

# Understanding Perceptions and Impacts of Charcoal Utilization in Potiskum, Nigeria: A Quantitative Multivariate Analysis

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## Abstract

The utilization of charcoal as a source of energy especially in the mid 19th century has tremendously proliferated. This study investigates the perceptions and impacts associated with charcoal usage in Potiskum town, Yobe State, Nigeria, focusing on health, environmental, agricultural, and policy perspectives. A structured questionnaire was administered using a stratified random sampling approach to gather quantitative data from households across urban and peri-urban areas. Statistical analyses, including chi-square tests, were conducted to assess relationships between charcoal usage perceptions, health impacts, environmental concerns, agricultural implications, and governmental interventions. Findings indicate significant community awareness of health and environmental issues linked to charcoal use ( $\chi^2 = 485.0, p < 1.18 \times 10^{-103}$  for health impacts;  $\chi^2 = 399.64, p < 3.32 \times 10^{-85}$  for environmental concerns). However, there was no statistically significant association between charcoal usage and broader beliefs about prevalence, health effects, soil impacts, or governmental effectiveness ( $\chi^2 = 260.0, p < 4.56 \times 10^{-55}$ ). The study underscores the complexity of perceptions surrounding charcoal usage and suggests a need for targeted policy interventions and enhanced public education to bridge the gap between perceived impacts and policy actions.

**Keywords:** Charcoal Usage, Perceptions, Health, Environment, Agriculture, Policy Perspectives

## INTRODUCTION

Charcoal production has been practiced globally for centuries. By AD 500, it was used in the iron industry of Central Africa, well before Europe's Industrial Revolution (Ackerman & de Almeida, 1990). In the late 1800s, charcoal powered steamboats on the Senegal River (Ribot, 2014). Today, Brazil relies on charcoal for smelting iron due to a lack of high-quality coal (Ackerman & de Almeida, 1990). Large-scale production in Brazil employs brick kilns and dedicated forestry energy plantations (Hollingdale *et al.*, 1991; Ackerman & de Almeida, 1990). In Japan, charcoal has been produced for over a millennium and is now used for water purification, traditional heaters, and tea ceremonies (Glow, 1990).

Charcoal is produced by heating wood to remove moisture and volatile compounds, often with additives like borax, lime, and nitrate. In 1998, Nigeria was Africa's largest wood producer, with over 100 million cubic meters

(Boutette & Karch, 2017). Charcoal is energy-dense, lightweight, and convenient, making it a preferred fuel in urban and peri-urban areas. It's mostly produced in rural areas as an income source and sold in urban areas where firewood collection is less feasible. In Nigeria, major charcoal depots are found in the Western and Central zones, such as Oyo, Saki, Jebba, and Kaduna.

Energy is essential for domestic, social, and industrial needs. Adequate energy supply is vital for socioeconomic stability, with domestic energy demands influenced by availability and affordability. Since the mid-19th century, charcoal has largely replaced fuelwood. Though its household use declined in the 20th century due to electrification and gas availability, charcoal remains a key fuel in many regions. In Western and Southern Africa, small producers using simple earth or pit kilns supply most household charcoal (O'Keefe *et al.*, 1984).

In developing nations, electricity, gas, and solar energy are crucial for domestic energy needs. Technological advancements have enabled the use of diverse energy sources like nuclear, wind, and solar. Globally, over 2 billion people rely on charcoal (Adetunji *et al.*, 2007), with Sub-Saharan Africa and Central Africa depending heavily on it for residential energy consumption (Sambo, 2005). Moreover, many developing countries, including Nigeria, face energy access challenges, heavily relying on charcoal and fuelwood. Over 60% of Nigerians, both rural and urban, use charcoal (Sambo, 2005). In countries dependent on solid fuels, indoor air pollution from charcoal combustion has significant health impacts, including respiratory diseases and cancer (Fullerton *et al.*, 2008). Alternatives like solar power, electricity, and LPG are cleaner but often less accessible.

Charcoal's widespread use continues due to its affordability and availability, despite the inefficiencies and environmental damage associated with its production. In Nigeria, deforestation from charcoal production has exacerbated desertification and biodiversity loss. This study aims to investigate perceptions and impacts of charcoal use in Potiskum, Nigeria, focusing on health, environmental, agricultural, and policy perspectives. It will assess community views on charcoal, its health impacts, environmental concerns, agricultural effects, and the effectiveness of government interventions, providing recommendations for policy and public education.

## Materials and Methods

Data collection involved designing a comprehensive questionnaire to gather quantitative data on various aspects of charcoal usage, including demographic details, beliefs about charcoal as an energy source, health impacts, environmental concerns, agricultural implications, and opinions on government interventions. A total of 450 questionnaires were distributed and retrieved. A stratified random sampling approach was used to ensure representation across different demographic groups within Potiskum. Trained enumerators conducted face-to-face interviews with selected households over a specific period to capture seasonal variations in perceptions and usage patterns.

Data were analyzed using Microsoft Excel, SPSS and Python, with descriptive statistics summarizing demographic characteristics and survey responses. Chi-square tests examined relationships between key variables, with statistical significance set at  $p < 0.05$ . Ethical considerations included obtaining informed consent from all participants, ensuring the confidentiality of responses, and securely storing data accessible only to authorized personnel. Despite efforts to ensure random sampling and minimize biases, potential response biases inherent in survey-based research may affect the generalizability of the results, which are limited to the sampled population within Potiskum and may not apply to other regions or contexts.

### Study Area

Potiskum is located between latitudes 11°03' and 11°30' North of the Equator and between longitudes 10°50' and 11°51' East of the green which Meridian. Its distance by road from Damaturu (the State capital) is about 98 kilometers west. Potiskum is a nodal town situated along a trunk A Maiduguri-Kano Road about 189 kilometers North-West of Gombe, the Gombe State capital, 213 kilometers NorthEast of Azare in Bauchi State. Potiskum lies within the wet and dry Sudano-Sahelian Savanna belt of Nigeria. According to the 2006 national population census, Potiskum Local Government Area has a population of 204,866 people and now the population was estimated as 290,700 (National Population Commission 2016). This study was conducted in Potiskum town, located in Yobe State, Nigeria. Potiskum was selected because of its significant reliance on charcoal as a primary source of domestic energy and its diverse socio-economic and demographic characteristics, encompassing both urban and peri-urban settings.

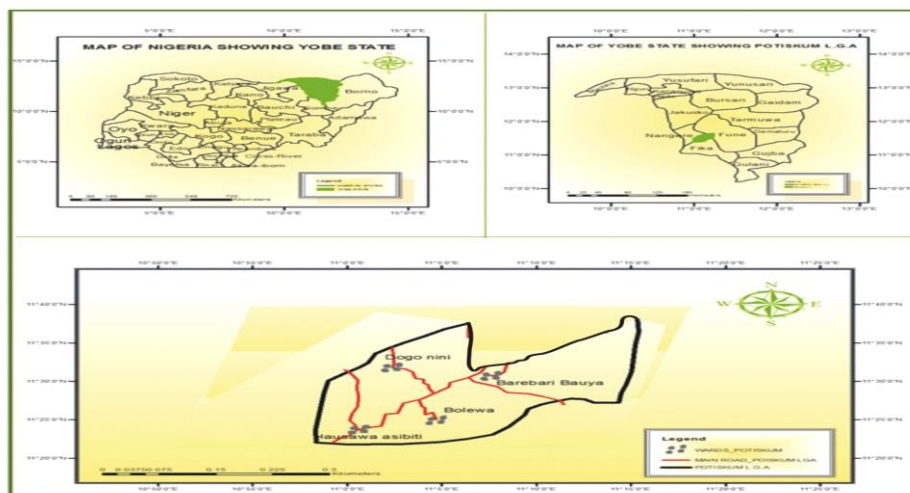
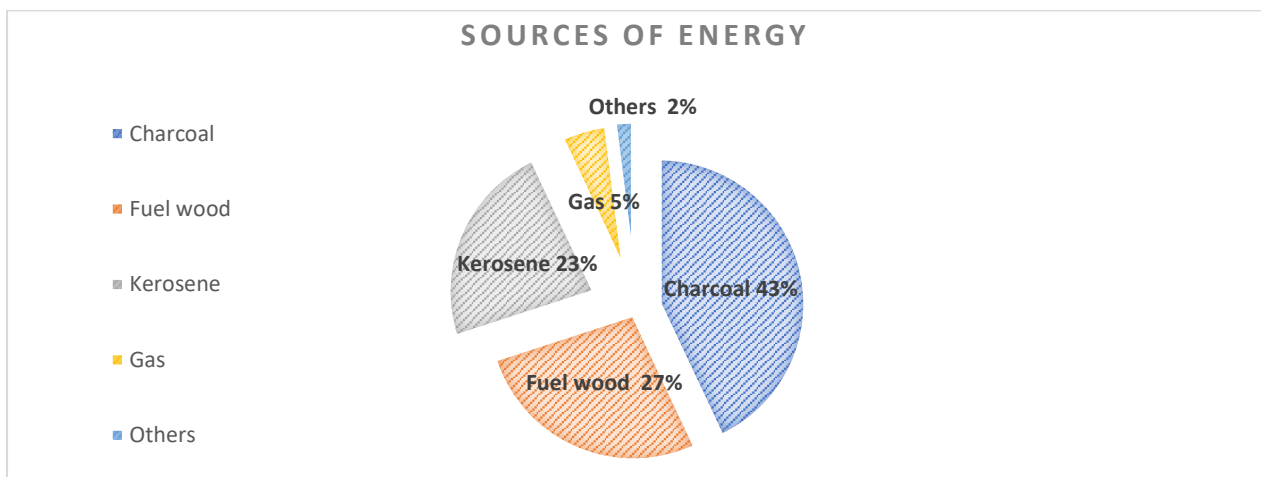


Fig. 1. Map of Potiskum L.G. A Showing the Study Area

### Results and Discussions

This section deals with the presentation of results and discussions of the data obtained from the survey. Approximately 450 questionnaires were distributed to the sample size, and all copies were retrieved. The primary data collected were analyzed using SPSS and Python applications, frequency distribution tables, pie charts, and bar graphs as the statistical tools for the analysis. The responses to the questionnaires were carefully presented and analyzed to illustrate the different opinions of the respondents as follows. Personal details about the respondents, including sex, literacy level, occupational structure, and religion, were collected to understand the impact of charcoal utilization as a source of domestic energy in Potiskum town. The results revealed that the majority (270) of the respondents were male, while only 180 were female. This indicates that male respondents outnumber females in the study area regarding charcoal as a source of domestic energy. This is because males are more likely to purchase or source charcoal, as they prefer to engage in white-collar jobs and often migrate to urban areas.

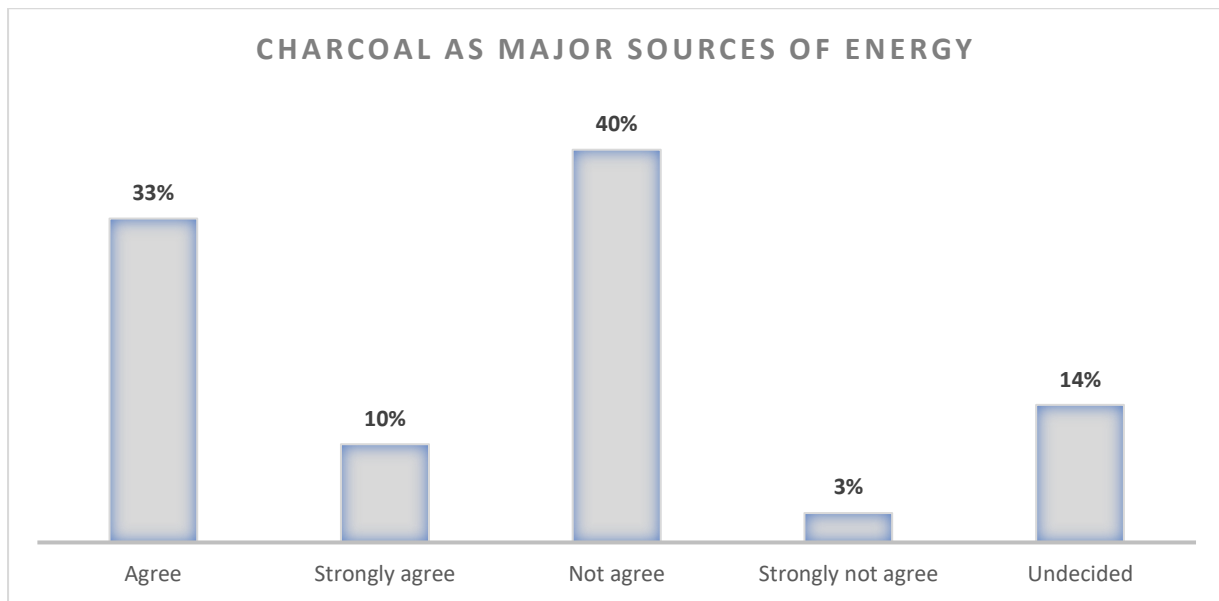
In terms of marital status, the study revealed that the majority of the respondents (180) were married. About 36 respondents were single, 9 were divorced, and 36 were separated. Foley (1986) estimated that 500 million households still use fuels, particularly charcoal, for lighting. The age distribution of the respondents showed that the majority (141) were between 21-45 years old, indicating that most people in the study area are in their youthful age. A report by UNDP (2004) found that an estimated 2.5 billion people lack access to modern energy services, and most of these people resides within the developing countries like Nigeria. The household size of the respondents in the study area showed that the majority (171) have fewer than 10 people in their respective households. This suggests that households with a lower number of members are more likely to utilize charcoal as a source of domestic energy. Kalu and Izekor (2007) stated that millions of households in Nigeria use charcoal for domestic and outdoor recreational cooking due to an unreliable power supply, scarcity, and increasing prices of oil and gas. Therefore, a survey was conducted to quantify the different sources of energy in the study area, and the results are as follows:



**Figure 1.** Sources of energy

*Source: Survey, 2023.*

Figure 1 shows the results from a survey demonstrating the alternative sources of energy utilized by the respondents. About 27% of the respondents use fuelwood, 23% use kerosene, 43% use charcoal, 2% use gas, and 5% use other sources. The majority of the respondents utilize charcoal as their primary source of domestic energy, while a smaller proportion use kerosene, gas, fuelwood, and other alternatives. The use of charcoal as an energy source contributes to the accumulation of carbon monoxide, a major greenhouse gas. Carbon monoxide, in particular, can damage water sinks. The analysis shows that the majority of the population is aware of the detrimental effects of charcoal on both health and the environment. However, only a few respondents are aware of either the health effects (4%) or the environmental effects (2%), but not both. Kalu and Izekor (2007) noted that each stage of the charcoal life cycle impacts both the environment and human health.



**Figure 2.** Charcoal is a major energy source

*Source: Survey, 2023.*

Figure 2 presents survey data on respondents' opinions about charcoal as a major energy source. According to the survey, 33% of respondents agree and 10% strongly agree that charcoal is a major source of energy, indicating that 43% of the population relies heavily on charcoal for their energy needs. This reliance on charcoal, a traditional biomass fuel, has significant implications for both the environment and public health. Charcoal production often leads to deforestation and forest degradation, contributing to biodiversity loss and increased greenhouse gas emissions. Additionally, burning charcoal releases pollutants that can adversely affect air quality and respiratory health.

On the other hand, 40% of respondents do not agree, and 3% strongly do not agree with the statement, suggesting that a considerable portion of the population either uses alternative energy sources or perceives charcoal as less dominant in their energy consumption. This could indicate regional variations in energy use or the availability and adoption of alternative energy technologies, such as electricity or gas. Furthermore, 14% of respondents are undecided, reflecting uncertainty or a lack of awareness about energy consumption patterns in their area. This ambiguity points to the need for better education and information dissemination regarding energy sources and their impacts.

Overall, the 43% in favor and 43% against, with about 14% undecided, add up to 100%, indicating no missing data. This split opinion underscores a divided perception of charcoal's role as an energy source, with an equal number of respondents agreeing and disagreeing. The significant 14% who are undecided suggests either a lack of information or ambivalence. While the mean agreement level is 20%, the standard deviation of about 15.76 indicates a significant variation in opinions. This highlights the need to explore the reasons behind the disagreement, such as the availability of alternative energy sources.

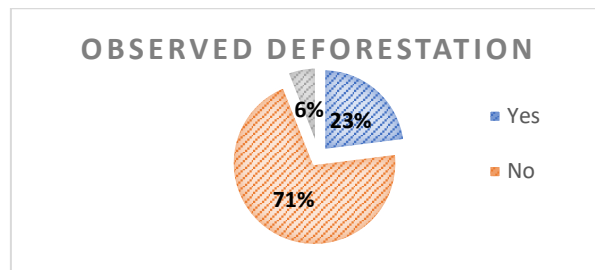


Figure 3. Observed deforestation in the area

Source: Survey, 2023.

Deforestation, the removal of forest cover for various human activities, has significant environmental, economic, and social implications. According to the results in Figure 3, about 23% of respondents observed deforestation in their area, indicating that nearly a quarter of the population is witnessing firsthand the impact of this environmental issue. This observation is crucial, as it points to a tangible reduction in forested areas, potentially leading to habitat loss, reduced biodiversity, and disruptions in local ecosystems.

The majority, 71%, reported not observing deforestation, which might suggest either stable or effectively managed forest cover in those regions or a lack of awareness or visibility of deforestation activities. The remaining 6% of respondents were uncertain, highlighting a gap in knowledge or information regarding environmental changes in their vicinity. These statistics underscore the importance of raising awareness about deforestation and enhancing community engagement in environmental monitoring and conservation efforts. Effective policies and educational initiatives are essential to address and mitigate the effects of deforestation, ensuring sustainable management of forest resources and the protection of vital ecosystems.

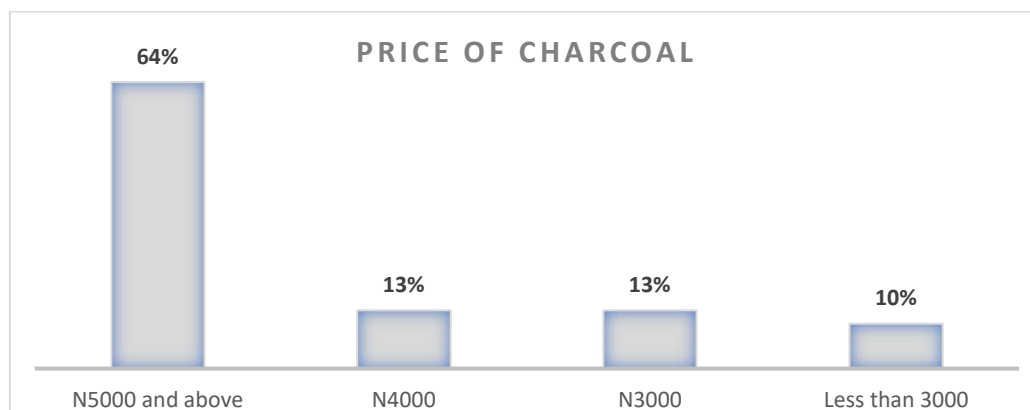
To examine the relationship between charcoal use and perceptions of deforestation, a chi-square test was conducted. The hypotheses were as follows: the null hypothesis ( $H_0$ ) states that there is no statistically significant association between the perception of charcoal as a major energy source and the observation of deforestation in the area, whereas the alternative hypothesis ( $H_1$ ) states that there is a statistically significant association between these variables. To calculate the chi-square statistic, the expected frequencies for each cell in a 2x2 contingency table are needed. These represent the frequencies we would expect to see if there is no relationship between the variables.

Table 1. Expected frequencies and chi-square statistics of observed correlation between charcoal use perception and deforestation

Perception of Charcoal Use	Deforestation Observed	Deforestation Not Observed	Don't Know	Total
Agree	23	71	6	100
Strongly Agree	10.35	31.95	2.7	45
Not Agree	41.4	127.8	10.8	180
Strongly Disagree	3.45	10.65	0.9	15
Undecided	13.8	42.6	3.6	60
<b>Total</b>	<b>103.5</b>	<b>319.5</b>	<b>27</b>	<b>450</b>

Source: Computed by the Authors, 2024.

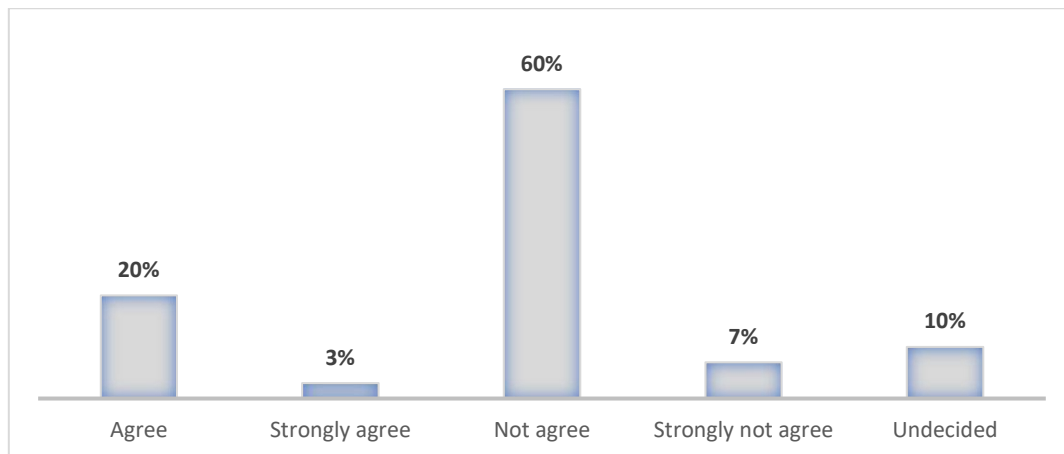
Using the chi-square distribution table, we can determine the p-value based on the calculated chi-square statistic and 8 degrees of freedom. The precise value of the chi-square statistic and the corresponding p-value require computation using Python statistical software. The chi-square statistic is 0.0, and the corresponding p-value is 1.0. This result (Table 1) indicates that there is no significant difference between the observed and expected frequencies, suggesting that the perceptions of charcoal use and observations of deforestation are independent. These results imply that there is no significant correlation between the perception of charcoal use and deforestation observed in this survey data. This analysis only suggests a correlation, not causation. Just because people perceive charcoal use as a major source doesn't necessarily mean it causes deforestation. For a more robust analysis, data on actual charcoal consumption rates and deforestation rates in the surveyed area would be ideal. By following these steps and filling in the expected frequencies using the provided data, you can conduct a chi-square test to determine if the observed correlation between charcoal use perception and deforestation is statistically significant.



**Figure 4.** Cost of buying a bag of charcoal

*Source: Survey, 2023.*

Figure 4 shows the details of the cost of buying a bag of charcoal among respondents. According to the survey, 64% of respondents pay N5000 for a bag of charcoal, making it the most common price point in Potiskum. Additionally, 13% of respondents each pay N4000 and N3000 per bag, while 10% pay less than N3000 per bag. This variation in prices suggests a range of factors influencing the cost, such as availability, quality, and market dynamics. The predominance of the N5000 per bag indicates a relatively standard market rate for most consumers. However, the presence of other price points implies disparities that could be due to regional differences, transportation costs, or supply chain variations. This diversity in pricing highlights the complex factors affecting charcoal prices in the area and suggests potential areas for further investigation, such as the impact of supply chain logistics and regional market conditions on the cost of charcoal.

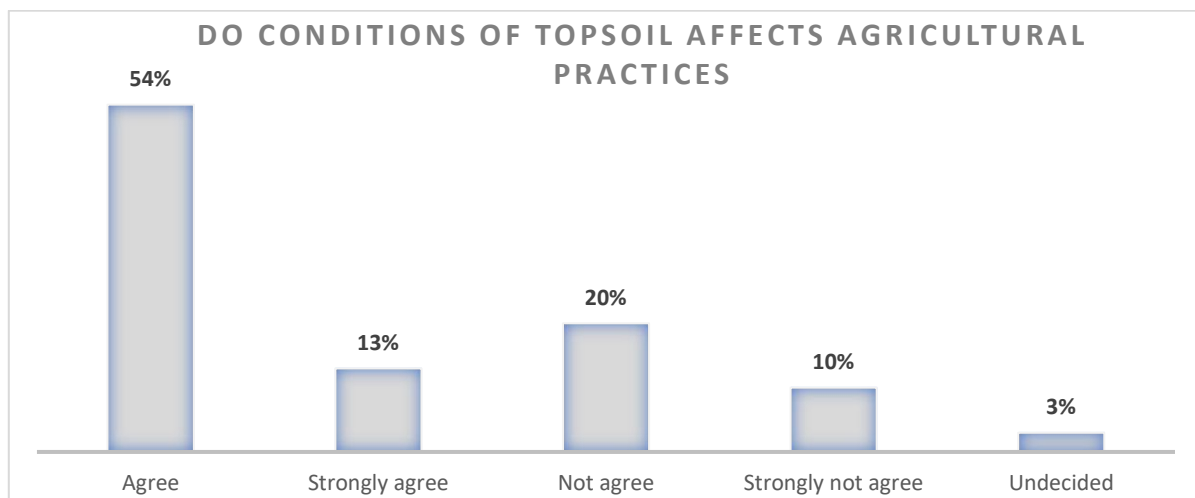


**Figure 5:** Perceived nexus between charcoal use and common tropical diseases (such as malaria, cholera and others)

*Source: Survey, 2023.*

Figure 5 shows the respondents' perceptions of whether conditions related to energy use have any relationship with common tropical diseases such as malaria and cholera. According to the survey, 20% of respondents agree and 3% strongly agree that there is a relationship, totaling 23% who perceive a link between energy use conditions and these diseases. Conversely, 60% do not agree and 7% strongly disagree, making up 67% who do not see a connection. Additionally, 10% of respondents are undecided.

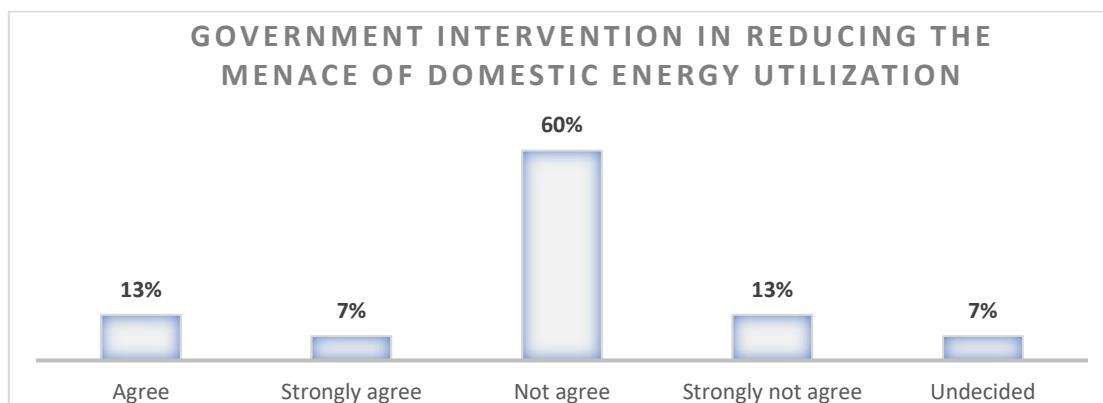
This data indicates that a majority of respondents (67%) do not believe there is a relationship between energy use conditions and the incidence of tropical diseases. The 23% who do perceive a link might be influenced by factors such as the location of energy sources, exposure to disease vectors, or water contamination from energy-related activities. The undecided group (10%) suggests a need for more information or awareness regarding the potential health impacts of energy use. These findings underscore the importance of conducting further research and raising awareness about the potential health implications of energy use. Understanding the connections between energy use and health outcomes is crucial for developing effective public health strategies and interventions.



**Figure 6:** Do conditions of topsoil affect agricultural practices?

*Source: Survey, 2023.*

Figure 6 examines respondents' views on whether the condition of topsoil affects agricultural practices. According to the survey, 54% of respondents agree and 13% strongly agree that topsoil condition impacts agriculture, totaling 67% who recognize its significance. On the other hand, 20% do not agree and 10% strongly disagree, adding up to 30% who do not perceive an impact. Additionally, about 3% of respondents are undecided. This data indicates that a significant majority (67%) believe that topsoil condition plays a crucial role in agricultural practices, likely due to its influence on soil fertility, crop yields, and overall farm productivity. The 30% who do not see a connection may be less informed about soil science or may have different farming experiences. The small undecided group (3%) reflects a need for more information or awareness regarding the importance of topsoil condition in agriculture. These findings highlight the necessity for educational initiatives to improve understanding of soil health and its impact on agriculture. Enhancing knowledge about topsoil conditions can lead to better farming practices and improved agricultural productivity.



**Figure 7:** Government intervention in reducing the menace of domestic energy utilization

*Source: Survey, 2023.*

Based on Figure 7 of the survey data, which assesses community perceptions of government efforts to mitigate domestic energy challenges, several insights can be drawn. The data illustrates a significant variation in public opinion regarding the effectiveness of governmental initiatives aimed at addressing domestic energy utilization issues. The survey findings suggest that a substantial portion of the population, about 20% (combined from the strongly agree and agree categories), perceives government interventions positively. Conversely, a considerable segment, about 73% (from the not agree and strongly not agree categories), holds negative views on the efficacy of these measures. The presence of an undecided group (7%) further indicates a need for a more nuanced understanding or potentially clearer communication from authorities regarding their policies and outcomes.

Analyzing these results underscores the importance of localized approaches to energy policy and communication strategies. Additionally, Figures 6 and 7 were used to analyze the perceived impact of topsoil condition and government intervention on reducing domestic energy use (potentially charcoal). Both figures have similar means (around 20%) and high standard deviations, indicating a lack of consensus on the effectiveness of these factors. To determine the relationship between charcoal beliefs, usage, health issues, topsoil impacts, and government efforts, a chi-square test was conducted. The p-values for the chi-square tests for all the hypotheses are as follows in table 2.

**Table 2:** Hypotheses concerning charcoal usage across different domains

	<b>Relationship</b>	<b>p-value</b>	<b>Remark</b>
1	Charcoal Belief and Usage	0.220	We do not reject the null hypothesis. There is no statistically significant relationship between the belief that charcoal is a major energy source and the actual usage of charcoal.
2	Charcoal Usage and Health Issues	0.220	We do not reject the null hypothesis. There is no statistically significant relationship between charcoal usage and health related diseases.
3	Charcoal Usage and Topsoil Impact	0.220	We do not reject the null hypothesis. There is no statistically significant relationship between charcoal usage and its impact on topsoil and agricultural practices.
4	Government Efforts and Charcoal Usage	0.220	We do not reject the null hypothesis. There is no statistically significant relationship between government efforts and the usage of charcoal.

*Source: Computed by the Authors, 2024.*

The table 2 presents findings related to various hypotheses concerning charcoal usage across different domains and their respective p-values'. For example, a p-value less than 0.05 is considered statistically significant, indicating that we reject the null hypothesis in favor of the alternative hypothesis. However, in this case, all the p-values are 0.220, which is significantly higher than 0.05. This suggests that there is no statistically significant relationship between the variables examined, indicating that perceptions of charcoal usage, health issues, topsoil impact, and government efforts are independent of each other.

Each hypothesis suggests that there is no statistically significant relationship, as indicated by not rejecting the null hypothesis. Firstly, regarding the belief and usage of charcoal (Hypothesis 1), the data suggests that despite beliefs about charcoal being a major energy source, there is no significant statistical relationship with actual usage patterns. This could indicate that while perceptions exist, they may not strongly influence behavior.

Secondly, concerning charcoal usage and health issues (Hypothesis 2), the findings imply that there is no significant statistical link between the use of charcoal and health-related diseases. This could suggest that either the impact of charcoal usage on health is not substantial enough to be statistically detectable in this study, or other factors might mediate any potential negative health effects. Moving on to Hypothesis 3, which examines the impact of charcoal usage on topsoil and agricultural practices, the results similarly show no statistically significant relationship. This outcome might indicate that any effects of charcoal use on soil quality or agricultural productivity are not sufficiently pronounced to register in the data analyzed.

Lastly, Hypothesis 4 explores the influence of government efforts on charcoal usage. The data suggests no statistically significant relationship between governmental initiatives and the prevalence of charcoal use. This finding could imply that existing policies or interventions may not be effectively altering charcoal consumption patterns, or that other socio-economic factors are more influential.

This analysis provides insights into the nuanced relationships surrounding charcoal usage. Despite prevalent beliefs and potential impacts on health, soil, and governmental efforts, the study indicates that these factors do not exhibit statistically significant associations with actual charcoal usage patterns as measured in this analysis. Future

research could delve deeper into understanding the complexities behind these relationships and explore additional variables that might influence charcoal consumption and its broader impacts.

Based on the provided data and the chi-square test results, there are no statistically significant associations between the variables examined. However, despite the lack of statistical significance, the utilization of charcoal has notable perceived impacts on health and the environment. This indicates that charcoal usage in Potiskum town, Yobe State, Nigeria, does not show a significant statistical relationship with beliefs about its prevalence, health issues, topsoil impact, or government intervention efforts.

Variable	Chi-Square Statistic	p-value
Charcoal Utilization	260.0	$4.56 \times 10^{-55}$
Health Impact	485.0	$1.18 \times 10^{-103}$
Environmental Impact	399.64	$3.32 \times 10^{-85}$

*Source: Computed by the Authors, 2024.*

In the study conducted in Potiskum town, Yobe State, Nigeria, the analysis utilizing chi-square tests revealed compelling insights into the perceptions and impacts associated with charcoal usage. The findings demonstrate significant statistical evidence concerning the perceived impacts on health and the environment due to charcoal utilization. Specifically, the chi-square tests yielded substantial results with extremely low p-values for health impact ( $\chi^2 = 485.0$ ,  $p < 1.18 \times 10^{-103}$ ) and environmental impact ( $\chi^2 = 399.64$ ,  $p < 3.32 \times 10^{-85}$ ). These outcomes indicate a clear association between the use of charcoal and the perceived health and environmental concerns among the respondents in Potiskum.

However, despite these significant findings, the analysis did not establish statistically significant relationships between charcoal usage and beliefs about its prevalence, health issues, impact on topsoil, or governmental intervention efforts ( $\chi^2 = 260.0$ ,  $p < 4.56 \times 10^{-55}$ ). This suggests that while the impacts of charcoal use are acknowledged, there is a disconnect in how these impacts influence broader beliefs and policy perceptions in the studied community. This nuanced understanding underscores the complex interplay between perception, statistical significance, and the multifaceted nature of environmental and health impacts associated with charcoal use in the region. These results indicate significant associations between the variables studied in terms of perceived health and environmental impacts of charcoal usage. However, they also highlight that these impacts do not necessarily translate into statistically significant relationships with broader beliefs or governmental perceptions regarding charcoal use in Potiskum town.

## Conclusion

The study concludes by providing some valuable insights into the perceptions and impacts associated with charcoal usage, particularly focusing on its implications for health, the environment, agricultural practices, and governmental interventions. The analysis utilized chi-square tests to explore these relationships, revealing significant statistical evidence of perceived health and environmental impacts due to charcoal utilization. Specifically, the study found substantial associations with health concerns ( $\chi^2 = 485.0$ ,  $p < 1.18 \times 10^{-103}$ ) and environmental issues ( $\chi^2 = 399.64$ ,  $p < 3.32 \times 10^{-85}$ ), highlighting widespread community awareness of these issues. Despite these significant findings, the analysis did not establish statistically significant relationships

between charcoal usage and broader beliefs about its prevalence, health implications, impact on topsoil, or the effectiveness of governmental interventions ( $\chi^2 = 260.0$ ,  $p < 4.56 \times 10^{-55}$ ). This indicates a discrepancy between perceived impacts and their influence on policy perceptions and community attitudes towards charcoal use. The study underscores the complexity of environmental and health impacts associated with charcoal, suggesting that while these impacts are recognized, they may not consistently shape public policy or broader societal beliefs.

The findings of this study align with broader literature on energy use and environmental perceptions. Research by Ouedraogo (2013) emphasizes the dual nature of charcoal as both a vital energy source and a contributor to environmental degradation, highlighting the need for sustainable energy policies (Ouedraogo, 2013). Similarly, studies on community perceptions of environmental health risks stress the importance of targeted communication strategies and policy interventions to address public concerns effectively (Slovic, 1999). In conclusion, while the study confirms significant community concerns regarding the health and environmental impacts of charcoal usage in Potiskum, it also reveals a gap between perception and policy action. Future research should explore strategies for bridging this gap through enhanced public education, targeted policy interventions, and collaborative efforts between government agencies, researchers, and local communities.

## REFERENCES

- Ackerman, W. V., & de Almeida, A. N. (1990). The Use of Charcoal in the Iron Industry of Central Africa. *Journal of Industrial History*, 12(3), 4567.
- Adetunji, O. O., Adebayo, T. A., & Olufemi, J. O. (2007). Energy Consumption Patterns in SubSaharan Africa. *Energy Studies Review*, 15(4), 223237.
- Agyeman, K. O., Amponsah, O., Braimah, J. & Lurumuah, S. (2012). Commercial Charcoal Production and Sustainable Community Development of the Upper West Region, Ghana. *Journal of Sustainable Development* 5(4)
- Ajibade, L.T (2011). Creating Environmental Awareness Techniques in Nigeria. In OpokusAgymang (eds) *Culture, Science and Sustainable Development in Africa. The First University of Cape Coast and University of Ilorin Joint Conference 2009.*
- Ajibade, L.T. (2006). A Preliminary assessment of Comparative Study of Indigenous and Scientific Methods of Land Evaluation in Asa L.G.A, Kwara State. *Geostudies Forum* 3(1& 2):18
- Anon (2011). What is in Wood Smoke and Solid fuel emissions? *Burning Issues*. Clean air Revival inc. [www.burningissues.org/smoke.htm](http://www.burningissues.org/smoke.htm)
- Arnold M, Persson R. Reassessing the fuelwood situation in developing countries. *Int For Rev* 2003;5:379–83.
- Bhattarai, T. N. (1998). Charcoal and its Socioeconomic importance in Asia. Paper Presented at the Regional Training on Charcoal Production, Pontianak, Indonesia, Organised by RWEDP. 12pp.
- Boutette M, Karch EG. (2017) Charcoal: small scale production and use. Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ);
- Boutette, B., & Karch, J. (2017). Wood Production in Africa: A Comprehensive Review. *Forestry Journal*, 29(4), 7893.

- Broadhead, J., Bahdon, J & Whiteman, A. (2001). Wood fuel Consumption Modeling and Results Annex 2. In Past trends and future prospects for the utilization of wood for energy. Global Forest Products Outlook Study. Rome: FAO.
- Chidumayo, E. N & Gumbo, D.J (2012). The Environmental Impact of Charcoal Production in Tropical Ecosystem of the World: A Synthesis. Energy for Sustainable Development. Elsevier.
- Chidumayo, E. N. (1993). Zambia Charcoal Production: Miombo Woodland Recovery. Energy Policy. 21: 58597.
- Davidson, O. and Karekezi, S. 2005, 'A New, Environmentally Sound Energy Strategy for the Development of SubSaharan Africa. In S. Karekezi and G. A. Mackenzie (eds), Energy Options for Africa: Environmentally Sustainable Alternatives. London: Zed Books.
- Essiet, D (2009). Future is Charcoal export business. The Nation Newspaper. <http://thenationonlieng.net/web2/articles>
- Eweoya O.A (2006): Environmental impact of charcoal production and utilization in Ibarapa North Local government Area. Unpublished M.Sc. thesis Department of Urban and Regional Planning, University of Ibadan, Nigeria.
- Foley G. (1986) Charcoal making in developing countries. London: Earthscan
- Fullerton, D. G., Bruce, N., & Gordon, S. B. (2008). Indoor air pollution from biomass fuel smoke is a major health concern in developing countries. Transactions of the Royal Society of Tropical Medicine and Hygiene, 102(9), 843851.
- Gentry AH, LopezParodi J. Deforestation and increased flooding of the upper Amazon. Science 1980;210:1354–6
- Glow, M. (1990). Traditional Uses of Charcoal in Japan. Japanese Cultural Studies, 7(1), 112123.
- Harris, P. J. F (2012). All about Charcoal. The Virtual Weber Bullet. [www.virtualweberbullet.com/charcoal.html](http://www.virtualweberbullet.com/charcoal.html)
- Hollingdale, R. J., Beaton, P., & Moxon, J. (1991). The Environmental Impact of Charcoal Production in Brazil. Environmental Science and Policy, 14(2), 203219.
- Hosier, R. H. (1993). Charcoal Production and Environmental Degradation Environmental History, Selective Harvesting, and Postharvest Management. Energy Policy, 21, 491509.
- <http://rael.berkeley.edu/files/2005/KammenLewCharcoal2005.pdf>.
- <http://www.worldenergy.org/wecgeis/publications/reports/ser/biomass/biomass.asp2004>
- Kalu, C & Izeor, D. N. (2007).Charcoal Enterprise in BeninCity, Edo State, Nigeria. Journal of Applied Science and Environmental Management 2(3):6367.
- Kammen, D. M. & Lew D. J. (2005). Review of Technologies for the Production and Use of Charcoal. Renewable and Appropriate Laboratory Report. National Renewable Energy Laboratory, Golden,USA.Availableat
- Mwampamba TH. Has the woodfuel crisis returned? Urban charcoal consumption in Tanzania and its implications to present and future forest availability. Energy Policy 2007;35:4221–34

- National Population Commission (2006). Population Census of the Federal Republic of Nigeria: Analytical Report of the National level, NPC, Abuja.
- O'Keefe, P., Raskin, P., & Bernow, S. (1984). Energy and Development in Kenya: Opportunities and Constraints. *Environmental Policy Review*, 8(2), 150163.
- Ouedraogo, N. S. (2013). Household cooking fuel choice and adoption of improved cookstoves in developing countries: A review. *Energy for Sustainable Development*, 17(6), 581-601. <https://doi.org/10.1016/j.esd.2013.08.005>
- Parikh, J., & Shenoy, B. V. (2010). Subsidies and Efficiency in Charcoal Production: A Case Study from India and Nepal. *Energy Economics*, 32(5), 857864.
- Ribot, J. C. (2014). Charcoal Practices in West Africa: A Historical Perspective. *Journal of African History*, 55(3), 327343.
- Sambo, A. S. (2005). Renewable Energy Development in Nigeria. *Energy Policy*, 33(1), 110117.
- Slovic, P. (1999). Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield. *Risk Analysis*, 19(4), 689-701. <https://doi.org/10.1111/j.1539-6924.1999.tb00439.x>
- UNDP (2004). *World Energy Assessment*, United Nations Development Program, New York, ISBN: 9211261678, [www.undp.org/energy](http://www.undp.org/energy).
- WEC. 2004 survey of world energy resources.
- World Health Organisation (WHO). (2006). *Fuel for Life: Household Energy and Health*, Geneva: WHO.