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Assessing Level of Awareness of Environmental Impacts of Charcoal Production and Consumption in the Southern Senatorial Zone of Nasarawa State, Nigeria

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Abstract: *Charcoal is a key source of energy in some Nigerian regions, but its production and use contribute to deforestation, loss of biodiversity, and risks to health. The aim of this research is to determine the level of awareness of the environmental, health and socio-economic effects of charcoal production and utilization in the Southern Senatorial Zone of Nasarawa State, Nigeria. A structured questionnaire was used to interview 120 respondents from Obi, Doma and Keana LGA and data were analyzed by descriptive analysis using SPSS and results were presented in the form of tables and charts. Findings indicate high awareness of ecological impacts: 96% of respondents perceived changes in biodiversity and 70% witnessed forest loss. Economic reason was stated by 48.3% as the key driver for use of charcoal in spite of health impacts such as eye irritation (70%). Almost all (94.2%) of the respondents recommended mitigation measures such as the plantation of trees. In conclusion, the study offers significant insights for policy makers and emphasizes the necessity for environmental education initiatives and use of sustainable alternatives for charcoal.*

Keywords: Charcoal production; Environmental awareness; Deforestation; Health impacts; Biodiversity; Nasarawa State

INTRODUCTION

Human activities worldwide are placing significant strain on natural environments and ecosystems, endangering biodiversity and forest health (Tassie et al., 2021; Yang et al., 2023). This situation is further worsened by urban expansion and rising populations, with increasing demand for charcoal production and consumption (Asare et al., 2022; FAO, 2020). Charcoal remain widely used for cooking in majority of African countries because of its affordability, high energy output, and ease of transportation (African Development Bank & WWF, 2012; Tassie et al., 2021). Yet, the growing

charcoal demand is contributing to ecological disruption, biodiversity loss and the deterioration of the region's tropical forests. Global energy sector is under pressure today due to its link to greenhouse gas emissions primarily from fossil fuel combustion which contribute to climate change and global warming (Abdulrazak et al., 2023). Charcoal, a fuel derived through the carbonization of biomass, is particularly associated with deforestation; the removal of forest or woodland cover. United Nations (2015) reports that Nigeria has the world's highest deforestation rate, with an estimated 3.7% forest loss each year, endangering biodiversity and environmental resources. Rural dwellers in many developing nations, depend heavily on biomass fuels such as firewood, charcoal, crop residues, and animal waste to meet their domestic energy needs. Carbon monoxide is produced from poor or incomplete combustion of carbon-based fuels, such as charcoal burning using an inefficient stove. Coupled with poor ventilation for those cooking in kitchens, the result can be instant death (Kim et al., 2018). Worldwide, smoke from kitchens is linked to more than 4 million deaths each year (Lim & Vos, 2012). Long-term exposure to PM2.5 and CO associated with inefficient cooking stoves and fuels is known to have negative health effects, especially on the respiratory system (Njenga et al., 2016; Branch 2022; WHO, 2018). Inefficient cooking stoves contribute significantly to indoor air pollution, and even some energy-efficient models can produce relatively high emissions.

Africa contributes approximately 63% of the world's total charcoal production and consumption (FAO, 2011). Around 94% of the rural population and 73% of the urban population in Africa rely on wood fuels as their main source of energy (Bailis et al., 2007), with rural communities primarily using firewood and urban populations largely dependent on charcoal to meet their energy demand. Charcoal and firewood, which are forms of wood fuel, represent the most widely used type of biomass energy in majority of African nations. Sassen (2015) noted that the impact of biomass consumption on forest sustainability, indicates that the continuous felling of trees for firewood and charcoal for domestic use could lead to severe forest degradation and species extinction. Fuel wood consumption constitutes roughly 90% of total energy consumption in Africa, with two-thirds of this used for household purposes (Bello et al., 2023). Charcoal production serves as an important alternative source of income to majority of the farming communities across West Africa during the periods when agricultural activity is low, helping to support their livelihoods (Girard, 2002). Local charcoal producers in Nigeria, contribute significantly to the spread of charcoal-making practices among various forest communities (Nabukalu & Gieré, 2019).

In Nigeria, charcoal serves as a major energy source, particularly for rural residents and low-income urban and semi-urban populations. The environmental impacts of charcoal production, particularly on soil quality, remain insufficiently studied and documented (Ogundele et al., 2012). Moreover, a significant portion of Nigeria's population lacks adequate access to modern energy sources, resulting in numerous adverse outcomes (Ahmed et al., 2023). Nigeria had an estimated forest growing stock of 2,166.16 million cubic meters as of 2020 and a total land area of 923,763 km² (approximately 21.63 million hectares), with forests covering less than 8% of this area (FAO, 2020). As of 2019, Nigeria produced 66.21 million cubic meters of firewood, up from 50.92 million cubic meters in 1990 an increase of 23% (FAO, 2020). Chomini et al., (2022) noted that felling of trees as a result of charcoal production has harmful environmental consequences. Deforestation is estimated to account for 87% of the country's total carbon emissions, largely because the trees that would normally absorb carbon dioxide are being removed daily, thereby intensifying global

warming and climate change (Lorenz et al., 2010; Gupta et al., 2010). Moreover, the destruction of forest habitats can lead to a significant decline in wildlife populations in the affected areas (Avila et al., 2011; Turkenburg, 2000; Hoogwij et al., 2003; Faaij, 2006; Hamelinck, 2006). This situation leads to food insecurity and displacement of settlement. However, Otu-Danquah (2010) noted that the production of charcoal contributes significantly to environmental degradation and deforestation. According to Ekhuemelo et al., (2019) charcoal production as a major contributor to the uncontrolled clearing of forest cover in Nigeria, a problem further intensified by illegal commercial logging. Revised deforestation statistics reveal that Nigeria has the highest rate of primary forest loss globally. Between 2000 and 2005, the country lost approximately 55.7% of its primary forests areas untouched by noticeable human activity. According to Gbiri & Adeoye, (2019) logging, subsistence farming, and the gathering of fuel wood, are the primary drivers of forest depletion in the West African nations.

In the Southern Senatorial Zone of Nasarawa State, a large proportion of the population depends on charcoal for cooking, heating, and small-scale businesses. While charcoal provides income and serves as a livelihood option for many households, its production and consumption contribute significantly to environmental challenges such as greenhouse gas emissions, deforestation, soil degradation, water scarcity, habitat destruction, biodiversity loss, erosion, and land degradation. These adverse impacts threaten ecological stability, drive climate change, foster desertification, and heighten the risk of food insecurity in the area. Without sufficient awareness in the study area, households are likely to continue the unsustainable practices, thereby deepening environmental degradation. Addressing this problem is crucial for developing public awareness initiatives, and alternative livelihood strategies that can balance energy access with environmental sustainability in southern senatorial zone of Nasarawa state. Hence, the rationale for undertaking this research.

1.1 Objectives of the Study:

i. Assess the effect of charcoal production on the biodiversity of the study area.
ii. Assess the factors responsible for the choice of charcoal as source of energy in the study area.
iii. Examine the perception of the residents of the study area on the effects of charcoal production on the environment.
iv. Examine the health implications of charcoal consumption on the residents of the study area.
v. Suggest measures that would mitigate the continuous depopulation of the woodlands in the study area and also contribute towards achieving the SDG 13 climate action on environment.

This study will address the following research questions:

i. What effect does charcoal production have on the biodiversity of the study area?
ii. What factors are responsible for the choice of charcoal as a source of energy in the study area?
iii. How do residents of the study area perceive the environmental effects of charcoal production?
iv. What are the health implications of charcoal consumption on the residents of the study area?

v. What measures can be suggested to mitigate the continuous depopulation of the woodlands in the study area and contribute towards achieving SDG 13 on climate action?

LITERATURE REVIEW/THEORETICAL FRAMEWORK

Theoretical Framework Guiding the Study

This study is informed by the Social-Ecological Systems (SES) and Commons Governance framework, to understand that human societies and ecological systems are interrelated and co-evolving over time (Ostrom, 2009). The SES framework identifies four central subsystems: the resource system, resource units, users and governance arrangements that interact in ways that yield outcomes of sustainability or degradation (McGinnis & Ostrom, 2014). From other types of common-pool resources like forests which are used for charcoal production, who has access and how this is defined, how the rules are enforced and how the community responds to external pressures, greatly affect outcomes (Anderies, Janssen, & Ostrom, 2004).

Applied to this study, the application of the SES approach enabled a study of how charcoal producers, traders and households access forest resources under the current governance system. It is also a guide through which to consider biodiversity loss, household consumption's impact on health, and implications for climate action under SDG 13. The examination, or the lack thereof, of collective-choice rules, monitoring and penalty is a key feature of the commons governance approach to the sustainability of resources (Ostrom, 1990) and has been stressed in (Cox and Arnold, 2007; Cox et al., 2010). Accordingly, the framework is relevant for analyzing both the demand and the institutional instruments that can be used to curb the presence of the environmental externalities in the Southern Senatorial Zone of Nasarawa State.

Charcoal Production and Deforestation

Globally, there is an increased demand for bioenergy, with close to a third of the global population using charcoal and firewood (FAO, 2022). This raises concerns about sustainability, especially in charcoal production and use in Sub-Saharan Africa (SSA) countries (FAO, 2022; Chidumayo et al., 2013; Mensah et al., 2022; FAO, 2020). Msuya et al. (2011) examined the environmental consequences of charcoal production and consumption in Darussalam, Tanzania. They found that high demand for charcoal, driven by urban energy needs, has led to an increase in deforestation and environmental degradation.

Emmanuel & Davidson (2013) noted that in tropical regions, charcoal production is widely regarded as having severe ecological and environmental consequences, with deforestation, the removal of forests or woodlands, being the most frequently mentioned. In the same vein, Anang et al. (2011), in their study, identified deforestation, declining wildlife species, bushfires, and the depletion of soil nutrients as the most significant environmental impacts linked to charcoal production.

Factors Responsible for the Choice of Charcoal as Source of Energy

Charcoal continues to be a primary source of household energy in majority of the developing nations, especially in Nigeria and other countries of the West African sub region, even though alternative energy options are available. The choice of charcoal as a source of energy in developing countries is shaped by a combination of economic, social, cultural, and infrastructural influences.

i. Economic Accessibility and Affordability

Many developing nations particularly Nigeria rely on charcoal as a main source of energy because it is more affordable than other alternatives energy sources. Babalola & Opii (2010) conducted a study on households in Benue State, Nigeria, and discovered that 76.7% of them relied on charcoal for daily use. The primary factors influencing this preference were its affordability, cited by 62.8% of respondents, and its steady availability compared to other energy sources. However, Salamatu et al. (2020) investigated the commercial production of charcoal in Nasarawa State and found that 46.4% of producers earned 20,000 naira or less per month and generally had low levels of education. In this context, the appeal of charcoal production is largely driven by poverty and a lack of alternative income-generating opportunities.

ii. Availability and Accessibility

Charcoal's consumption, particularly in countries rich in forest resources, is largely driven by its easy availability. According to IEA (2021), although environmental issues persist, the simplicity of local production and distribution maintains strong demand. Often sold through numerous informal vendors, charcoal remains readily accessible, even in remote and semi-urban communities. However, Nabukalu & Gieré (2019) reported that, more than 80% of urban households in Africa rely on charcoal as their main cooking fuel due to it availability and accessibility, and this trend is projected to persist in many areas up to 2030. Nnaji et al. (2024) observed that the continued demand for charcoal is linked to inadequate electricity supply, the high cost of cleaner energy alternatives, and the availability of nearby forests for charcoal production.

iii. Lack of Access to Modern Energy Alternatives

A major factor behind the ongoing reliance on charcoal as a source of energy is the limited access to reliable modern energy alternatives. Majority of the developing countries especially Nigeria, electricity is either inaccessible, too expensive, or prone to frequent power cuts, while LPG is often hindered by supply challenges and high startup expenses. According to the World Bank (2021), more than 600 million people in Africa lack electricity access, and even those connected to the grid frequently experience outages or face electricity costs that are beyond their means. These challenges make charcoal a more reliable option for everyday energy needs. Nabukalu & Gieré (2019) found that in Uganda, households with access to electricity or biogas still rely on charcoal, as it remains more cost-effective for each use, is available in small, budget-friendly quantities, and suits the practical needs of daily household activities.

iv. Livelihood and Employment Opportunities

Charcoal production and business serve as a vital source of income for numerous people living in rural and urban areas. Timothy (2013) conducted a study in Adamawa, Borno, and Gombe States, revealing that 88% of participants were engaged in local charcoal production. Additionally, 92%

viewed the activity as profitable, noting its role in job creation and trade enhancement, with some indicating it represents a multi-billion-dollar industry in Nigeria. Ekhuemelo et al. (2023) found that in Adoka District of Benue State, almost all participants were involved in daily charcoal production. About 73% reported earning approximately ₦5,000 each day, while 66.7% made over ₦30,000 per month, using their income to support activities such as trading, farming, building homes, paying school fees, and funding marriage expenses.

v. Government Policy

Poor enforcement of policies and inadequate energy infrastructure contribute to the continued reliance on charcoal. Majority of the developing countries of Africa, lack well-defined or effectively implemented regulations to prevent deforestation caused by charcoal production. As noted by Doggart *et al.*, (2020) charcoal continues to be the most commonly used and affordable cooking fuel, despite government policies promoting a shift toward LPG and electricity. Instead of completely transitioning, households tend to combine different fuel sources a practice known as fuel stacking. However, Eniola, (2021) noted that when governments fail to provide basic amenities like electricity or cooking gas, households continue relying on charcoal.

Effects of Charcoal Production on the Environment

Charcoal production poses serious environmental challenges, especially in areas where it is heavily relied upon as a primary energy source. In Africa, the high demand for charcoal has resulted in extensive tree cutting to supply wood for its production (Zulu & Richardson, 2013). This practice, often done without sustainable management, leads to the depletion of forest cover and the destruction of natural habitats, negatively affecting biodiversity. Additionally, the reduction in tree populations diminishes the environment's ability to absorb carbon dioxide, which in turn contributes to global warming and climate change (Chidumayo & Gumbo, 2013).

i. Forest Degradation

Zulu & Richardson (2013) reported that charcoal production plays a major role in deforestation across Africa, particularly around urban areas. According to Mwampamba et al. (2013), traditional earth-mound kilns, commonly used in rural settings, are highly inefficient, consuming large quantities of wood to yield small amounts of charcoal, thereby intensifying forest degradation and destroying habitats. Similarly, Adebayo et al. (2019) surveyed charcoal producers in agrarian communities of Oyo State, Nigeria, and found that over 73% of respondents viewed charcoal production as a serious environmental concern, citing issues such as tree loss, erosion, deteriorating air quality, and the decline of ecosystem services.

ii. Biodiversity Decline

The expansion of charcoal production into forested areas has led to a decline in biodiversity in many countries. Since various plant and animal species rely on natural forests for their habitats, the destruction of these forests can result in the extinction of certain species. Chidumayo & Gumbo (2010) noted that unregulated charcoal production disrupts ecosystems and threatens the survival

of plant and animal species that rely on forest habitats. Similarly, Okode et al. (2021) in their study, revealed substantial forest cover loss, increased soil erosion, reduced biodiversity, and micro-climatic changes, largely attributed to the use of traditional earth-kiln methods. In the same vein, Ekpo & Mba, (2020), in their assessment of commercial charcoal production in the savannah woodlands of Nasarawa State, Nigeria, found that the activity causes significant woodland degradation. It disrupts the habitats of numerous species, thereby diminishing the ecological productivity of the area and playing a major role in both deforestation and biodiversity decline.

iv. Contribution to Climate Change

Charcoal production generates greenhouse gases such as methane (CH_4), carbon dioxide (CO_2), and black carbon. These emissions, particularly when biomass is harvested in an unsustainable manner, play a role in accelerating global warming. According to FAO (2017), the degradation of forests caused by charcoal production diminishes the ability of ecosystems to sequester carbon, thereby worsening the impacts of climate change. However, Belay et al. (2024) reported that approximately 63% of the carbon in the original wood is lost during charcoal production, resulting in the emission of about 1.67 kg of carbon for every kilogram of charcoal produced, which is equivalent to a warming impact of around 7.6 kg CO_2-equivalent per kilogram of charcoal. This impact is even greater for less efficient kilns, reaching up to 9.4 kg CO_2-equivalent per kilogram.

Implications of the Use of Charcoal

World Health Organization (WHO) reports that smoke inhalation causes the death of 1.5 million people annually, with women and children being the most affected (Ibrahim et al., 2021). According to Oladipo et al. (2023), both the production and use of charcoal are associated with numerous health problems and work-related risks. According to Abdul Raheem et al. (2022), households using charcoal and firewood experienced carbon monoxide (CO) levels ranging from approximately 9.9 to 57.8 ppm, with the highest concentrations occurring during evening cooking times levels considered hazardous based on local air quality standards. In contrast, homes using LPG maintained CO levels within safe limits (around 3 to 10 ppm). Prolonged exposure to these elevated CO levels presents significant health risks. Prolonged exposure to charcoal smoke also cause neurological problem to human.

Mitigation Measures

To address the ongoing loss of forested areas, promoting sustainable forest management is essential. This involves practices such as afforestation, reforestation, and community forestry initiatives that actively involve local populations in preserving forest resources. Sustainable Development Goal (SDG) 13, which focuses on Climate Action, highlights the critical need to address climate change and its consequences on the environment. According to the Intergovernmental Panel on Climate Change (IPCC, 2023), human activities particularly fossil fuel combustion, deforestation, and unsustainable land use have greatly led to an increase in greenhouse gas levels, contributing to global warming and more frequent extreme weather events. SDG 13 seeks to enhance resilience and the ability to adapt to climate-related threats, incorporate climate considerations into policy and planning, and promote education and awareness on climate mitigation and adaptation strategies. Achieving this goal demands a comprehensive approach that includes governments, the private sector, and civil society.

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METHODOLOGY

Study Area

The study area lies within the Southern Senatorial Zone of Nasarawa State, Nigeria. This zone is made up of five Local Government Areas (LGAs): Lafia, Doma, Keana, Awe, and Obi. For this study, the focus is on three of them, namely Doma, Keana, and Obi. The area extends from latitude 7°50′N to 8°30′N and longitude 7°60′E to 9°05′E. It shares boundaries with Benue State to the south and Taraba State to the east.

In physical terms, the area is part of the Lower Benue Trough and falls within the forest–savannah transition belt of Nigeria. The soils are generally fertile, made up largely of alluvial deposits, which support farming on a wide scale. The climate is tropical sub-humid with two clear seasons. The wet season begins in May and ends in October, while the dry season runs from November to April. Annual rainfall is between 1,000 and 1,500 millimeters. Mean annual humidity is about 70 percent, and relative humidity usually ranges from 60 to 80 percent (Akwa et al., 2007).Most of the people living in the area depend on farming for their livelihood, a reflection of the favourable soils and climate that encourage crop production and related agricultural activities.

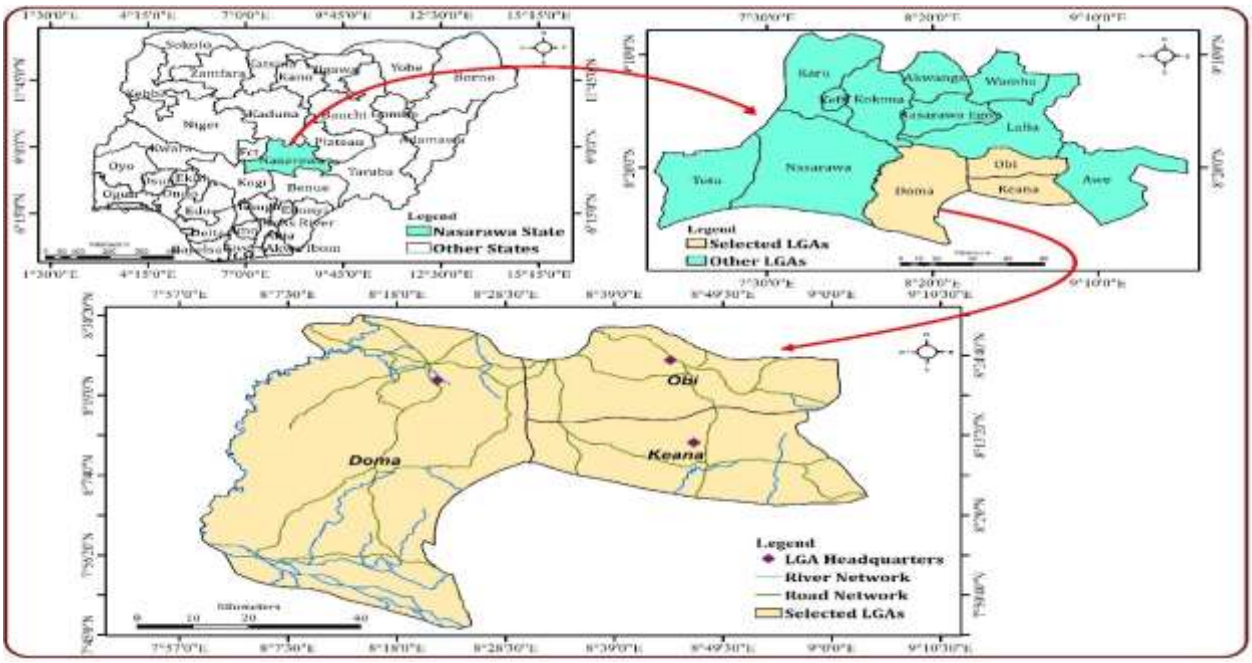

Figure 1. Map of Nasarawa State showing the Study Area

Data Collection

A reconnaissance survey was first carried out in the five Local Government Areas (LGAs) to identify communities where charcoal production takes place regularly. From this exercise, three LGAs were chosen because they showed the highest levels of charcoal production and

consumption. In these areas, 120 carefully designed questionnaires were distributed with the help of trained field assistants.Out of the total respondents, 18 were identified as charcoal producers and 11 as charcoal sellers. The remaining 91 respondents represented people engaged in other occupations and made up the largest share of the sample. The distribution of the 120 questionnaires across the LGAs was guided by the 2006 population census figures, which are presented in Table 1.

Table 1. Questionnaire Distribution

S/N	LGA	2006 Population Census Figure	Estimate	Number of Questionnaire
1	Obi	148,874	148/366 = 0.40 * 120	48
2	Doma	139,607	139/366 = 0.38 * 120	46
3	Keana	79,253	79/366 = 0.22 * 120	26
	Total			**120**

Table 2. Sites Visited to Inspect Charcoal Production

S/N	LGA	Ward	Location	Geographic Coordinates
1	Obi	Tudun Adabu	Kwashiri	8°26′N & 8°49′E
		Agwatashi	Agwatashi	8°19′N & 8°51′E
		Obi	Alagba	8°24′N & 8°47′E
		Tudun Adabu	Kayarda-Gidan Onuku	8°29′N & 8°52′E
2	Doma	Madaki	Ohina	8°18′N & 8°21′E
		Alage	Dogon Kurmi	8°17′N & 8°20′E
		Agbashi	Idadu	8°08′N & 8°15′E
		Doka	Yelwa Ediya	8°16′N & 8°10′E
3	Keana	Aloshi	Aloshi	8°14′N & 8°48′E
		Amiri	Bega	8°07′N & 8°50′E
		Oki	Oki	8°09′N & 8°47′E

Data Analysis

The Statistical Package for Social Sciences (SPSS-IBM 28) was used for data analysis. The various data and variables inputs were carefully harnessed and analyzed based on the stated research questions. Variables were cross tabulated, analyzed, and presented in form of tables and charts for proper interpretation.

DISCUSSION

This section presents the main findings of the study and offers a careful and evidence-based interpretation of the results which revolves around the five main research questions stated under the objectives of the study. Where useful, the findings are compared with those of other scholars for wider academic conversation.

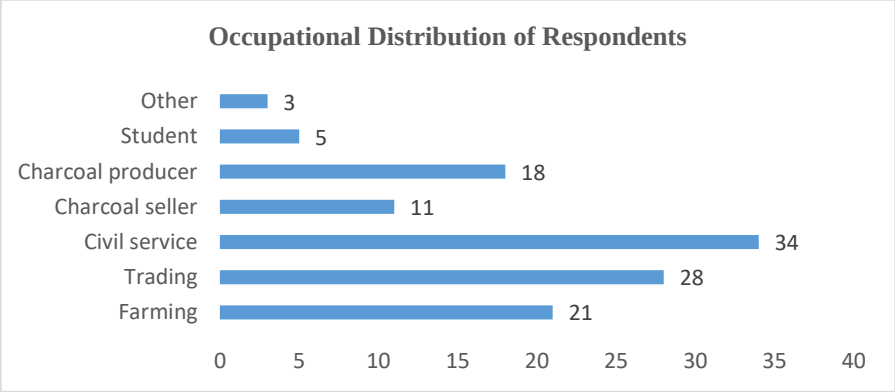

Figure 2. Occupational Distribution of Respondents
Source: Field Survey, 2025

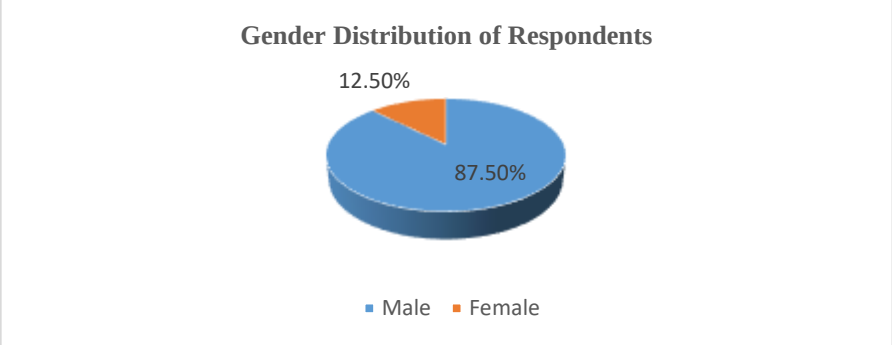

Figure 3. Gender Distribution of Respondents
Source: Field Survey, 2025

The description also confirms that (as anticipated since they are more involved in tree cutting and charcoal processing) men (87.5%) are more in this survey. Women (12.5%) seem underrepresented but relevant in the household energy decision making.

Occupationally, a mixed occupation base is observable: involving public servants and traders summing 51.6%, meaning that charcoal cannot be relegated to rural/agricultural homes but is eaten across other income group. Charcoal producers (15.0%) and sellers (9.2%) are thus a substantial minority, meaning that close to a quarter of the respondents participate in the charcoal sector. This helps in underlining the economic significance of charcoal beyond domestic use. Farming is still significant (17.5%), emphasizing that terrestrial livelihoods and wood-fuels extraction are still associated. These distributions provide evidence that charcoal production and consumption extends across various socio-economic strata rather than a marginal activity.

Effect of Charcoal Production on Biodiversity

The study reveals a well-acknowledged perception of the harm of biodiversity through charcoal production among the respondents. Almost 96% agreed that biodiversity has been altered, 73% of whom said there was reduced forest cover. Over half reported that certain plant species (56%) and animal species (67%) had gone missing. There is also significant concern about environmental indicators related to ecological stability. More than 50% felt that soil erosion was higher (55%) and almost 50% said their water source was different (48%).

Table 3. Effect of Charcoal Production on Biodiversity

Factor	**Percentage (Finding)**
Reported change in biodiversity	95.8 (Yes)
Decrease in forest cover	73.3 (Yes)
Disappearance of plant species	55.8 (Yes)
Disappearance of animal species	66.7 (Yes)
Change in water sources	47.5 (Yes)
Increase in soil erosion	50.0 (Yes)
	Mean Impact
Mean impact on forest cover (1-5)	4.03
Mean impact on wildlife population (1-5)	3.99
Mean impact on plant diversity (1-5)	3.75
Mean impact on soil fertility (1-5)	3.65
Mean impact on water availability/quality (1-5)	3.47
	Percentage (Finding)
Perceived severity of deforestation	88.3
Perceived severity of wildlife loss	90.8
Perceived severity of soil degradation	82.5
Perceived severity of climate change	82.5
Perceived severity of water impact	60.0

The results obviously show that production of charcoal is one of the main causes of biodiversity losses in the study area. Its effects are many; it diminishes forests, destroy species, causes soil erosion, affect water flows, and undermines the fertility on which the health of nature and agriculture depend. This strongly agrees with the findings of Kiruki et al. (2017) who investigated the effect of charcoal production and other land uses on diversity in a semi-arid area in Kenya. The public knows about these processes and sees them as serious and worsening. The high "Yes" responses combined with the strong severity ratings indicate the magnitude of these effects on the communities. Scholarly, this means that charcoal production has not only become a livelihood but also an ecological menace with subsequent implications on forest ecosystem, wildlife habitat, and human-environment interaction, just as Arko et al. (2024) also discovered on the Afram Plains of Ghana in their study on the multifaceted socio-ecological impacts of charcoal production. Our findings further produces empirical evidence that unsustainable fuel practices are depleting the environmental capital of the area, echoing general concerns of the environmental literature on the pernicious nature of wood-fuel dependence in sub-Saharan Africa.

Figure 4. A kiln (heating wood at limited oxygen)

Figure 5. Charcoal produced & stored in sacks

Factors behind the Choice of Charcoal

Table 4. Factors behind the Choice of Charcoal

Factor	Percentage (Finding)
Affordability (cheaper)	48.3 (Yes)
Availability (easy to obtain)	43.3 (Yes)
Produce less smoke	36.7 (Yes)
Burns longer/more efficient	35.0 (Yes)
Easy to transport	30.0 (Yes)
Reliability of supply	27.5 (Yes)
Lack of access to alternatives	22.5 (Yes)
Traditional/cultural preference	1.7 (Yes)
Charcoal cost compared to other fuels	Most affordable (37.5) Cat. 2 (32.5)
Access to alternative energy	Moderate (54.2) Cat. 2 (23.3)
Willingness to switch to alternatives	86.7 (willing to switch)

Charcoal remains the primary source of energy for many households because it slots so neatly into the economy of survival. It is cheaper, more readily available and a more reliable piece in supply chains where modern fuels are not widely available. Nabukalu & Gieré (2019) reported that, more than 80% of urban households in Africa rely on charcoal as their main cooking fuel due to it availability and accessibility, and this trend is projected to persist in many areas up to 2030. There is the perception of efficiency and lower smoke, making it suitable for everyday use. The findings corroborate with a study conducted by Babalola & Opii (2012) who investigated the factors influencing consumption of charcoal as household energy in Benue State.

But the cultural preference is almost non-existent, and the extremely high switching willingness suggest that there is a potential demand for alternatives. In other words, the use of charcoal is not based on tradition at all, only structural limitations in terms of affordability and access. Our data indicate that energy programs that enhance access to cleaner fuels at competitive prices could rapidly displace charcoal in the study area.

Perception of Environmental Effects

Table 5. Perception of Environmental Effects

Perception Indicator	Percentage (Finding)
Awareness of environmental effects	86.7 (Yes)
Awareness level (self-rated)	Moderated awareness
Perceived severity of deforestation	88.3
Perceived severity of soil degradation	82.5
Perceived severity of wildlife loss	90.8
Perceived severity of climate change	82.5
Perceived severity of water impact	60.0
Overall severity of environmental effects	80.0

Analysis indicates that the study population had a very good understanding of the environmental damage resulting from charcoal production. The majority (86.7%) indicated they knew the negative environmental impact of charcoal production. Self-reported awareness tended to cluster at the middle, so there seems to be knowledge but not always in depth. The results reveal that charcoal production is not regarded as a neutral livelihood activity but as an environmental menace by mostly all inhabitants. The populace associates it with clearance of forests, reduction of wildlife, soil erosion and climate deterioration. This aligns with the findings of Adebayo et al. (2019) who surveyed charcoal producers in agrarian communities of Oyo State, Nigeria, and found that over 73% of respondents viewed charcoal production as a serious environmental concern, citing issues such as tree loss, erosion, deteriorating air quality. Crucially, people's perceptions reach well beyond local impacts to encompass global environmental change, indicating community awareness of charcoal's part in climate action challenges. The slightly lower rating of water impacts (60%) may indicate that hydrological impacts are not as easy to see as forest clearing or wildlife loss. However, the pattern of uniformly high severity in multiple domains indicates that environmental concern is widespread and informed by practical experiences.

Health Implications for Residents

Table 6. Health Implications for Residents

Health Indicator	Percentage (Finding)
Coughing/respiratory problems	56.7 (Yes)
Eye irritation	70.0 (Yes)
Headache/dizziness	11.7 (Yes)
Chest pain	15.0 (Yes)
Frequency of health issues	55.8 (moderate)
Awareness of health risks	69.2 (acknowledged yes)
Awareness of health risks (self-rated)	Moderate awareness

The results of the SPSS analysis indicate charcoal use in the study area to have definite health implications, mainly associated with exposure to smoke. This result reiterates the fact that charcoal burning is not only an environmental threat, but also a public health problem. The high prevalence of respiratory complaints and eye irritation is also consistent with reports on indoor air pollution

due to biomass fuel burning. The symptoms of headaches and chest pains, although less common, suggests low-level exposure to dangerous pollutants like carbon monoxide.
The skew of the symptom frequency distribution indicates that although there are very few severe cases, the majority of people suffering have their health disrupted on a recurring basis, highlighting that this is a chronic problem. The fact that two-thirds of the respondents are already aware of the risk, the need for interventions like clean cook stoves, indoor ventilation, etc., becomes necessary and urgent.

Measures to Mitigate Woodland Depletion and Contribute to SDG13

Table 7. Measures to Mitigate Woodland Depletion and Contribute to SDG13

Measure	Percentage (Finding)
Tree planting initiatives	94.2 (Yes)
Tree planting (general)	80.8 (Yes)
Cooking outdoors	75.8 (Yes)
Educating communities	75.0 (Yes)
Public awareness campaigns	75.0 (Yes)
Adoption of alternative energy	73.3 (Yes)
Good ventilation while cooking	70.0 (Yes)
Community engagement	54.2 (Yes)
Economic alternatives to charcoal	51.7 (Yes)
Forest management practices	48.3 (Yes)
Educating community (local efforts)	48.3 (Yes)
Watch groups/community monitoring	44.2 (Yes)
Not using charcoal	40.8 (Yes)
Providing subsidies	39.2 (Yes)
Enforcement of environmental laws	38.3 (Yes)
Alternative energy sources	37.5 (Yes)
Stricter regulations	33.3 (Yes)
Research and development	32.5 (Yes)
Improved charcoal production techniques	31.7 (Yes)
Reporting illegal activities	28.3 (Yes)
Improved cook stoves	27.5 (Yes)
Subsidizing clean energy	26.7 (Yes)
Contribution to SD 13 (rated 1-4)	94.2 (believed measures will contribute to SD13)

The findings in Table 6 indicates a strong preference for community-driven initiative and practicable means to arrest woodland removal and integrate with climate change strategies. Tree planting was the most popular of the measures: 94.2% of respondents would support organized efforts to plant trees, and 80.8% supported general tree planting. This highlights reforestation being the most attractive and most visible solution. There's no lack of resistance to change, but there's a push for solutions that are visible, that take place locally, that are within their control. The findings reveal that change could come in the form of reforestation, outdoor cooking, and awareness

campaigns. The extremely strong support for tree planting confirms a common understanding that deforestation must be actively opposed by reforestation. The recommendation to support educational and awareness-raising activities indicates that communities recognize knowledge empowerment as a route to sustainability. The enthusiasm for alternative energy is a great indicator that the use of charcoal is not a cultural addiction; people use it because they see no choice, and when they have a proper choice, they are ready to embrace it.

On the other hand, limited support for regulatory enforcements, subsidies and technical fixes, suggests a trust deficit with governance and/or unfamiliarity with external interventions. This suggests that for SDG 13-linked actions to be successful, programmes will need to link community-led activities and government or institutional response, in ways that resource, render affordable, make legitimate as well as credible.

CONCLUSION

The results of this study indicate that charcoal making activity in southern Nasarawa State is an intricate challenge that serves as an economic life wire, as well as a severe environmental and health threat. Biodiversity is dwindling as forests are being cut, soil is eroding, and species are dying. Charcoal is the primary household energy source not because of its culture but rather as it is cost effective, easily available and its supply is reliable. Its adverse health outcomes, from respiratory issues to eye discomfort, underscore the public health burden it poses. Crucially, communities are very knowledgeable on such practices, and consider charcoal production as a cause of environmental degradation and global warming. The widespread openness to new ways of doing things reveals that, while cooking with charcoal is traditional, charcoal dependence is not; it is a function of poverty and energy insecurity. Tackling the problem requires aligning livelihoods and sustainability, while guaranteeing interventions that are affordable and reliable.

The following recommendations are proffered:

i. Advocate for reforestation and afforestation: Support for tree planting programmes and community forestry as the most widely recommended action.
ii. Increase access to affordable clean energy: Promote subsidized and reliable substitutes, such as LPG, solar, or efficient cook stoves, to reduce charcoal use.
iii. Raise public awareness and environmental education: Develop public campaigns to inform communities the damage caused by charcoal on the environment and the human health, and provide sustainable alternatives.
iv. Initiate livelihood diversification initiatives: Create substitutes for charcoal producers and sellers in order to limit reliance on forest resources.
v. Connect bottom-up interventions with top-down action: Connect community reforestation and awareness efforts with government law enforcement, subsidies and climate policies in order to achieve SDG13 targets.

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