 2400 km<sup>2</sup>, Asia 5100 km<sup>2</sup>, and Africa 29,760 km<sup>2</sup>. Africa appears to be leading when it comes to deforestation resulting from charcoal production [27].

The high identification of tree biodiversity loss as one of the two major effects of commercial charcoal production corroborated the assertion of [25] loss of biodiversity nowadays is mainly a consequent of economic activities despite the numerous services human beings get from it, further opined that the raw material for charcoal production in most parts of the world is wood harvested from the natural forest/woodland [27]. The cutting down of trees for charcoal production has led to disappearance of certain tree species as well as wild animals and micro-organisms in both the forest and savanna ecological zones in

Ghana [33]. Commercial charcoal production processes starts with cutting down of trees, cutting them into trunk parts and transporting to the charcoal production site for the burning process that takes days and excess tree cutting without reforestation program causes deforestation [35,36]. Several studies on soil qualities using in both charcoal burning sites and adjacent field sites have shown substantial variation where soil properties are expected to be the same thereby indicating that charcoal burning impacts on the soil especially at the kiln site [37,38].

#### 4. RECOMMENDATION AND CONCLUSION

Challenges posed by this charcoal production in Nigeria can be solved though policy, awareness, prudent forest management, getting involve the private sectors and policies enforcement. This commercial charcoal production technology in the study area has resulted in the depletion of 14.9% of woodland forests and the loss of 28928.88 hectares of tree covers between 2001 and 2018 and charcoal producers in the state are aware of some environmental consequences of their activities, but they are motivated by the associated financial benefits to carry on with the destruction of natural environment and poor people are most vulnerable to environmental hazards and combined with unequal distribution of assets in the country, increasing the opportunity on the basic amenities for the vulnerable is the only way to sustain overall growth and reduce disparity. Disparity on amenities like kerosene, cooking gas and electricity should be provided in other to encourage the poor populace to obey the laws if enforced *Emeodilichi, 2018*. This charcoal producers should be engaged by creating an enabling environment, educating them the advantages of tree planting which will preserve their business and public sectors and private sectors comprising NGO's, research and academics also has a role to play by finding best species of trees and ways of planting them.

There is good enabling environment for charcoal business in Nigeria which if expended in scope with good policy implementation will preserve our forest reserves from total extinction. Government and citizens will benefit from a well-articulated forestry policies programs if implemented significantly will reduce the amount of trees cut down for this charcoal business combined with an afforestation program.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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