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RESEARCH ARTICLE

Environmental and Socioeconomic Impacts of Charcoal Production on Agricultural Land Use, Soil Fertility, and Crop Productivity in Apa Local Government Area, Benue State, Nigeria

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Abstract

The study explores the impact of charcoal production on agricultural activities in Apa Local Government, Benue State, Nigeria. The economic activity provides income and employment but often leads to environmental degradation and reduced agricultural productivity. The research uses a mixed-method approach, combining quantitative data from questionnaires and qualitative insights from interviews and field observations. Results show that 45% of arable farmland has been converted to charcoal production sites, resulting in a significant reduction in available agricultural land. Additionally, 60% of respondents reported declining soil fertility due to deforestation and tree cover removal, exacerbated by soil erosion and nutrient depletion. However, 10% of respondents observed improved soil conditions in areas where charcoal byproducts were used as soil amendments. The socio-economic analysis shows a dual impact: 40% acknowledge the economic benefits of charcoal production, while 50% highlight its negative consequences, including reduced crop yields and labor diversion from agriculture. The study emphasizes the need for sustainable land management practices that balance the economic benefits of charcoal production with agricultural productivity preservation.

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Introduction

Charcoal production is a critical economic activity in many rural and semi-urban areas, particularly in regions with abundant forest resources. It involves the carbonization of wood under controlled conditions to produce a fuel source that is widely used for cooking, heating, and small-scale industrial applications (FAO, 2020). Charcoal is highly valued for its affordability, accessibility, and high energy efficiency, making it a popular alternative to other energy sources, especially in developing countries where access to electricity and gas may be limited (Zulu & Richardson, 2013).

Economically, charcoal production provides significant livelihood opportunities. It serves as a source of income for producers, transporters, and vendors, and it is often a critical source of employment in regions with limited alternatives (Mwampamba et al., 2013). However, despite its economic benefits, charcoal production is associated with several environmental challenges, including deforestation, soil degradation, and loss of biodiversity, which can adversely affect agricultural productivity and sustainability (Chidumayo & Gumbo, 2013).

Balancing the economic benefits of charcoal production with its environmental and agricultural impacts is essential for promoting sustainable development. In communities such as the Apa Local Government Area, where both charcoal production and agriculture are vital to the local economy, understanding these dynamics is critical for developing policies that ensure both economic viability and environmental sustainability.

Agriculture is a key economic activity in Apa Local Government Area (LGA), located in Benue State, Nigeria. The area is predominantly rural, with a substantial portion of its population engaged in farming as their primary source of livelihood. The fertile soil and favorable climate make Apa LGA suitable for diverse agricultural activities, including crop cultivation, livestock rearing, and fishing (Benue State Ministry of Agriculture, 2018).

The primary crops grown in the region include yam, cassava, maize, rice, and beans. These crops are cultivated for both subsistence and commercial purposes, contributing to food security and economic development within the area. Additionally, Apa LGA is renowned for its production of cash crops such as groundnuts and soybeans, which are traded in local and regional markets (National Bureau of Statistics, 2020).

Livestock farming is another significant component of agriculture in Apa LGA. Residents rear animals such as goats, sheep, poultry, and cattle, which serve as sources of income, food, and cultural wealth. Fishing activities, particularly along the banks of the River Benue, also play a vital role in supporting the livelihoods of communities living close to water bodies (Adebayo et al., 2020).

Despite its agricultural potential, Apa LGA faces several challenges, including limited access to modern farming tools, inadequate infrastructure, and the impact of environmental degradation. Charcoal production, a prevalent economic activity in the area, has been linked to deforestation and soil degradation, which threaten the sustainability of agricultural practices (FAO, 2020).

Efforts to enhance agricultural productivity in Apa LGA must address these challenges through sustainable land management practices, improved access to agricultural inputs, and policies that mitigate the negative impacts of activities such as charcoal production. By doing so, the region can maximize its agricultural potential while ensuring environmental conservation.

Charcoal production and agricultural activities are intricately linked, particularly in rural areas like Apa Local Government Area, where both serve as primary livelihood strategies. While both activities are critical to the local economy, their interconnection often results in competing land uses and environmental challenges.

Charcoal production often involves the clearing of forests and woodlands, which reduces the availability of arable land for farming. Farmers in areas heavily impacted by charcoal production frequently report limited access to fertile land, as deforested areas may suffer from soil degradation and reduced productivity (FAO, 2020). This competition for land exacerbates the challenges faced by local agricultural activities, including lower crop yields and reduced food security.

Charcoal production is a major driver of deforestation in many rural areas, including Apa LGA. Forest clearing for charcoal impacts the natural vegetation cover, which serves as a critical buffer against soil erosion and nutrient depletion. Studies have shown that deforestation associated with charcoal production leads to decreased soil fertility, rendering lands less suitable for agriculture (Chidumayo & Gumbo, 2013). This degradation further affects agricultural productivity and sustainability.

The removal of forests for charcoal production can alter local climatic conditions, such as temperature regulation, rainfall patterns, and humidity levels. Forests play a vital role in maintaining the ecological balance necessary for successful farming. When forests are removed, agricultural activities are negatively affected by increased temperatures, reduced soil moisture, and disrupted hydrological cycles (Naughton-Treves & Chapman, 2002).

Despite these challenges, charcoal production can indirectly support agricultural activities by providing an alternative source of income for farmers, particularly during non-planting seasons. The income generated from charcoal sales can be used to invest in farming inputs such as seeds, fertilizers, and equipment. However, the long-term sustainability of this dual reliance on agriculture and charcoal production depends on adopting practices that minimize environmental degradation.

To address the interconnection between charcoal production and agriculture, sustainable land management practices are essential. Strategies such as agroforestry, where trees are integrated into farming systems, and the use

of alternative energy sources, such as solar or biomass briquettes, can reduce the pressure on forests. These approaches can help balance the needs of both charcoal production and agricultural activities while promoting environmental conservation.

Conceptual Framework

Charcoal production involves the transformation of wood into charcoal through a pyrolysis process, where organic material is heated in the absence of oxygen, known as carbonisation. This method reduces the wood's water content and volatile matter, leaving behind a high-carbon residue known as charcoal. The process typically involves several stages: harvesting the wood, preparing the raw material, carbonizing it in kilns or pits, cooling, and finally, packaging for commercial use (Akinmoladun et al., 2020). Charcoal is widely used as a domestic fuel, especially in areas where alternative energy sources are scarce, and it is also used in industries such as metallurgy and chemical production (Umar et al., 2019). The widespread use of charcoal is particularly evident in developing countries, where it serves as a primary cooking fuel (He et al., 2016). While charcoal production is economically beneficial, it often has adverse environmental and agricultural consequences, particularly when conducted unsustainably.

The production process, though vital for local economies, can lead to significant environmental degradation if proper management is not employed. Deforestation, loss of biodiversity, and soil degradation are direct consequences of intensive charcoal production (Okoro et al., 2019). The expansion of charcoal production is often tied to the need for more wood, leading to unsustainable harvesting practices that deplete forest resources. These practices can have long-term ecological consequences, affecting water cycles, local climate, and agricultural activities.

In Apa Local Government Area, agriculture is the primary livelihood for the majority of residents, with farming activities focused on the cultivation of staple crops such as cassava, maize, yam, beans, and rice, as well as the rearing of livestock (Yusuf et al., 2016). The region's agricultural sector faces several challenges, including land degradation, declining soil fertility, and the impacts of climate change, which result in reduced agricultural productivity. Land degradation is particularly concerning as it leads to the depletion of essential nutrients from the soil, reducing crop yields and affecting food security (Sangodoyin et al., 2019).

In addition to natural challenges, human-induced factors such as deforestation, overgrazing, and the expansion of urban areas contribute to the degradation of farmland (Agboola, 2015). In recent years, the practice of charcoal production has compounded these challenges. As demand for charcoal rises, forested areas are increasingly cleared, leading to the loss of arable land and further soil erosion. Charcoal production also impacts soil quality by removing tree cover that would typically help to retain soil moisture and prevent erosion (Akinmoladun et al., 2020). The shifting of land use from farming to charcoal production disrupts local agricultural activities, as the land becomes less fertile and more prone to degradation (Babatunde et al., 2021). Moreover, the pressure on agricultural land from charcoal production is compounded by inadequate infrastructure and lack of access to modern agricultural techniques, which make it difficult for farmers to adapt to these environmental changes.

The combined effects of deforestation and land degradation from charcoal production threaten the long-term sustainability of agriculture in Apa Local Government Area. With increasing pressures on agricultural land and resources, it becomes crucial to examine the balance between the economic benefits of charcoal production and the need for sustainable agricultural practices that can support the livelihoods of local farmers.

Theoretical Framework

Sustainable development theory is a broad framework that emphasizes the need to balance economic growth with environmental conservation and social equity, ensuring that resources are managed in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). This theory underscores the importance of managing natural resources responsibly to avoid depletion, degradation, and destruction. It proposes that human development should align with environmental sustainability, and it advocates for practices that promote long-term ecological health while fostering economic and social well-being (WCED, 1987).

In the context of resource management, sustainable development focuses on the efficient use of resources, minimizing waste and environmental damage, and fostering practices that allow for the regeneration of resources. This is particularly relevant to activities such as charcoal production, which rely heavily on natural resources, including forests and soils. Charcoal production is often criticized for its unsustainable nature, as it can contribute to deforestation, soil degradation, and the depletion of biodiversity if conducted irresponsibly. However, through the lens of sustainable development theory, it is possible to consider how charcoal production could be integrated into resource management strategies that prioritize conservation, reforestation, and responsible harvesting (Foley et al., 2005).

According to sustainable development theory, for resource extraction activities like charcoal production to be sustainable, they must be carried out in ways that promote long-term ecological balance. This could involve adopting practices such as controlled harvesting, replanting trees to replace those used, and using alternative, more efficient technologies for carbonization that minimize the environmental impact. Furthermore, sustainable development theory encourages the active participation of local communities, including farmers and charcoal producers, in decision-making processes that affect their environment. In this case, farmers and charcoal producers must collaborate to ensure that agricultural and charcoal production activities complement each other, rather than competing for land and resources.

The relationship between sustainable development theory and resource management is central to addressing the challenges of balancing the economic benefits of charcoal production with the need for agricultural productivity. It calls for an integrated approach to land management that promotes both economic growth and environmental stewardship. By adopting sustainable practices, local communities can generate income from charcoal production while simultaneously preserving the land for future agricultural use. This approach ultimately supports the long-term viability of both agriculture and charcoal production in the Apa Local Government Area.

Empirical Review

Research on the relationship between charcoal production and agriculture often emphasizes the dual impact of both activities on the environment and local economies. Charcoal production, typically relying on the unsustainable harvesting of trees for fuelwood, can significantly alter land use patterns, leading to land degradation and reduced agricultural productivity. In many regions, especially in sub-Saharan Africa, charcoal production is seen as a livelihood activity that provides essential income for rural communities. However, studies have shown that the over-extraction of wood for charcoal production can lead to soil erosion, loss of soil fertility, and a reduction in the availability of arable land for farming (Bailis et al., 2009; Kimaryo & Monyo, 2011).

Charcoal production and agriculture are often seen as competing land uses, with farmers sacrificing land for the production of charcoal rather than for growing crops. This results in less fertile land being available for agriculture, diminishing crop yields over time. A study by Shively (2012) demonstrated that in regions where charcoal production is prominent, the expansion of charcoal production activities negatively impacts agricultural productivity, as farmers lose valuable soil resources and face challenges in maintaining their land's fertility. The growing pressure for agricultural land use intensifies when charcoal production practices lack sustainability, making it difficult for farming communities to balance both land uses effectively. However, with improved management practices, such as agroforestry or sustainable charcoal production techniques, it is possible to create synergies where both activities can coexist without depleting natural resources (Peters, 2008).

Studies have also explored the potential for integrating sustainable charcoal production with agricultural practices through the promotion of agroforestry systems. By planting tree species alongside crops, farmers can maintain soil fertility, reduce the risk of erosion, and generate income from both crops and sustainable charcoal production (Mallo et al., 2014). These integrated approaches allow for the long-term coexistence of agriculture and charcoal production, supporting economic resilience in rural communities while safeguarding the environment.

Deforestation, often driven by activities such as charcoal production, has profound consequences for farming communities, particularly in tropical and subtropical regions where agriculture is heavily dependent on forest resources. A significant body of research highlights the negative impact of deforestation on farming communities, with studies indicating that the loss of forests leads to reduced agricultural yields, increased vulnerability to floods and droughts, and a decline in biodiversity, which can further limit the availability of non-timber forest products essential to local livelihoods (FAO, 2010). For instance, in East Africa, deforestation resulting from charcoal production has been linked to increased soil erosion, which leads to lower agricultural productivity, particularly in regions where communities rely on rain-fed agriculture (Kaimowitz et al., 2005).

The loss of forests, which are integral to regulating local microclimates, has also been associated with changes in rainfall patterns, leading to droughts that affect crop growth and water availability for farming communities. In many contexts, such as in parts of Central Africa, charcoal production is a major driver of deforestation, contributing to the depletion of critical resources, which, in turn, adversely affects the livelihoods of rural farming communities who rely on forests for firewood, food, and income (Lindhjem et al., 2012). Furthermore, the degradation of forests due to unsustainable charcoal production practices can exacerbate poverty, as farmers face reduced land productivity, increased input costs, and the erosion of vital ecosystem services.

However, research also suggests that through the adoption of sustainable land use practices, deforestation's impact on farming communities can be mitigated. For example, the introduction of forest management systems that combine conservation efforts with charcoal production can help prevent environmental degradation and support the resilience of farming communities (Alemu et al., 2017). By promoting responsible harvesting, reforestation, and

agroforestry, it is possible to restore ecosystems and improve the overall sustainability of both farming and charcoal production activities, providing long-term benefits to rural communities.

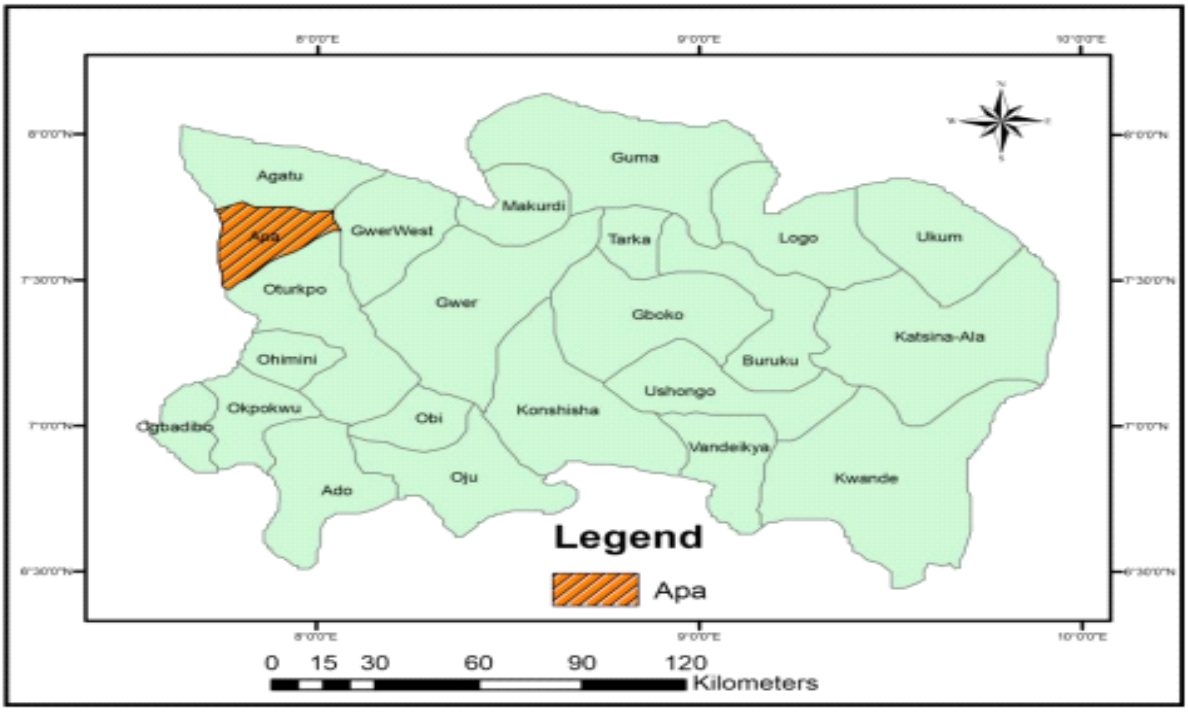
Methodology

Research Design

This study were adopt a descriptive and analytical research design, aimed at examining the effects of charcoal production on agricultural activities in Apa Local Government Area. The design enabled the researcher to collect detailed, factual data on both the processes and impacts of charcoal production, while also allowing for an in-depth analysis of how these activities influence agricultural land use, soil fertility, and farmers' perceptions.

Study Area

Apa Local Government Area (LGA) is located in the middle-belt region of Nigeria, within Nasarawa State, and it plays an important role in the agricultural economy of the state. The area is characterized by its geographic and socio-economic features, which influence both farming and charcoal production activities.



Results and Discussion

Results

The study revealed that a significant portion of agricultural land in Apa Local Government Area has been converted to charcoal production sites. The findings indicate that the increasing demand for charcoal has driven the expansion of production activities, often at the expense of farmland.

Table 4.1: Extent of Farmland Conversion to Charcoal Production

Category	Percentage (%)	Insights
Farmland converted to charcoal production	45	Significant reduction in arable land, impacting food security and agriculture.
Farmland unaffected	55	Indicates some areas remain dedicated to traditional agricultural practices.

Table 4.2: Respondents' Perceptions of Soil Quality Changes

Perception of Soil Quality	Percentage (%)	Description
Decreased soil fertility	60	Soil degradation due to loss of organic matter and increased erosion.
No significant change	30	Respondents observed no major soil fertility changes despite deforestation.
Increased soil fertility	10	Rare cases where charcoal byproducts, such as ash, were seen to improve soil.

Table 4.2: Respondents' Perceptions of Soil Quality Changes

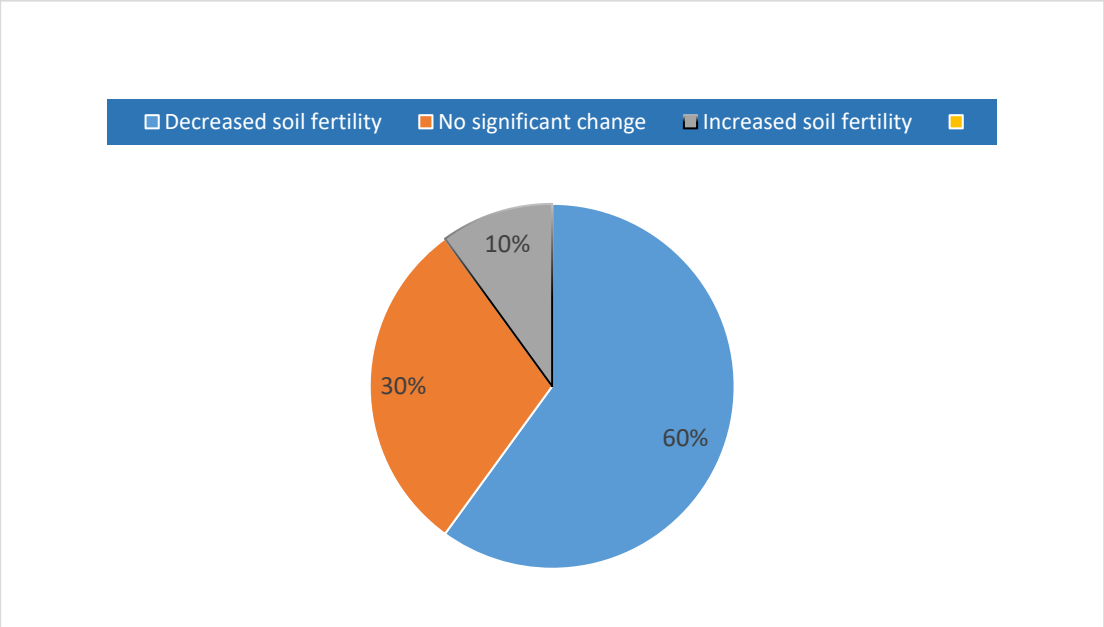


Table 4.3: Socio-Economic Impacts of Charcoal Production

Socio-Economic Impact	Percentage (%)	Details
Positive impact (additional income)	40	Charcoal production supplements income, particularly in lean farming seasons.
Negative impact (reduced productivity)	50	Reduced land fertility and labor diversion decrease farming outputs.
No significant impact	10	No observable economic or productivity changes reported.

Table 4.4: Community Perceptions of Charcoal Production

Community Perception	Percentage (%)	Comments from Respondents
Concerned about environmental impact	55	Emphasized deforestation, loss of biodiversity, and erosion risks.
Neutral	25	Recognized both benefits and challenges without taking a strong stance.
Supportive of charcoal production	20	Acknowledged economic benefits outweighing perceived environmental concerns.

Discussion

The findings revealed that 45% of respondents reported farmland being converted to charcoal production areas. This highlights a significant challenge, as agricultural land availability is crucial for sustaining food production and community livelihoods. Conversion of farmland for charcoal production often leads to land-use conflicts, prioritizing short-term economic benefits over long-term agricultural sustainability. Studies such as those by Zulu and Richardson (2013) corroborate this, emphasizing that charcoal production, while economically beneficial, often results in land-use changes that reduce arable land availability.

The remaining 55% of respondents indicated no observable impact on farmland, suggesting that the effects of charcoal production may be localized or depend on community-specific factors. This finding aligns with research by Chidumayo and Gumbo (2010), who noted that the extent of land-use change often varies depending on the intensity of charcoal production and local governance practices.

Soil fertility emerged as a critical issue, with 60% of respondents reporting declines due to deforestation and tree removal. This aligns with findings by FAO (2017), which stated that deforestation disrupts soil ecosystems, leading to erosion, loss of organic matter, and diminished agricultural productivity. Tree roots play a crucial role in maintaining soil structure and nutrient cycling, and their removal often results in degraded soils that cannot support sustainable farming.

Interestingly, 10% of respondents observed improved soil fertility, likely due to the use of charcoal byproducts like ash, which can enrich the soil with nutrients. However, such cases are rare and often dependent on specific agricultural practices, as noted by Lehmann and Joseph (2015) in their work on biochar and its potential to enhance soil health.

Charcoal production has mixed socio-economic impacts, with 40% of respondents citing additional income as a positive effect. For many, charcoal production serves as a vital income source, particularly during agricultural off-seasons, echoing findings by Arnold et al. (2006), who highlighted its role in rural livelihoods.

However, 50% of respondents reported negative socio-economic effects, primarily due to reduced agricultural productivity caused by land degradation and labor diversion. This supports research by Zulu and Richardson (2013), which emphasized that the economic benefits of charcoal production often come at the expense of long-term agricultural and environmental sustainability.

Community perceptions were divided, with 55% expressing concerns about environmental impacts, such as deforestation and biodiversity loss. This aligns with findings by Hosonuma et al. (2012), who identified charcoal production as a major driver of deforestation in tropical regions.

However, 20% supported charcoal production, citing its economic importance, particularly for households reliant on it for income. This reflects the duality of perspectives highlighted by Mwampamba et al. (2013), where communities often balance the immediate economic benefits of charcoal production against its long-term environmental costs.

Conclusion

The study examines the impact of charcoal production on agricultural activities in Apa Local Government Area, focusing on land use, soil fertility, socio-economic implications, and community perceptions. It found that nearly half of respondents converted farmland into charcoal production areas, reducing crop cultivation and soil fertility. The removal of tree cover also led to soil degradation, negatively impacting crop yields. Despite providing an income source, charcoal production poses challenges to agricultural sustainability and food security. Community perceptions highlight the long-term environmental and agricultural consequences of unchecked production. To address these issues, sustainable resource management practices must be adopted, involving policymakers, farmers, and environmentalists to ensure the sustainability of agriculture and local communities' livelihoods.

Recommendations

- Promote Sustainable Charcoal Production Practices
- Introduce Alternative Livelihood Opportunities for Farmers
- Strengthen Community Awareness and Policy Enforcement

Ethical Considerations

This study involved the collection of primary data through questionnaires, interviews, and field observations. Ethical principles of voluntary participation, informed consent, anonymity, and confidentiality were strictly observed throughout the research process. Participants were informed of the purpose of the study and their right to withdraw at any stage without consequence. No personal identifiers were recorded, and all data were used solely for academic

research purposes. The study did not involve vulnerable populations or sensitive personal data, and it complied with institutional and national ethical guidelines for social and environmental research.

Author Contributions

Both authors contributed significantly to the completion of this study. Shamsu A. Idris conceptualized the research, designed the methodology, conducted fieldwork and data collection, and drafted the initial manuscript. Nura Saleh contributed to data analysis, interpretation of results, literature review, and critical revision of the manuscript. Both authors reviewed and approved the final version of the paper and accept responsibility for its content.

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