ISSN: 3141-5636 E-ISSN: 31415644 Vol. 1, No. 2; December (2025)

Traditional Charcoal Production and Its Environmental Impacts in Sustainable Energy Transition: Evidence from Nsukka, Enugu State, Nigeria

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Abstract
The conscious advancement towards cleaner energy sources has become one of the major strategies for curbing the emission of greenhouse gases whose over-concentration in the atmosphere brings about climate change. In Nigeria, the traditional charcoal production practices have become a worrisome trend due to their adverse impact on the environment. This paper examines the practices associated with traditional charcoal production in Nsukka, Nigeria and its implication on the environment. The paper further analyses the implication of continued charcoal production on Nigeria sustainable energy transition plan. The study deployed a qualitative, exploratory research design to gain deep insight on charcoal production practices. This approach involves the use of primary and secondary sources of data. The primary sources include key informant interviews, and focused-group discussion while the secondary sources include journals and documented reports. Participants were selected using purposive sampling to ensure the possessed relevant knowledge or experience related to charcoal production. Data were analysed using the qualitative analytical method. The study found that charcoal production is still being practices among Nsukka rural dwellers and the practitioners use crude method of controlled oxidation that has serious environmental impact. Also, the activities of the producers result to continuous and unmitigated deforestation. The study recommends for the deployment of efficient production technologies that would pose minimum hazard to the environment and use of sustainably sourced wood. The study further recommends for policy regulation, community engagement and education as approaches to reducing deforestation and environmental degradation.
Keywords: Climate Change, Energy Transition, Environment, Charcoal, Production Practices

Introduction

The shift toward cleaner energy sources is conventionally considered as a key strategy for reducing greenhouse gas emissions, whose excessive accumulation in the atmosphere drives climate change. Climate change stands as one of the foremost challenges confronting the world in the twenty-first century. Alterations in average global climate conditions are attributed to greenhouse gas (GHG) emissions resulting from fossil fuel combustion. The intensification of these gases, which accelerates climate change, is fueled by rising energy consumption. Heavy reliance on fossil fuels has adversely affected global climatic conditions, leading to persistent calls for a transition to renewable energy and cleaner energy sources.

In Nigeria, the effects of climate change have been evident over the past two decades. Between 1988 and 1998, average temperatures rose by 7.3%, and between 2011 and 2021, they increased by 4.27%, each corresponding to economic contractions of -23.3% and -1.065%, respectively (Amare & Balana, 2023). These declines are linked to losses in agricultural output. A 1% increase in precipitation is associated with a 0.23% decrease in economic growth (Chamma, 2024), while a 1% rise in average rainfall reduces agricultural productivity by 1.23% (Chamma, 2024). This suggests that although adequate rainfall is vital for farming, excessive precipitation—particularly torrential rains and flooding—harms crops, farmland, transport infrastructure, manufacturing, services, and overall economic activity, leading to widespread losses (Arogundade, Hassan, & Mduduzi).

Nigeria, along with Sierra Leone, Senegal, Niger, and Mauritania, belongs to a group of high-risk countries where a one-unit temperature increase results in a GDP per capita decline of 0.0028% (Chamma, 2024). Several factors place Nigeria at significant risk for climate change impacts, including its large population, proximity to the coast, infrastructure deficits, and governance challenges. In response, Nigeria has initiated several measures to mitigate the effects of climate change and curb the emission of greenhouse gases. As part of its obligations under the Paris Agreement, Nigeria established its Nationally Determined Contributions (NDCs), a key requirement of the accord. In 2021, Nigeria enacted the Climate Change Act to domesticate the Paris Agreement. Through this legislation, the country put in place enforceable measures aimed at minimizing greenhouse gas emissions. The Act introduced various mechanisms for achieving Nigeria's climate goals, including the National Council for Climate Change (NCCC), the Climate Change Fund, Carbon Tax and Carbon Emission Trading, and Climate Change Education.

In 2022, Nigeria further demonstrated its commitment to reducing its greenhouse gas footprint by launching its Energy Transition Plan, which builds upon the Climate Change Act of 2021. The plan outlines the steps necessary to achieve the net-zero target pledged by Nigeria in its NDCs during COP26, while simultaneously addressing the country's energy needs and creating economic opportunities. Five key sectors are highlighted in the plan: power, cooking, oil and gas, transport, and industry. Collectively, these sectors account for 65% of Nigeria's GHG emissions. The plan envisions that Nigeria will achieve net-zero emissions by 2060 and estimates that approximately USD 10 billion annually will be required to reach this goal. Within its Energy Transition Plan, Nigeria has expressed a commitment to expanding gas infrastructure and transitioning away from fuels such as kerosene (DPK) toward cleaner gas and grid-supplied stoves. However, despite these stated commitments and moves toward cleaner energy sources, the increasing reliance on charcoal for cooking poses a serious challenge to the practical

achievability of the Energy Transition Plan. Rapid urbanization and the rising cost of cooking gas have pushed many households toward charcoal use, which carries negative environmental implications. The production of charcoal involves deforestation and the release of vast amounts of carbon into the atmosphere. Charcoal is a fuel produced through the carbonization of biomass.

In Nigeria, charcoal production is widely recognized as having devastating ecological and environmental effects, and the government, public forestry institutions, and non-governmental organizations have expressed particular concern over these impacts. The most frequently cited consequence is deforestation—that is, the clearing of forests or woodlands. The process of charcoal production, which involves the incomplete combustion of logs, releases enormous quantities of greenhouse gases such as carbon dioxide and methane into the atmosphere. Furthermore, the procurement of wood for charcoal production drives unsustainable deforestation, leaving the environment more vulnerable to climate change impacts such as flooding. Deforestation weakens soil structure, increasing susceptibility to flooding, and often affects agricultural lands, thereby contributing to food insecurity challenges. This paper examines traditional charcoal production in Nsukka, Enugu State, and its implications for sustainable energy transition.

Research on charcoal production has identified several global drivers of the industry. These include rapid industrialization and population growth leading to increased demand, primarily among the urban poor (Ogwumike & Ozughalu, 2001; Kituyi, 2002); growing interest in woodfuel as an alternative to fossil fuels in developed countries (FAO, 2010); the versatility of wood-based fuels and their high potential for technological innovation (Sepp, 2010); the scarcity and rising cost of modern fuels (Gbadegesin & Olorunfemi, 2011); relatively low capital and operating costs that facilitate production (Uisso & Balama, 2011); and rural poverty resulting from declining crop productivity coupled with climate variability (Uisso & Balama, 2011). These drivers have pushed up the business of making charcoal from logs for the domestic and export market.

Determining whether woodfuel supply sources are sustainable depends on understanding the basic drivers behind the continued harvest and production of these energy sources. Approximately 64% of Nigerians reside in rural areas with limited industrial activity. Studies suggest that over 70% of the Nigerian population depends on charcoal and other forms of biomass, and over 80% of rural charcoal production exemplifies the conflict between short-term ecosystem services and the long-term supporting services needed to regenerate ecosystems (Adedayo et al., 2013; Yusuf, 2008). Wood energy systems involve complexities such as multi-stakeholder participation, interactions with livelihood and food security, climate change mitigation, and environmental impacts. Beyond land degradation, another climate change-inducing factor is the emission of greenhouse gases during harvesting and, even more significantly, during pyrolysis. This process results in the formation of products such as methane, carbon monoxide, alkenes, oxygenated compounds, and particulate matter (NTL, 2002; UNEP, 2005; Palmula & Beaudin, 2007).

Given that Nigeria is a major consumer and exporter of woodfuel, concerns have arisen regarding the sustainability of woodfuel sources and the implications for the nation's drive toward clean energy use. Worries about the capacity of commercial production to deplete forest

resources have been heightened by the concentration of production in small lots, changes in production locations depending on tree availability, and the low efficiency of traditional kilns, which are predominantly used in the area. The implication is that rising demand will encourage incursions into natural forests in search of feedstock. This factor, combined with others such as expanding agricultural land, uncontrolled logging activities, and grazing by transhumant herders, will continue to accelerate the depletion of the country's forest reserves (FME, 2006). In addition to land degradation, greenhouse gas emissions during harvesting and pyrolysis contribute further to climate change. As earlier noted, this process produces methane, carbon monoxide, alkenes, oxygenated compounds, and particulate matter which exacerbate global warming (NTL, 2002; UNEP, 2005; Palmula & Beaudin, 2007).

Bridging the Research Gap

Nigeria is at a critical crossroads in its pursuit of sustainable energy and climate action. In response to the Paris Agreement and global calls for reduced greenhouse gas emissions, the Nigerian government has enacted the Climate Change Act (2021) and launched an ambitious Energy Transition Plan aimed at achieving net-zero emissions by 2060. Central to this plan is a shift away from carbon-intensive fuels such as kerosene and firewood toward cleaner alternatives like liquefied petroleum gas (LPG), electric cooking, and renewable energy sources. However, despite these policy commitments, a significant gap exists between national energy transition goals and the lived realities of energy practices at the local level. The advocacy for a shift towards cleaner energy use in Nigeria especially as it concerns charcoal production has not attracted sufficient scholarly attention. Existing studies on charcoal-related practices are focused on the processes and impacts without linkage to Nigeria's energy transition plan. This study is designed to review practices vis-à-vis Nigeria's energy transition plan.

One of the most pressing challenges to Nigeria's energy transition is the persistent and growing reliance on charcoal as a primary cooking fuel. In areas such as Nsukka, Enugu State, charcoal production has become an increasingly significant economic activity driven by a combination of factors: declining agricultural productivity due to climate variability, rural poverty, unemployment, rising costs of modern fuels, and demand from both domestic urban centers and international markets. While charcoal provides a relatively cheap and accessible energy source for millions of Nigerians, its production is associated with severe environmental consequences, including deforestation, biodiversity loss, soil degradation, and substantial emissions of greenhouse gases such as carbon dioxide and methane. These environmental impacts directly undermine Nigeria's climate commitments and threaten the long-term sustainability of its forest resources.

Existing studies have documented the global drivers of charcoal production and its environmental effects, but there is a lack of localized, qualitative research that examines the intersection of traditional charcoal production practices and national energy transition policies in specific Nigerian contexts. Most policy discussions focus on technological solutions and top-down regulatory measures without adequately addressing the livelihoods, motivations, and constraints of the rural producers who are central to the charcoal value chain. Therefore, this study was designed to fill that gap by investigating traditional charcoal production in Nsukka, Enugu State, with a focus on three core objectives: (1) to assess the current charcoal production activities in the study area, (2) to evaluate the environmental impacts of these activities, and (3)

to analyze the implications of continued charcoal production for Nigeria's sustainable energy transition. By doing so, the research aims to provide evidence-based insights that can inform more effective, context-sensitive policies—policies that balance environmental sustainability, climate commitments, and the socio-economic survival of vulnerable rural populations.

Therefore, the study focuses on charcoal production in the Nsukka area of Enugu State, Nigeria, a recognized charcoal-producing area, with the specific objectives to: assess charcoal production activities in the study area; evaluate the impact of charcoal production on the environment; and analyse the implications of charcoal production for sustainable energy transition in Nigeria. This study holds significant value across multiple domains, including academic research, environmental policy, energy transition planning, rural livelihood improvement, and practical interventions in charcoal production practices. By examining traditional charcoal production in Nsukka, Enugu State, and its implications for Nigeria's sustainable energy transition, the research addresses critical gaps in knowledge and offers actionable insights for a wide range of stakeholders.

From an academic perspective, while charcoal production and its environmental effects have been studied in various African contexts, there is a scarcity of localized, qualitative research that specifically examines the interplay between traditional charcoal production practices and national energy transition policies in southeastern Nigeria. This study contributes original empirical data from Nsukka, an area not extensively covered in existing literature on woodfuel and energy transition. By documenting the lived experiences, motivations, and constraints of charcoal producers and marketers, the research enriches the academic understanding of informal energy economies and their resistance to top-down policy frameworks. Furthermore, the study adds to theoretical discussions on the drivers of deforestation, climate change mitigation, and the socio-economic trade-offs inherent in rural livelihood diversification.

In terms of policy relevance, Nigeria's Energy Transition Plan, launched in 2022, sets an ambitious goal of achieving net-zero emissions by 2060, with a strong emphasis on shifting away from carbon-intensive fuels like charcoal and firewood toward cleaner alternatives such as LPG, electric cooking, and renewable energy. However, the plan pays insufficient attention to the deep-rooted socio-economic and cultural factors that sustain charcoal production and use at the local level. This study provides policy-relevant evidence by highlighting how poverty, unemployment, declining agricultural productivity, and the high cost of modern fuels drive charcoal production in rural areas. Policymakers and implementing agencies—including the National Council on Climate Change, the Ministry of Environment, and state-level bodies—can use these findings to design more realistic, context-sensitive interventions that address the root causes of charcoal dependence rather than merely outlawing or discouraging the practice.

The Study Area

The study was conducted in Nsukka Local Government Area of Enugu State, Nigeria. Nsukka is one of the 17 local government areas in the state and serves as the headquarters for the Enugu North Senatorial Zone. It is home to several communities, including Nsukka Town. Geographically, Nsukka is situated in the northern part of southeastern Nigeria, approximately between latitudes 6°51' and 7°00' N of the equator and longitudes 7°23' and 7°45' E of the Greenwich Meridian (Ali & Agbiogwu, 2014). The area covers approximately 484.2 km² to

495.87 km^2, with a mean elevation of 1,810 feet (552 meters) above sea level. As of 2022, the estimated population of Nsukka was 444,100 (NBS, 2022). The landscape is characterized by lush green hills and fertile soil, making it highly suitable for agricultural activities. The communities that make up Nsukka include Edem Ani, Ibagwa Ani, Opi, Eha-lumona, Orba, Ede-Oballa, and Obimo.

According to the Köppen climatic classification system, Nsukka experiences a tropical wet and dry climate. The area receives ample sunshine throughout the year. The average daily maximum and minimum temperatures are 27°C and 23.3°C, respectively, while the average monthly maximum temperature is approximately 31.5°C (Inyang, 1978). Rainfall in Nsukka is abundant and intense. Average monthly rainfall ranges from 250 mm in April to 380 mm in October, with a mean annual total of 1,500 mm (Inyang, 1978). The dry season, characterized by a lack of rain, lasts from November to March, while the wet season extends from April to October. The harmattan season, marked by dry and dusty northeasterly trade winds, occurs between late November and the end of February. The underlying geology consists primarily of two formations: the false-bedded sandstone (Ajalli sandstone) and the Lower Coal Measures (Nsukka Formation). The soils of Nsukka LGA are classified into two main groups: ferrallitic soils (deep, porous red soils derived from sandy deposits, along with red and brown soils derived from sandstones and shales) and hydromorphic soils. Agriculture is the predominant socio-economic activity engaged in by the area's inhabitants. Farmers in the region cultivate various crops, including yams, cassava, cocoyam, pigeon peas, pepper, maize, and vegetables. Cash crops such as palm produce, tobacco, kola nuts, oranges, mangoes, and many other fruit plants also thrive well in the region.

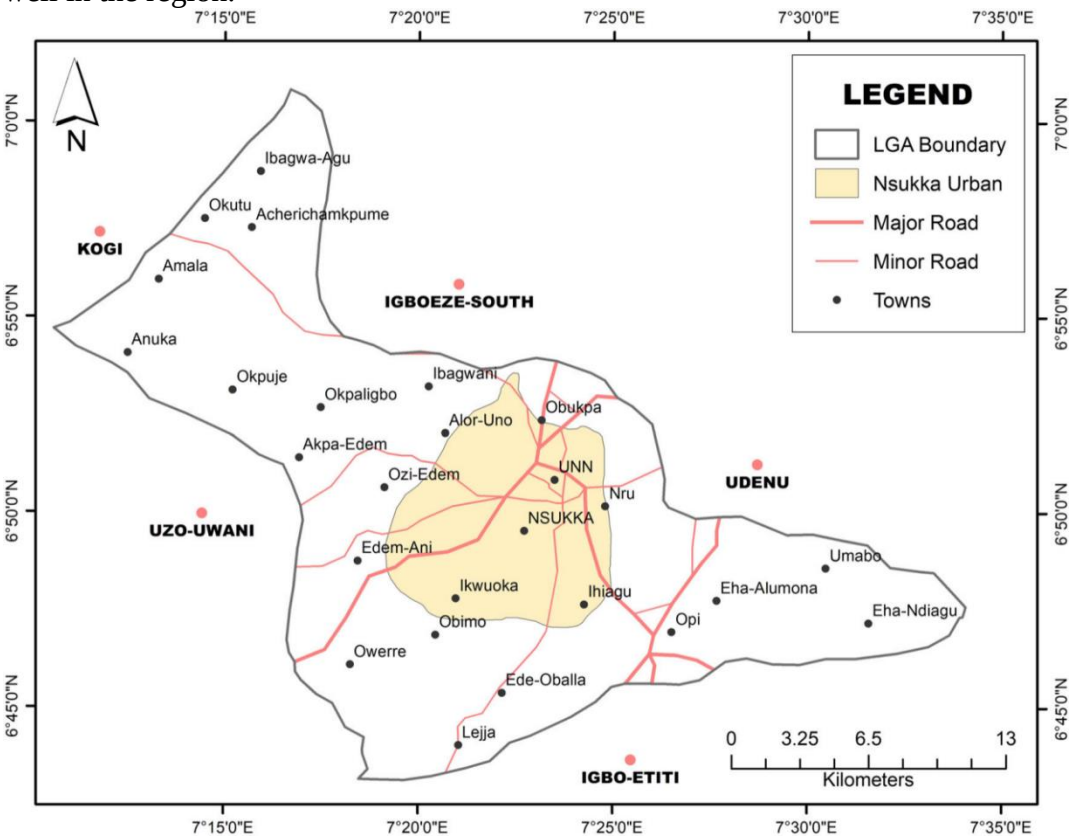


Fig. 1: Nsukka Local Government Area

Source: Nsukka Town Planning Authority

Methodology

This study employed a qualitative research approach to gain an in-depth understanding of charcoal production practices and their implications for sustainable energy transition in Nsukka, Enugu State, Nigeria. Qualitative data were collected through two primary methods: key informant interview and focused group discussion. These methods allowed the researcher to capture the nuanced experiences, attitudes, and motivations of individuals involved in the charcoal production value chain.

A total of sixty (60) interviews comprising fifty-four (54) key informant interviews and six (6) focused group discussion were conducted. Focus groups provided a platform for collective reflections and enabled participants to build upon each other's responses, revealing shared norms, disagreements, and group dynamics that might not emerge in one-on-one interviews. The sample size for the interview was based on Moser and Korstjens (2018) position that the sample size is considered appropriate when the selected participants and setting are sufficient to provide the information needed for a full understanding of the phenomenon under study. Purposive sampling was deployed to ensure that only individuals who have knowledge of charcoal production activities or directly engaged in charcoal production, marketing, or related activities were included in the study. This sampling strategy enabled the researcher to gather rich, relevant data from key informants with direct knowledge of the subject matter. An open-ended interview protocol was developed to guide both individual and group discussions. The questions covered a broad range of topics, including the motivations for entering the charcoal business, feedstock sourcing practices, production techniques, storage methods, and marketing channels. The open-ended format allowed participants to express themselves freely and provided rich qualitative data.

The qualitative analytical method was deployed in the analysis of data. The analysis is based on the interpretative perspective, leading to drawing of specific conclusions from the reviewed corpus of data. Data analysis proceeded in stages. Preliminary analysis was conducted immediately after data collection to gain a general sense of the emerging themes and to reflect on the overall meaning of the responses. This was followed by a more detailed, systematic analysis in which the data were divided into smaller segments or units, each reflecting specific thoughts, attitudes, and experiences of the participants. Key themes related to charcoal production practices and demand drivers were then summarized based on the structured personal interviews held with producers and marketers.

Results and Discussion

The Production Practices

Charcoal production in Nsukka is largely an informal sector activity that is unregulated. The sourcing of woodstock involves an unregulated deforestation. The method widely used for processing wood to charcoal is crude and harmful to the environment. The method of the control oxidation involves the use of inefficient kilns that release carbon and carbon dioxide into the atmosphere. People who are mostly involved in the charcoal processing are largely poor farming households seeking alternative means of income. Most individuals involved in charcoal

processing see the business as a necessary survival strategy or enterprise irrespective of the threat that charcoal production activities pose to the environment.

Feedstock sourcing as earlier stated is largely unregulated, and despite the existence of licensing requirements, forest monitoring remains weak and under-resourced. The socio-economic realities of producing communities—dominated by poor farming households seeking income diversification—are often at odds with environmental preservation and energy transition objectives. Many producers and marketers view charcoal production as a necessary survival strategy rather than an environmental threat. The government on the other hand seems to be aloof as there is lack of information on the part of the charcoal producers on the dangers of massive deforestation and inefficient methods of processing. There appear to be a significant knowledge chasm that could be filled through effective education of the local people on the dangers of deforestation poor production practices.

Key Drivers of the Charcoal Processing Activities

The following key drivers of the charcoal production business were identified:

Alternative Source of Income: Residents of the study area are predominantly engaged in farming but increasingly seek supplementary sources of income. This trend is linked to declining crop productivity, compounded by climate variability, as suggested by Olusola and Adenegan (2011). Faced with diminishing returns from agriculture, many residents have turned to other low-capital income sources that offer better guarantees on investment returns. While most of the interviewed dealers were primarily farmers, others included artisans and civil servants. Approximately 37% of stakeholders noted that their entry into the charcoal business was motivated by a desire to diversify and expand their income base. Over time, the business has gained popularity. Among the producers were retirees from active service — mostly former teachers—, who sought local businesses capable of sustaining them in retirement, leading them to adopt charcoal production. The marketers were predominantly women, many of whom were family members of charcoal producers or independent traders selling charcoal alongside other items such as cooking pots, provisions, and farm produce.

Rising Charcoal Demand: This driver is closely related to the preceding one. Locally, there is a growing charcoal demand, especially among urban dwellers. Processed charcoal is used as alternative source of energy for cooking, especially among urban dwellers. Charcoal stoves are found in many urban households across Nigeria. Charcoal is also a vital export commodity. As Jamala et al. (2013) noted, regular charcoal export demand occurs from May to August, coinciding with the summer months in Europe. However, large-scale importers in Europe, Kuwait, Israel, and some Asian countries place orders throughout the year. This situation prevails in the study region. Charcoal merchants often visit the local producers for bulk purchase. If, as stated, approximately 30% of charcoal produce is exported, it can be reasoned that perpetual pressure is transferred to both producers and available forest resources, driving continuous production and resource extraction.

Optimal Use of Cleared Trees: Three main tree-clearing activities occur in the study area: agriculture, logging, and charcoal production. The predominant farming system in the area is bush fallow, which involves cultivating different land parcels in rotation, allowing one parcel to regenerate while another is used. The land preparation season for cassava and yam—the major

crops cultivated in the region—runs from March to June, which coincides with the peak charcoal production period. Closely related is the use of tree branches and "wastes" from logging activities. Producers define these "wastes" as tree parts that are either not straight enough for log production or too small in diameter to be processed. Logging is typically carried out during the dry season because it is easier to transport logs along rough, unpaved village roads, which become challenging to navigate during the rainy season. The fact that tree species used for timber production are mostly heavy-weight, charcoal-compliant trees further emphasize this route to feedstock acquisition.

Family Business: For a small number of producers, charcoal production is a family business that they grew up knowing and have continued as long as it remains feasible. Additionally, retail opportunities for mostly female members of the association—who serve as marketers—were also identified as a supply-side driver.

Forest Management: Producers agreed that one driver of continuous production are their efforts to manage the forest resources available to them. In this regard, old trees are cut down to aid the regeneration of young sprouts and to decongest the forest. Producers also believe that this approach improves soil fertility in the forest. The belief that tree regeneration occurs relatively easily in the region allows for the harvest of feedstock and continued production on the same piece of land over time.

Alternative Energy Sourcing: The search for alternative sources of woodfuel was identified as the most paramount demand driver, accounting for 31.4% of responses. In this context, importing countries have turned their focus to nations with seeming excess woody biomass, which are also relatively cheaper to import from. Nigeria has become one of the highest exporters of charcoal in Africa—a trend that may continue for some time.

Relative Affordability: The charcoal market is dominated by caterers and cottage industries that purchase the product in large quantities. The stated reason for this preference is that charcoal is relatively cheaper for large-scale cooking compared to modern fuels. Furthermore, its seeming availability all year round means that supply can always meet demand, unlike the occasional scarcity of modern fuels. Household demand for charcoal in surrounding urban areas was said to be driven primarily by the scarcity and relatively high price of modern fuels.

Energy Content of Charcoal: Charcoal has been found to possess a higher calorific value than fuelwood, averaging 30 MJ/kg, just behind kerosene at 43 MJ/kg. Charcoal has also been identified as the most suitable biomass fuel for indoor cooking because of its smokeless burning process. This finding is consistent with the submissions of producers and marketers, who believe that charcoal is regarded as a cleaner and less burdensome cooking fuel. It can also be used for other household functions, such as ironing with the traditional charcoal iron.

Ease of Packaging: Closely related to the above is the agreement that charcoal can be stored for long periods without fear of insect infestation or loss of energy content, as long as it is kept dry. Its relative ease of transportation and packaging makes it a better fuel choice for many users.
Charcoal is mostly consumed by urban households, providing cheap fuel for all income classes (Kambewa et al., 2007; Uisso and Balama, 2011; Agyeman et al., 2012). The unavailability and

high cost of modern fuels, especially kerosene, in most urban centers in Nigeria greatly increase household consumption of charcoal. There are signs of continuous increase in charcoal production, and increased advertisement of the product indicates that it is currently one of the most profitable export commodities in Nigeria.

The Impact of Charcoal Production on the Environment

The charcoal production process significantly impacts the environment, primarily through deforestation, greenhouse gas emissions, and soil degradation. The process involves cutting down trees for fuel, leading to habitat loss and biodiversity decline. Incomplete combustion releases harmful gases such as carbon dioxide, methane, and nitrous oxide, contributing to climate change. Additionally, soil quality can be negatively affected by the heat generated during charcoal production, impacting microbial activity and nutrient levels. Charcoal production invariably leads to deforestation and biodiversity loss. Charcoal production relies on the extraction of wood, often leading to deforestation and the destruction of forest ecosystems. This loss of habitat threatens numerous plant and animal species, disrupts food chains, and contributes to biodiversity loss. Selective logging of valuable tree species, such as shea butter and mahogany, further exacerbates the problem by reducing the diversity and resilience of forest ecosystems.

Greenhouse Gas Emissions is another major impact of charcoal processing. Traditional charcoal production involves incomplete combustion, resulting in the release of substantial amounts of greenhouse gases. Carbon dioxide, methane, and nitrous oxide are released into the atmosphere, contributing to global warming and climate change. In tropical countries, traditional charcoal production is estimated to emit significant quantities of these gases, equivalent to a substantial percentage of emissions from deforestation. The process also results in soil degradation. The heat generated during charcoal production can negatively impact soil properties. Soil microbial activity and nutrient levels can be significantly affected, potentially leading to reduced soil fertility. Erosion and reduced plant cover can also occur, further impacting soil quality and the long-term productivity of the land. Most of the large-scale producers do not reside in the feedstock source areas and are therefore barely affected by the myriad of environmental problems identified above. This situation is a microcosm of the entire charcoal market in the country. Nigeria has been noted as one of the highest producers of charcoal in Africa and also one of the highest net losers of forests and woodlands (FAO, 2011). It is therefore a case of losing local forests to produce alternative energy for developed countries while those countries retain the sustainability of their own environments.

Implications for Nigeria's Energy Transition Plan

The continued production and use of charcoal in Nigeria carry significant negative implications for the country's energy transition plan. Charcoal production is a major driver of deforestation and desertification, leading to the loss of forest resources, biodiversity depletion, soil degradation, and erosion. This threatens the sustainability of the environment and diminishes forest carbon sinks, thereby undermining efforts to combat climate change. Charcoal burning releases greenhouse gases such as carbon dioxide, contributing to global warming and climate change. It also causes indoor air pollution, posing serious health risks such as respiratory diseases to users, especially in rural and urban poor households. Women and children, who spend more time near cooking areas, are particularly vulnerable to these health impacts. The

paradox of the charcoal production business is striking; charcoal is consumed as a relatively cleaner fuel in urban areas and even exported to developed countries for recreational use, but its production imposes disproportionate environmental and health burdens on rural communities in Nigeria. This situation raises fundamental questions about the feasibility of Nigeria's Energy Transition Plan in the face of entrenched informal energy economies. Can Nigeria realistically achieve net-zero emissions by 2060 when charcoal production continues unabated, driven by poverty, market demand, and weak regulatory enforcement? What are the specific production practices, environmental impacts, and socio-economic drivers of charcoal production in key areas like Nsukka? And how do these factors collectively threaten the country's transition to sustainable energy?

From an energy transition perspective, Nigeria's plan aims to shift from traditional, carbon-intensive fuels like charcoal and firewood to cleaner, low-carbon energy sources, including liquefied petroleum gas (LPG), electric cooking, and renewable energy technologies. Continued reliance on charcoal directly conflicts with this transition goal, as it perpetuates high CO_2 emissions and depletes natural resources that are vital for sustainable development. The energy transition plan highlights the need for investments and policies that promote clean cooking technologies and reduce biomass reliance, thereby reducing emissions by about 98% compared to fuelwood and charcoal use. Therefore, the implications are clear, without decisive reduction in charcoal production and use, Nigeria risks hampering its energy transition aspirations, worsening environmental degradation, and exacerbating health problems for its population. Sustainable forest management, adoption of clean cooking alternatives, and reforestation efforts are critical to aligning charcoal use reduction with the country's net-zero emissions target by 2060.

Conclusion

The challenges posed by climate change to terrestrial and aquatic ecosystems call for serious commitments to remediation and mitigation strategies, as well as to the entrenchment of sustainable energy use practices. Unregulated production of charcoal poses a serious threat to Nigeria's plan to migrate away from carbon-intensive fuels. Although charcoal is a relatively clean source of energy at the point of use, the process of its production leaves an unacceptable carbon footprint. People who use charcoal in urban areas enjoy a cleaner cooking experience, but the communities where charcoal is processed suffer its undesirable environmental impacts.

The socio-economic realities of residents of production communities cannot be ignored. These communities are dominated by poor farming households struggling to meet their basic needs, hence their diversification into charcoal production as an additional income source. It is therefore imperative that proactive steps be taken to ensure sustainability in view of current socio-economic realities. For tropical countries like Nigeria to record outstanding progress in development, they must intensify their focus on the promotion of rural agriculture and the protection of their forest resources, de-emphasizing short-term financial rewards that carry long-term environmental and socio-economic consequences.

Recommendations

The following recommendations are presented to chart a way forward in achieving the goal of sustainable energy transition while addressing the challenges posed by charcoal production:

1. Formalization of the charcoal production sector: Charcoal production has gained very significant popularity among Nigerian’s, yet the sector has remained an informal

production sector. It is essential that the government take bold steps to formalize this sector. It is proposed that annual re-licensing be required for producers. To be licensed, each producer must provide records of volume of production, including estimated volume of trees and tree species used. This must be accompanied by replanting reports detailing the number of trees replanted and the location of plantations.

2. More effective forest monitoring: The government usually turns a blind eye to what the local charcoal producers do in their various communities. There is an apparent neglect of community or individual-owned lands from which trees are felled and logged for charcoal production. Forest guards typically work on government-owned forest reserves. The government should as a matter of urgency checkmate the activities of charcoal producers through regulations and monitoring. Forest-related activities should be effectively monitored to ensure that indiscriminate felling of trees is stopped. Community forest management should be promoted by the government through education, community engagement and monitoring.
3. Use of efficient charcoal production systems: Efficient methods of charcoal processing should be used by practitioners to reduce the rate of carbon emission and overheating of the soil. The government should mandate the producers to use only approved production techniques that pose minimal harm to the environment.
4. Aggressive pursuit of improved farming productivity: Rural income diversification has been linked to declining agricultural productivity. It is therefore imperative that efforts be made to reverse this trend and promote other sustainable rural income sources. Increased efforts must be made to spread mechanized farming and the use of soil improvement technologies to restrict the practice of perpetual bush fallowing, which causes total tree removal in several places in preparation for crop planting.
5. Community forest management: Community forest management should be promoted. This approach gives communities a sense of ownership of the forests and ideally initiates the desire to preserve them, especially if they are well educated on the benefits that can accrue beyond the paltry income from charcoal production.

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