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TRADITIONAL CHARCOAL PRODUCTION METHODS WITHIN SAVANNAH WOODLANDS OF NYARAVUR SUB-COUNTY, NEBBI DISTRICT, UGANDA: EVIDENCE FROM EARTH MOUND, EARTH PIT AND DRUM KILN PRACTICES

Okumu George[1] & Mbaziira James[1,2]

[1] Department of Education Foundations, Kampala International University
[2] Department Geography, Geoinformatics, and climatic Sciences, Makerere University
* Corresponding Author: george.okumu@studmc.kiu.ac.ug

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ABSTRACT

Biomass especially Charcoal and wood remain the primary households energy source in Uganda and the major source of fuel for cooking and lighting both in rural and urban settings. The high demand has led to commercial production intensifying the harvesting and cutting of the most desired tree species for mass production affecting the entire savannah woodland diversity and ecosystem. Limited research has explicitly examined how traditional charcoal production methods influence woodland diversity in Uganda, The main objective of the study was to explore on the traditional charcoal production practices within the savannah woodland. The study adopted a descriptive and field-based ecological survey design, integrating quantitative and qualitative approaches. Data was collected from charcoal producers, local leaders and key informants using questionnaires, interviews and field observations. Findings reveal that Earth mound kilns were the dominant method of charcoal production across Mbaro West, Angal Lower and Angal Upper parishes, followed by earth pit kilns, while Drum kilns were used only minimally. The analysis show that charcoal remains a major household energy source and livelihood activity in Uganda, yet its production is commonly dominated by traditional technologies that consume large quantities of wood and contribute to woodland degradation It concludes that, that charcoal production in Nyaravur Sub-County remains largely traditional and labour-intensive and suggests that practical training in improved kiln use, producer-group demonstrations and community-based woodland management be adopted.

Keywords: Charcoal production, Earth mound kiln, Earth pit kiln, Drum kiln, Savannah woodland, Nyaravur Sub-County, Nebbi District, Uganda

INTRODUCTION

Charcoal remains one of the most important cooking fuels in sub-Saharan Africa because it is accessible, portable, storable and relatively affordable for many households that cannot consistently depend on electricity, liquefied petroleum gas or other modern energy sources. Rose, Bensch, Munyehirwe and Peters (2022) estimate that about 195 million people in sub-Saharan Africa depend on charcoal as their primary cooking fuel, while many more use it as a secondary fuel. This regional dependence makes charcoal a matter of energy security, household welfare, urbanisation and environmental governance, rather than a narrow forestry problem (Branch, Phillips, & Agyei, 2023; Julien Schure 2019). Uganda reflects this wider regional reality because biomass remains central to household cooking, while charcoal is particularly important in urban and peri-urban energy systems (Elasu Ntayi, Orobia, Adaramola, & Onyinyi, 2025).

The charcoal sector presents a practical dilemma. On the one hand, charcoal production creates cash income for rural households, connects rural producers to urban energy markets and supports local livelihood resilience where formal employment is limited (Kiruki, van der Zanden, Kariuki, & Verburg, 2020; Wekesa, Mutta, Larwanou, Kowero, & Roos, 2023). On the other hand, poorly regulated production, selective harvesting of preferred hardwoods and continued use of inefficient kiln technologies can accelerate woodland degradation, depletion of mature trees, soil disturbance and weakening of ecosystem services (Thelma Arko, Chidumayo & Gumbo, 2025). This duality requires balanced academic interpretation because charcoal producers are often responding to poverty, energy demand and market opportunity, even when the ecological effects of production are serious.

Charcoal production is technically based on carbonization or pyrolysis. During carbonisation, wood is heated under restricted oxygen conditions so that it decomposes into charcoal rather than burning completely into ash (Amer & Elwardany, 2020; FAO, 1987). The quality and quantity of charcoal produced depend on kiln design, wood moisture content, air control, stacking technique, carbonisation time and post-burning handling (Adam, 2009; Tazebew Wondie Worko 2023). The Article therefore explores the traditional charcoal production methods and techniques within in the savannah woodland region of Nyaravur Sucounty Nebbi district.

Theoretical Framework

This article is anchored in pyrolysis kinetic theory and supported by a livelihood-oriented resource dependence perspective. Pyrolysis kinetic theory explains charcoal production as a thermochemical process in which biomass is heated under limited oxygen, producing charcoal, gases and vapours (Amer & Elwardany, 2020; FAO, 1987). The theory is useful because it explains why kiln structure, temperature, air control and carbonisation time influence charcoal yield and quality. In practical terms, every charcoal production method in Nyaravur Sub-County depends on the same underlying process: producers restrict oxygen supply so that wood carbonises instead of burning fully. Earth mound kilns, earth pit kilns and drum kilns differ mainly in how they enclose the wood, control oxygen, retain heat and allow producers to manage the burning process (Adam, 2009; Tazebew Wondie Worko, 2023).

The resource dependence perspective complements pyrolysis theory by explaining why charcoal producers continue to use traditional methods despite known ecological risks. Rural producers often depend on woodland resources for income, household energy and survival, while urban demand maintains the market for charcoal (Branch et al., 2023; Harun M. Kiruki et al., 2020). This perspective is important because it prevents a one-sided interpretation that blames producers without examining poverty, affordability, local knowledge, land access, regulation and limited alternatives (Julien Schure 2019; Chemukuku Wekesa 2023). The two perspectives together show that charcoal production methods are simultaneously technical and socioeconomic: kiln choice is shaped by carbonisation requirements, but also by livelihood pressure, capital availability, skill level and market demand.

Review of Related Literature

Charcoal as an Energy and Livelihood Resource

Charcoal occupies a complex position in African energy systems. It is widely criticised for contributing to woodland degradation, yet it also remains a major cooking fuel and income source for millions of households (Rose Twine 2022; Julien Schure 2019). Adam Branch (2023) describe charcoal as a commodity embedded in value chains, resource politics and energy regimes, meaning that production cannot be separated from traders, transporters, local authorities, urban consumers and national energy policies. In Uganda, charcoal use is linked to the continuing dominance of biomass in cooking, limited affordability of clean fuels and slow

adoption of modern cooking technologies: Joseph Elasu, Joseph M. Ntayi and Muyiwa Adaramola 2025; Wasswa Hannington, Wasswa Nsubuga 2025). Bamwesigye et al. (2020) further argue that charcoal and wood biomass utilisation in Uganda carries socioeconomic importance while also creating environmental and public health concerns. This literature is relevant to Nyaravur Sub-County because local producers operate within a wider energy economy in which rural supply is driven by urban demand, household poverty and limited access to alternative energy options.

Carbonisation and the Logic of Kiln Choice

Charcoal production depends on carbonisation, a slow pyrolysis process in which wood is heated under restricted oxygen to leave a carbon-rich residue (Amer & Elwardany, 2020; FAO, 1987). Kiln choice matters because it influences temperature distribution, oxygen leakage, conversion efficiency, smoke emissions, labour time and product quality (Adam, 2009; Tazebew et al., 2023). Traditional earth mound and earth pit kilns are attractive in rural settings because they require little capital, depend on local materials and can be constructed near harvested wood (FAO, 1987; Schure et al., 2019). However, they often provide weak control over oxygen and heat, which can result in incomplete carbonisation, low yield and high wood demand (Adam, 2009; Batchelor et al., 2022). Improved kilns, including Casamance kilns, steel kilns, retort systems and improved earth mounds, are designed to increase conversion efficiency and reduce emissions, but adoption depends on cost, training, technical confidence, producer organisation and market incentives (Jolien Schure 2019; Mulat Tazebew, 2023). Therefore, literature shows that kiln choice is not only a question of technical superiority; it is also a matter of affordability, familiarity and institutional support.

Traditional Earth Mound and Earth Pit Kilns

Earth mound kilns are among the most widely used charcoal production systems in rural Africa because they can be constructed using wood, grass, leaves and soil available at the production site (FAO, 1987; Julien Schure 2019). In this method, wood is stacked above the ground, covered with vegetation and soil, and then ignited under controlled air entry. FAO (1987) explains that the earth mound system is versatile because it can serve both small-scale and relatively larger-scale production, especially where permanent kilns are not available. Earth pit kilns operate on a related principle but differ in design because producers dig a pit, place wood inside it, cover it with grass and soil, and initiate controlled burning. The pit method may be convenient where soils are deep, well drained and easy to excavate, but less convenient in rocky, shallow or waterlogged areas (FAO, 1987). The main weakness of both methods is low control over carbonisation conditions. Where kilns are poorly sealed or managed, air leakage may cause parts of the wood to burn into ash while other parts remain under-carbonised, increasing waste and demand for fresh wood (Adam, 2009; Mulat Tazebew 2023).

Improved Kiln Technologies and Adoption Barriers

Improved charcoal production technologies are promoted because they can increase the quantity of charcoal obtained from a given quantity of wood and reduce harmful emissions. Adam (2009) found that improved retort kiln systems can perform better than traditional charcoal production systems, while Mulat Tazebew (2023) reported that improved kilns in Ethiopia increased wood-to-charcoal conversion efficiency by 41-72% compared with traditional earth mound kilns. Getahun, Tared, Fogelholm and Tuan (2024) also show that improved charcoal systems can be designed to increase yield and reduce environmental pressure when technical design is matched with local resource conditions. Nevertheless, Schure et al. (2019) caution that solutions should go beyond the kiln because efficiency gains are limited when producers lack training, capital, market incentives, secure resource access and supportive governance. This means that introducing drum kilns or improved earth mounds in Nyaravur Sub-County would require practical

demonstration, producer confidence, community acceptance and financial support rather than mere technical recommendation.

Policy and Sustainability Context in Uganda

Uganda is pursuing cleaner cooking and energy transition goals, but progress remains constrained by affordability, infrastructure, cultural cooking preferences and reliability of alternatives (Batchelor et al., 2022; Elasu et al., 2025; Wasswa et al., 2025). Recent policy discussions show that charcoal remains deeply entrenched in Uganda's energy mix, particularly in urban areas where it remains more convenient and affordable than many cleaner alternatives (Economic Policy Research Centre [EPRC], 2026). Literature from Uganda and other African contexts suggests that abrupt restrictions on charcoal can create livelihood shocks and informalisation of production when alternatives are weak (Branch et al., 2023; Wekesa et al., 2023). Therefore, sustainable charcoal management in places such as Nyaravur Sub-County should combine improved production methods, regulated harvesting, woodland restoration, producer training, clean-cooking expansion and alternative livelihood support. Such an approach is more likely to protect savannah woodland diversity while recognising the real social and economic dependence of rural producers on charcoal income.

Methods

The study adopted a descriptive and field-based ecological survey design. This design was appropriate because the study sought to describe existing charcoal production methods as they were practiced in natural savannah woodland settings, while also linking field observations to community-level explanations. A mixed-methods orientation was used because quantitative data helped establish the frequency of different production methods, while qualitative data explained the reasons for method preference, the practical steps followed by producers and the contextual factors shaping kiln adoption (Creswell & Creswell, 2018; Leavy, 2022).

The study was carried out in Nyaravur Sub-County, Nebbi District, in the West Nile sub-region of Uganda. The sub-county comprises Mbaro East, Mbaro West, Angal Lower, Angal Upper and Pamora Lower parishes. Fieldwork concentrated on Mbaro West, Angal Lower and Angal Upper because they were active charcoal-producing parishes with savannah woodland resources suitable for charcoal production. The population consisted of charcoal producers, local leaders and key informants from district, sub-county and parish structures. Charcoal producers were central because they possessed practical knowledge of kiln construction, wood preparation, burning time, sorting, bagging and transportation, while local leaders and key informants provided information on regulation, production patterns and woodland-use concerns.

Data were collected using questionnaires, interviews and structured field observation. Questionnaires captured information from charcoal producers on kiln methods used in the selected parishes. Interviews generated qualitative explanations from local leaders and key informants regarding production practices, regulation and environmental concerns. Observation enabled the researcher to physically verify kiln types, wood stacking, covering materials, burning sites and postburning handling. The use of several data sources strengthened triangulation and reduced overdependence on self-reporting (Braun & Clarke, 2021; Creswell & Creswell, 2018). Quantitative data were analysed using descriptive statistics, especially frequencies and percentages, while qualitative responses and observation notes were analysed thematically to identify recurrent explanations for the dominance of particular charcoal production methods (Braun & Clarke, 2021). Ethical considerations included voluntary participation, confidentiality, respect for respondents and adherence to local authority procedures during field access.

Results

Field findings revealed that charcoal production in the selected parishes of Nyaravur Sub-County was

dominated by traditional methods, particularly earth mound kilns and earth pit kilns. Drum kilns were observed but were used only minimally. The results confirm that charcoal production in the study area remains strongly dependent on low-cost, locally constructed technologies rather than improved or semi-modern kiln systems. Table 1 presents the distribution of methods across Mbaro West, Angal Lower and Angal Upper.

Table 1. Methods of Charcoal Production in Selected Parishes of Nyaravur Sub-County

Parish	Earth mound Kiln	Earth pit kiln	Drum kiln	Total	Share of all counts
Mbaro West	88	37	10	135	41.8%
Angal Lower	73	31	5	109	33.7%
Angal Upper	55	22	2	79	24.5%
Total	**216**	**90**	**17**	**323**	**100.0%**

Source: Field survey, April 2025. Note. Percentages are based on 323 method-frequency counts. The earth mound total was recalculated from parish figures for consistency.

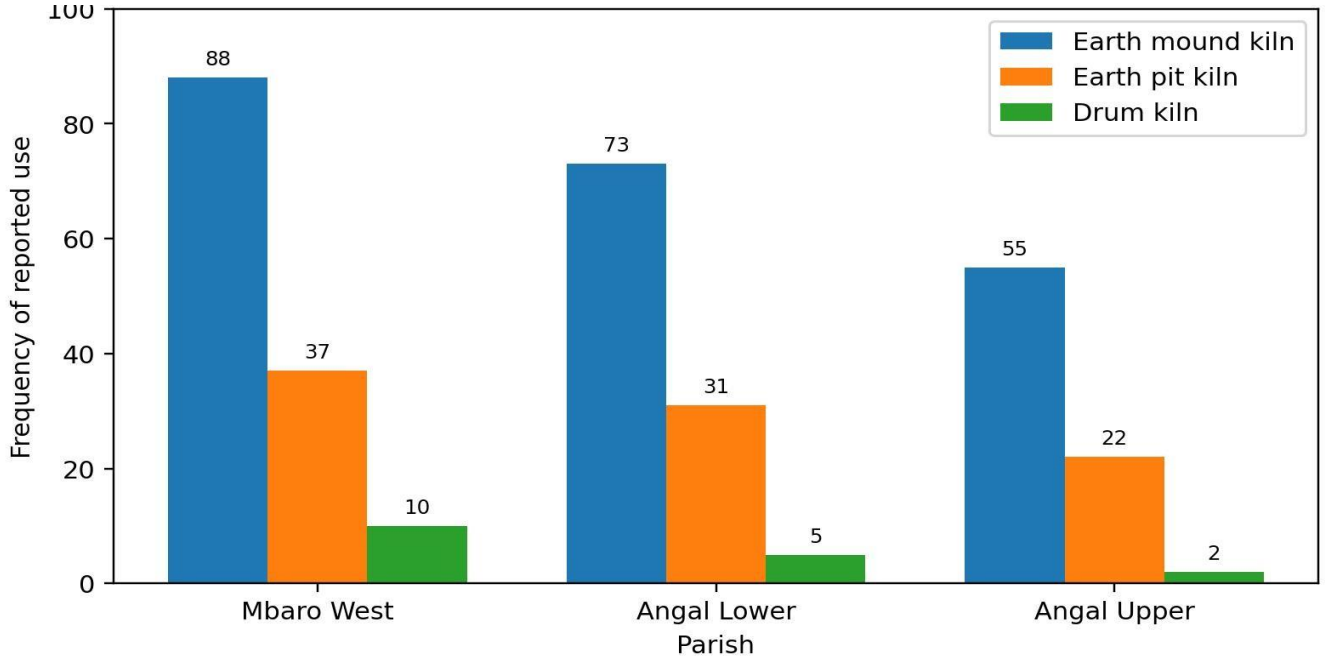

Figure 1. Distribution of charcoal production methods by parish. Source: Field survey, April 2025.

The results show that earth mound kilns accounted for 216 method-frequency counts, representing 66.9% of all reported method frequencies. Earth pit kilns accounted for 90 counts, representing 27.9%, while drum kilns accounted for only 17 counts, representing 5.3%. This pattern demonstrates that charcoal production in Nyaravur Sub-County remains dominated by traditional earth-based methods. The finding is consistent with wider African evidence showing that earth mound systems remain common where producers have limited capital, depend on local materials and operate in dispersed woodland production sites (FAO, 1987; Julien Schure 2019).

The earth mound kiln was the most common method across all three parishes. Field observations showed that producers first harvested wood and crosscut logs into manageable billets. Larger logs were placed at the base, while smaller branches and twigs were arranged above them to form a compact stack. The stacked wood was then covered with grass, leaves and soil, leaving controlled air openings for ignition and regulation of the burning process. The method

was labour-intensive and required felling, trimming, crosscutting, stacking, sealing, monitoring, cooling, sorting and bagging. Its dominance can be explained by affordability and familiarity: producers did not need expensive equipment, permanent structures or advanced technical knowledge. The main tools were axes, machetes, hoes, shovels, forks and sickles, while covering materials such as soil and grass were readily available within the production sites.

The earth pit kiln was the second most common method. In this method, producers dug a large pit, stacked wood inside it, covered the stack with grass and soil, and created small air openings to regulate burning. The kiln was then lit and left to carbonise slowly. The earth pit kiln was more common in Penji forest zone, especially in Angal Upper, suggesting that some producers preferred below-ground carbonisation where soil conditions allowed excavation. However, its lower frequency compared with the earth mound kiln indicates that producers generally found aboveground mounds more convenient and adaptable. Drum kilns were the least used method, with only 17 frequency counts across the three parishes. This low adoption indicates that improved or semi-improved kiln technologies had not been widely incorporated into local charcoal production. The limited use of drum kilns may be linked to cost, limited access to metal drums, lack of training, small production capacity and uncertainty about whether drum kilns can meet commercial production needs.

Mbaro West recorded the highest overall method-frequency count, followed by Angal Lower and Angal Upper. This suggests that Mbaro West may have had more active charcoal production sites, greater producer concentration or more accessible woodland resources. Across all parishes, the ranking of methods was consistent: earth mound kilns were first, earth pit kilns second and drum kilns last. This consistency points to a common production culture across the selected parishes. Charcoal producers appeared to prefer methods that reduce financial barriers, rely on local materials and can be constructed near harvested wood. However, the same pattern also reveals a sustainability challenge because the methods most accessible to producers are also the ones commonly associated with lower conversion efficiency and greater wood demand (Adam, 2009; Mulat Tazebew et al., 2023).

Discussion

The findings confirm that charcoal production in Nyaravur Sub-County is dominated by traditional earth-based kiln technologies. This is consistent with wider Ugandan and sub-Saharan African evidence showing that traditional earth mound kilns remain common because they are cheap, flexible and compatible with small-scale rural production (Batchelor et al., 2022; FAO, 1987; Julien Schure 2019). The pattern in Nyaravur is therefore not unusual; it reflects a broader regional production system in which producers rely on local materials, practical experience and low-capital techniques. The dominance of earth mound kilns is particularly significant because this method fits the economic realities of rural producers who may lack access to metal kilns, credit facilities, formal training and organised producer associations. In this sense, kiln choice is not merely a technical decision but an economic and social decision shaped by poverty, woodland access, market demand and inherited production knowledge (Branch et al., 2023; Kiruki et al., 2020).

However, the same advantage of affordability creates an environmental concern. Traditional earth mound and earth pit kilns often have lower conversion efficiency because air regulation is imprecise and heat loss is high. This means that more trees may be harvested to produce the same quantity of charcoal than would be required under improved kiln systems (Adam, 2009; Mulat Tazebew 2023). demonstrate that improved kilns can significantly increase conversion efficiency and reduce harmful gas emissions compared with traditional earth mound kilns, while Julien Schure (2019) emphasise that improved carbonisation can reduce wood demand when accompanied by

appropriate training and governance. The implication for Nyaravur Sub-County is that the observed dominance of earth mound and earth pit kilns may contribute to continued pressure on savannah woodland resources if production remains poorly regulated and unaccompanied by restoration.

The rare use of drum kilns points to a major technology-adoption gap. This limited adoption is not merely a technical failure; it is also institutional and socioeconomic. Improved kilns are unlikely to spread where producers cannot afford equipment, do not receive training, lack producer groups or cannot see immediate benefits in yield, time saving and income (Julien Schure 2019; Chemuku Wekesa 2023). Therefore, promoting improved kilns in Nyaravur Sub-County would require practical demonstrations, access to affordable materials, peer learning, local champions and supportive regulation. A top-down approach that simply condemns traditional kilns may fail because it ignores why producers prefer them. This confirms the argument by Branch et al. (2023) that charcoal policy must account for value chains, social relations and energy politics rather than treating charcoal as a simple technical problem.

The findings also show that charcoal production is labour-intensive and knowledge-based. Field observations indicated that production involves felling, crosscutting, stacking, covering, burning, cooling, sorting and bagging. These stages require considerable labour, patience and local experience. This human dimension is important because sustainable charcoal strategies should not disregard producers' practical knowledge. Instead, interventions should build on what producers already know by improving kiln sealing, wood stacking, moisture management, air control, site selection and post-carbonisation handling. Such incremental improvements may be more realistic than expecting immediate adoption of expensive technologies. At the same time, the ecological risks are real: recent studies from Ghana and Mozambique show that intensive charcoal production can transform forest-savannah and woodland landscapes, reduce open forest cover, degrade mature tree populations and shift vegetation structure where production is uncontrolled (Arko et al., 2024; Mabutana et al., 2025).

Overall, the findings establish an important foundation for understanding charcoal production and savannah woodland diversity in Nyaravur Sub-County. Before tree species preference and woodland degradation can be fully interpreted, it is necessary to understand the methods by which wood is converted into charcoal. The dominance of earth mound and earth pit kilns helps explain why wood demand may remain high and why woodland pressure may continue unless production technologies, producer skills and resource governance improve. The most balanced interpretation is therefore that Nyaravur producers require support rather than mere blame: they need improved kiln knowledge, realistic alternatives, organised production, restoration obligations and access to cleaner energy transitions that do not undermine rural livelihoods (Elasu et al., 2025; Wasswa et al., 2025; Wekesa et al., 2023).

Conclusion

The study established that charcoal production in the savannah woodland region of Nyaravur SubCounty is mainly carried out using traditional methods. Earth mound kilns were the dominant method in Mbaro West, Angal Lower and Angal Upper, followed by earth pit kilns, while drum kilns were used only minimally. This indicates that charcoal production in the area remains low technology, labour-intensive and heavily dependent on locally available woodland resources. The preference for earth mound and earth pit kilns is understandable because these methods are affordable, familiar and easy to construct using local materials. However, their continued dominance raises sustainability concerns because they are less efficient in wood-to-charcoal conversion and may

intensify harvesting pressure on savannah woodland.

The article concludes that improving charcoal production in Nyaravur Sub-County requires a balanced and livelihood-sensitive approach. Producers should not simply be criminalised, because charcoal production is tied to rural income and urban energy demand. Instead, interventions should focus on improving kiln efficiency, strengthening community woodland governance, restoring degraded areas, supporting producer organisation and expanding affordable clean cooking options for consumers. Without such a balanced approach, strict enforcement may push production further into informal channels while doing little to reduce the urban demand that drives charcoal harvesting.

Recommendations

Nebbi District authorities, Nyaravur Sub-County leadership, forestry officials and relevant energy agencies should organise practical training for charcoal producers on improved earth mound, drum, Casamance and other efficient kiln technologies that reduce wood wastage while remaining affordable to rural producers. This should be done through demonstration sites in Mbaro West, Angal Lower and Angal Upper so that producers can directly compare charcoal yield, burning time, labour demand and income benefits before adoption. Charcoal producer groups should also be formed or strengthened to support collective training, monitoring, licensing, savings, technology sharing and sustainable harvesting practices.

Community-based woodland management should be promoted so that charcoal-producing communities participate in regulating harvesting, protecting regenerating trees, restoring degraded sites and monitoring illegal cutting. Tree planting and assisted natural regeneration should be prioritised in major production zones, especially where earth mound and earth pit kilns have been repeatedly used. Restoration efforts should include both preferred indigenous species and fastgrowing woodlot species suitable for sustainable fuelwood supply, while local by-laws should guide harvesting rotations, minimum tree sizes, kiln siting and post-harvest regeneration responsibilities.

Charcoal regulation should be linked to livelihood and energy-transition support. Alternative income-generating activities such as agroforestry, beekeeping, tree nursery management, improved crop production and small livestock enterprises should be promoted to reduce overdependence on charcoal income. At the same time, urban charcoal demand must be addressed through affordable clean cooking options, improved cookstoves, electric cooking where feasible, LPG access and consumer sensitisation. Producer-level reforms alone may not protect Nyaravur woodlands if urban demand for cheap charcoal remains high.

Limitations and Areas for Further Research

This article focused on charcoal production methods and therefore does not provide a full analysis of the dominant tree species used for charcoal production or the broader influence of charcoal production on savannah woodland diversity. The article is also geographically limited to selected parishes in Nyaravur Sub-County, which may limit generalisation to other parts of Nebbi District or West Nile. Another limitation is that kiln efficiency was inferred from method type and literature rather than directly measured through experimental wood-to-charcoal conversion tests.

Future research should measure the actual efficiency of earth mound, earth pit and drum kilns in Nyaravur Sub-County by recording wood volume, wood moisture content, kiln size, burning time, charcoal yield, emissions and economic returns. Further research should also examine why improved kiln adoption remains low, with attention to producer attitudes, technology affordability, access to training, market incentives, land tenure, enforcement practices and institutional support. Such evidence would help design realistic interventions for sustainable charcoal production in Nebbi District.

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Conflict of Interest

The author declares no conflict of interest in the preparation of this article.

Data Availability Statement

The data used in this article were drawn from the author's field survey conducted in Nyaravur SubCounty, Nebbi District. Additional data may be made available by the author upon reasonable academic request.

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