



**Cost Benefit Assessment of Clean Household Cooking Energy in Niger Delta
Nigeria**

Edwin Isotu Edeh

**A Thesis Submitted in Fulfillment of the Requirements for the Degree of Doctor
of Philosophy in Sustainable Energy Management (International Program)**

Prince of Songkla University

2024

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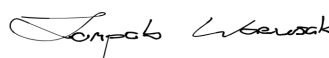
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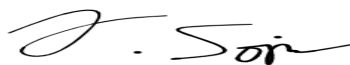
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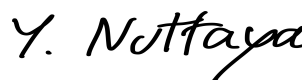
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ABSTRACT

Energy access, particularly for cooking, aligns with SDG 7 for achieving affordable, reliable, and modern energy for all by 2030. This study investigates household energy consumption for cooking in the Niger Delta region of Nigeria, focusing on the choice of energy sources, consumption patterns, and factors influencing these choices. The methodological approach, using a mix of probabilistic and non-probabilistic modeling collected data from 1,111 households across 10 states using a multi-stage sampling technique. The results show that 57% of households use LPG as their primary cooking energy source, followed by 13% using charcoal. Household heads aged 36-45 years make up the largest group (22%), while 64% of household heads are male. The study also reveals that 45% of households consume between 300-500 kg of fuelwood per month, while 48% of households consume between 11-15 kg of LPG per month. Charcoal remains the most common alternative energy source, with 37% of households using it, and only 18% of households have access to cooking energy sources within 1000 meters. Principal Component Analysis (PCA) indicates that affordability (0.762) is the strongest factor influencing energy choice, followed by health and safety concerns (0.767) and government policies (0.599). The benefit-cost analysis shows that electricity and LPG offer the highest benefit-cost ratios, with electricity at 2.08 and LPG at 1.47. These findings highlight a transition toward cleaner energy options, influenced by affordability, availability, government incentives, and health considerations.

Key words: Energy, Niger Delta, cost-benefit, household cooking, environment, sustainability

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- Assistant Professor Dr. Montri Luengchavanon,
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List of Abbreviations and Symbols

AHP - Analytical Hierarchy Process
IAE - International Energy Agency
ICS - Improved Cook Stoves
LPG - Liquefied Petroleum Gas
MCDA) - Multi-Criteria Decision Approach
RIH - Relative Income Hypothesis
SDG - Sustainable Development Goals
TCS - Traditional Cook Stoves

CHAPTER 1 INTRODUCTION

BACKGROUND OF THE STUDY

1.0 Introduction

Access to energy, particularly cooking energy plays a key role for human survival, wellbeing and in physical and economic development of people. “Energy access” constitutes of the major Sustainable Development Goals (SDG) of the United Nations to be achieved by 2030 SDG 7 seeks to ensure that everyone has access to modern, dependable, affordable energy. Which states that by 2030, everyone should have access to services that are affordable, dependable, and modern (UN, 2020). Approximately 2.6 billion people, or 81% of the world's population, do not have access to contemporary clean cooking energy. This huge proportion of population still relies on solid biomass, kerosene, or and coal as their primary source of energy (IAE, 2020). However, this figure as continued to decline in last decade, in which over 450 million people has gained access to clean cooking energy, specifically in India and China (IAE, 2020). Though one third of the world population still do not have access to clean and reliable energy technologies. It is pertinent to note that about 2.6 billion people are concentrated in Sub-Saharan Africa and in developing Asia. Only 17% of Sub-Saharan African population have access to clean cooking energy (some of such countries includes Mali, Sudan, Nigeria and Congo having just 3% of its population with primary access to clean cooking facilities). While Nigeria in particular have only 28 million of its population having access to clean energy (IEA, 2020b).

Traditional and modern, is the two major classes of cooking energy, in which traditional cooking energy includes wood, charcoal and agricultural residues, while modern cooking energy include petroleum products and electricity (Niriezono & Kilangla,

2018). In the last decades Nigeria as witnessed a massive shift towards the use of Liquefied Petroleum Gas (LPG) for cooking (Danlami, 2018). However, due to the drastic increase in cost of LPG, this shift has been marred. Thereby, pushing most household to the use of more traditional energy source. This is due to the local availability, cost, collection and utilization of biomass fuels (Niriezono & Kilangla, 2018).

The consequences of cooking with traditional biomass on human wellbeing and the environment are enormous. The key consequences however is the health impacts due to the exposure to air pollutants, burns suffered while cooking, physical impacts due to heavy loads of firewood, beyond others. It also limits the opportunities of working and studying or doing other productive activities. This is however a gender-based issue, which disproportionately affects women based on the fact that there are dominantly in charge of the cooking activities in the house, as such expanding gender inequalities (World Bank, 2020c). As such, several initiatives have been taken in form of initiatives and policies which have been devised and executed over the last 40 years. One of such several initiatives has been to encourage household's transition from Traditional Cook Stoves (TCS) to Improved Cook Stoves. It is important to note that when compared to TCS, Improved Cooking Stoves (ICS) have been known for their fuel-efficient qualities, which also reduce the time spent cooking and gathering fuel (Urmee & Gyamfi, 2014a); energy-efficiency, especially when fitted with energy insulating materials; and drastically reducing Indoor Air Pollution (IAP) when also fitted with Chimney or hood (Johnson et al., 2019; Kshirsagar & Kalamkar, 2014; OEOECD/IEA, 2016).

Problems with household energy cannot be resolved in isolation from related issues with poverty, food, culture, and the environment (Danlami et. al., 2018). According to recent studies by Masera et al. (2000), Kammen (2000), Heltberg (2003), and Danlami et al. (2018), the concept of "energy ladder" continues to be the basis for household cooking energy demand and consumption. which contend that households would typically switch from an inefficient fuel source to one that was more efficient if their household income increased. Pundo and Fraser (2006) countered this claim by asserting that households typically use a variety of fuels rather than switching between sources. Due to household characteristics and fuel prices, a typical household typically pools high-cost and low-cost fuels (World Bank, 2010). As such, households ends up adopting the concept of “fuel stack” (i.e. multiple fuel use).

Consequently, it is accurate to state that factors other than income affect the pattern of household consumption (Nazer, 2016). There are some elements that, if ignored, could exacerbate the fuel energy issues in homes. For the purpose of formulating policies that could assist in addressing three crucial strategy issues related to fuel security, it is important to have a thorough understanding of the pattern of fuel demand in a country or particular locality. It is helpful to highlight the most likely political solutions to these problems in order to reduce household energy consumption. Second, it is beneficial to also highlight various fuel energy planning strategies that the government must implement. For sectoral and macroeconomic policy analyses, household fuel demand information behavior is crucial.

1.2 Statement of Problems

Around 2.4 billion people use firewood, charcoal, and agricultural waste as their main sources of cooking energy worldwide, mostly in developing nations (Ruiz-mercado et.

al., 2011). Similar to this, 81% of households in sub-Saharan Africa rely on biomass fuel for cooking (World Bank, 2011). However, in Nigeria, fuelwood, which provides about 70% of all domestic energy needs, is the most widely used source of energy for household cooking (UNDP, 2016). Subsequently, in order to eliminate the problems associated with households' energy consumption pattern, there is need for focus efforts on moving household from the use of firewood and other traditional sources towards clean energy source use. The strategies that would reduce massive fuelwood use depends on the operationality of the available policies necessary for making such a shift, which must in fact be based on comprehensive research that investigates and explore household consumption pattern and factors that pushes household towards adopting clean source of energy in Niger Delta, Nigeria. Although, several household energy studies on choice have been carried out in different countries across the globe, but limited within the context of Nigeria (Ogwuimike et. al., 2014; Naibbi and Healey, 2013). Onoja and Emodi (2012) in Kogi State, Nigeria; Oyekale et al. (2012) in Ekiti State, Nigeria; Nnaji et al. (2012) concentrating on Enugu State, Nigeria; and Julius (2013) conducted in Abuja, Nigeria) are examples of studies that are specific in approach and focus primarily on local government area or and state. As a result, results from one location cannot be generalized due to environmental, socioeconomic, and cultural differences. It is pertinent to note therefore that none of all these studies used Niger Delta Nigeria as the case study of the analysis. All the highlighted studies, except that conducted by Ogwuimike et al., (2014) concentrated solely on just cooking aspects only, without highlighting the cost benefit of these different uses. Furthermore, most of those studies only uses descriptive percentage as a tool of their analysis and therefore they lack the wider application of econometric tools.

Likewise, none of the reviewed studies on household cooking energy as applied the use of Cost benefit tools and Relative Income Hypothesis (RIH) in their analysis. As such, this study would test this tool and hypothesis household energy use and would come up with a conclusion that may be useful for policy making.

1.3 Aim and Objectives

This research aim to examine the extent to which cost and benefits of household cooking fuel influence the choice of household primary cooking energy, with a view of developing a framework for the consumption of sustainable cooking energy.

1. Assess the socio-economic characteristics of household that uses different cooking energy sources in Niger-Delta Region, Nigeria
2. Examine the household choice of primary and alternative cooking energy (i.e. charcoal, fuel wood, and electricity), and their characteristics.
3. Assess the cost and benefits of household's primary cooking energy.
4. Analyse the factors that influences household's choice of primary cooking energy

CHAPTER 2 LITERATURE REVIEW

2.0 Introduction

The reviews of empirical research on the many facets of family energy usage and choice, as well as any discovered gaps, are summarized in this chapter.

2.1 Definition of Energy

Energy defined according to IEA (2004), as the capacity to perform action or and create heat. Bhattacharyya (2011) is of the view that energy is expressed in form like; motive force, chemical transformation and heat which has the ability to be harnessed from different sources found in various states. As such, energy means any substance which has the ability to make any system function properly.

2.2 The Concept of Energy Demand

Energy demand, according to Bhattacharyya (2011), is any form of energy used to meet domestic energy requirements. Such consumption may take the shape of heating, cooling, and cooking. Anytime energy is used as a fuel, there is a need for energy consumption. According to Ozcan et al., household energy demand is divided into direct and indirect types (2013). On the one hand, direct home energy demand is concerned with the energy used for lighting, heating and cooling, transportation, and other household appliances. On the other hand, the term "indirect energy consumption" includes the use of energy for goods production and transportation.

2.2 Theoretical Framework of the Study

This section presents the various theories and models that serves as a framework for the study. The various theories discussed in this section includes: Theory of traditional demand, Utility random theory and relative income hypothesis. In the understanding

household's energy consumption and choice behaviour, these theories and models are key.

2.2.1 The Theory of Demand

According to Tawiah (2000), there is a relative relationship between the quantity of a good and its price. In other words, the relative quantity of a commodity that is purchased decreases as its price increases and vice versa. However, the price of one commodity affects the demand for it in terms of quantity, which depends on the relationship between the two. However, in addition to price, other non-price determinants such as consumer income, preference and taste, the availability of substitutes, and the total number of consumers also play a crucial role.

The relationship between commodity demand and affects affecting it is expressed as

$$Q_x = (P_x, Y, P_s, P_c, T, N), \dots, = f(P_x, P_s, P_c, T, N) \quad (3.1)$$

Where;

Q_x = quantity demanded

P_x = price of good X

Y = income

P_s = price of substitute

P_c = price of complement

T = preferences

N = number of consumers

Through the use of demand energy theory for household energy demand analysis, previous studies (Lee, 2013; Couture et al., 2012; Song et al., 2012) were able to identify the association amongst some factors and energy demand quantity. For instance, the following multiple linear regression model can be used to determine how certain factors, such as household size, household head, age, gender, marital status, education, and household disposable income, affect the size of household consumption:

$$Y_i = \beta_0 + \sum_{i=1}^n \beta_i X_i + u_i \quad (3.2)$$

$$i = 1, 2, \dots, n$$

Y_i = Quantity of energy consumption

X_i = Various independent variables which can be in form of continuous or dummy

β_i = Coefficients

u_i = Unobserved error term

When all other determinants (variables) are held constant, the effect that a particular variable has on demand can be observed.

2.3.2 The Random Utility Theory

The thinking of economists like Alfred Marshall and Hicks from the early 20th century is deeply ingrained in the Random Utility Theory of Consumption (Albarran, 2010). The fulfilment, pleasure, and/or values obtained from using or consuming a specific good or service are referred to as utility. According to this theory, given such budgetary restrictions, households tend to select goods that would maximize utility. Consumers are assumed to behave rationally and to have predictable, orderly predilections that are invariant and known. The following is an example of a household's typical utility function:

$$U = u(S(E, CS), X, D, G)$$

(3.3)

where:

S = the composite energy commodity

E = significant energy sources such as; kerosene, fuel-wood, electricity, LPG, diesel and petroleum

CS = capital stock energy use appliances

X = the purchased goods that directly yield satisfaction

D = demographical features of households

G = geographical features of households

This theory served as the foundation for the analysis in a number of earlier studies on household energy choice, including those by Suliman (2010), Jumbe and Angelsen (2010), Louw et al. (2008), and Wilson and Dowlatabadi (2007). Given that the purpose of the household budget is:

$$Y = P_1X_1 + P_2X_2 + \dots + P_nX_n$$

(3.4)

In which Y is the household income

$P_1, P_2, \dots, P_n$ are the various prices of the relevant commodities.

$X_1, X_2, \dots, X_n$ are the quantity of commodities to be consumed.

Although the adopted household utility function and the associated financial limitations can be stated as follows by focusing on household energy consumption and choice:

$$U = u(ES(E_1, E_2, \dots, E_n, CS), D, G)$$

(3.5)

$$\text{st. } Y \leq P_1 E_1 + P_2 E_2 + \dots + P_n E_n$$

where: U, D, CS and G are as known before.

ES= expressed composite energy consumption function

E1= energy source for option 1

E2= energy source for option 2

En= energy source for option n

So as to maximize household utility from energy consumption, Lagrangian multiplier function is adopted as follows:

$$L = U(ES, (E_1, E_2, \dots, E_n, C_s)D; G) + \lambda(Y - P_1 E_1 - P_2 E_2 - \dots - P_n E_n)$$

(3.6)

However, the Lagrangian function first order condition for utility maximization could enable the Marshallian demand function to be derived with respect to different energy sources as:

$$\frac{\partial L}{\partial E_1} = U_1 - \lambda P_1$$

(3.7)

$$\frac{\partial L}{\partial E_2} = U_2 - \lambda P_2$$

(3.8)

$$\frac{\partial L}{\partial E_3} = U_3 - \lambda P_3$$

(3.9)

As such, when there is more than two categories of fuel, multinomial logit model (MNL) can be used to analyse the household fuel choice determinant.

$$Prob(Z_{ij}) = \frac{\exp(\beta_j X_i)}{1 + \sum_{m=1}^m \exp(\beta_j X_i)} \quad (3.10)$$

Where:

$j = 1, 2, \dots, m$ i.e. the various energy source options.

X = the various independent variables

Ceteris paribus, households tend to choose from the numerous energy sources available that best maximizes their utility.

2.3.3 The Relative Income Hypothesis (RIH)

James Duesenberry created RIH in 1949 as a consumption theory. He proposed the idea that household consumption functions depend not only on income but also on the consumption habits of nearby households. Households almost always follow the consumption patterns of the community because they are constrained by the standards of the community in which they live. As a result, there is an interdependence between a household's consumption behavior and that of its immediate neighbor. Everyone tries to keep up with joneses, to quote Duesenberry (1949). This statement can be translated to mean that households incline to select an energy source that is frequently used by their close neighbors by applying it to their energy consumption behavior and choices.

2.4 Review of Empirical Studies

The review of empirical studies on the variables affecting household energy usage and choice is presented in this section. Each of the following elements is anticipated to have

an impact on how much energy households consume, either negatively or positively. Additionally, they are the elements that have a positive influence on how a household uses energy, influencing it to utilize traditional or cleaner sources depending on the circumstances. The degree and scope to which these factors really have an impact on household energy adoption and consumption often differs from region to region and from one form of energy to another. The rationalization of how several categories of factors affect household energy usage and choice is provided below.

2.4.1 Economic Factors

These parameters assess the household's economic situation and can have an impact on how much fuel is consumed by the household. These factors include household income, home ownership, the quantity of energy-consuming equipment in the home, the cost of fuel, and the cost of alternative forms of energy.

Income: The adoption of clean energy is positively correlated with income, according to studies (Danlami et al., 2016; Mensah & Adu, 2013; Ozcan et al., 2013; Couture et al., 2012). In contrast to wealthier homes, who are more likely to utilize energy from more sustainable sources, such as gas and electricity, impoverished households, particularly those in developing nations, are more likely to use firewood, plant leftovers, animal dung, and other unclean energy sources. For instance, Onoja (2012) found that household revenue has a negative impact on the utilization of firewood in Kogi state in a two stage least square analysis. On the other hand, Oyekale et al. (2012) found using a probit analysis that the consumption of firewood by households is positively correlated with household income.

In contrast, Heltberg (2003) came to the conclusion that a rise in household spending per capita motivates households to utilize more non-solid fuels. Petersen (1982) carried

out a study to look at the factors influencing variation in household energy usage. He used OLS regression. One factor that significantly improved the influence of household electricity usage was family income. Abrahamse and Steg (2009) found, using the same OLS model that overall household energy use rises as household income rises. In a similar vein, Louw et al. (2008) discovered that a rise in wealth greatly increases the amount of power used by households.

Similarly, some research, such as Pourazam and Cooray (2013), Svoboda and Br (2013), Cebula (2012), and Ziramba and Kavezeri (2012), used time series data to examine the various elasticities of household energy use. The findings were that the revenue elasticities of demand for several household energy are usually good for both short and long run periods. The use of time series data to analyze home energy behavior, on the other hand, is a macro-based study that does not mirror the disaggregated heterogeneous nature and behaviors of distinct households.

In addition, a quite number studies (Braun, 2009; Laureti & Secondi, 2012; Couture *et al.*, 2012. Furthermore, other studies (Braun, 2009; Laureti & Secondi, 2012; Couture et al., 2012; Ozcan et al., 2013; Nnaji et al., 2012; Maryam, 2011; Jeuland, et al. 2018) examined the impact of income on household energy choice using a multinomial logit model. According to Braun (2009), increasing income improves gas adoption while decreasing family consumption of solid energy. Similarly, Laureti and Secondi (2012) observed that when income levels rise, more households switch to gas and less switch to coal-wood as a source of energy. According to Couture et al. (2012), a rise in household income inhibits the use of wood and encourages households to use electricity, gas, and fuel oil as significant sources of energy. Ozcan et al. (2013)

observed that higher household income leads to increased usage of coal, natural gas, and liquid fuel at the expense of firewood.

Additionally, Nnaji et al. (2012) used a multinomial logit model to analyze the factors influencing household energy decisions in rural Enugu State. The study demonstrates that when household wealth rises, more charcoal or kerosene is used in place of firewood by households. This is consistent with Maryam's (2011) research findings and conclusions. Ordered probit models were used by Nlom and Karimove (2014) and Mensah and Adu (2013) to analyze the factors that influence household energy switching from non-cleaned to the greatest level of cleaned sources. According to the findings of both studies, household income promotes the usage of cleaner energy. Meanwhile, Link et al. (2011) discovered that higher household income increases the likelihood of households using firewood as a source of energy. Jiangchao and Kotani (2011), on the other hand, estimated five distinct Tobit models in their experiments to examine the factors of home energy use from various sources (coal, electricity, LPG, fuel wood and crop residue). According to the findings, increased per-household member revenue increases households' usage of coal, electricity, and LPG. Furthermore, Abebaw (2007) conducted a study to investigate the factors of household fuel-wood use in Jimma, Ethiopia. The consumption of fuel wood was shown to be influenced by per capita income. This is consistent with Song et al. (2012) findings. Furthermore, Lee (2013) examined how much kerosene, charcoal, and firewood families used; the findings indicated that higher per capita spending was linked to increased usage of all three energy sources.

Home Ownership: Home ownership, as one of the indications of a household's economic standing, influences their choice of energy sources. Previous research has

shown that those who own their home use cleaner energy sources (Couture et al., 2012; Zhou, K., & Yang, S. 2016). Similarly, Sardianou (2007) assessed the factors of household energy saving habits in Greece Households. According to the OLS results, home ownership is one of the variables that have a beneficial impact on households' energy conservation behavior. Meanwhile, Laureti and Secondi (2012) discovered that home ownership increased the likelihood of using gas as an energy source. Meanwhile, Pundo and Fraser (2006) discovered that households that reside in their self-owned home had higher likelihood of adopting charcoal compared to firewood.

Price of Energy: The cost of energy has a bad impact on how much energy is used. When an energy source's cost is high, consumers will often switch to another alternative fuel. This is consistent with the rule of demand and has also been proven by numerous earlier research (Frederiks, et al. 2015; Nlom & Karimove, 2014; Lee, 2013; Jingchao & Kotani, 2011; Ganchimeg & Havrland, 2011; Osiolo, 2010). For instance, Abdurrazak et al. (2012) discovered that households continuously increase their usage of biomass fuel over time due to its availability and affordability. Similar to this, it has been asserted that households turn to alternative fuel sources as the price of firewood increases (Oyekale et al., 2012). Similar to this, Dodgson et al. (2001) and Koshal et al. (1999) found that the time series analysis revealed that the different price elasticities of household energy use are negative and inelastic. Less than 1% less electricity is used for every 1% rise in price (Frederiks, etl al. 2015; Yanagisawa, 2011; Metcalf, 2008). In order to analyze household usage of kerosene, charcoal, and firewood, Lee (2013) calculated three distinct Tobit models. The price of kerosene is demonstrated to be adversely associated to the consumption of kerosene, which is one of the study's findings that is consistent with the idea. The study also discovered a negative

correlation between the consumption of firewood and the price of firewood. Additionally, a multinomial logit model was employed in certain studies (Behera, B., & Ali, A. 2016; Mensah & Adu, 2013; Couture et al., 2012; Maryam, 2011; Osiolo, 2010) to analyze how the price of energy affected household fuel switching. Mensah and Adu (2013) discovered that the cost of firewood had a favorable impact on the transition of home fuel to greener energy.

Specifically, more households switch to greener energy sources as the price of firewood rises. Similar to this, Couture et al. (2012) found that an increase in the price of wood deters people from using it as fuel in favor of non-wood sources. Similar to this, Maryam (2011) found that the cost of stove or cooker gas promotes users to use less kerosene or gas and more firewood, respectively. Contrary to the prevalent idea of demand, Osiolo (2010) came to the opposite conclusion, finding a positive correlation between LPG and electricity prices and household adoption. Conclusively, Couture et al. (2012) OLS research of firewood usage in France revealed that as firewood prices rise, consumption volume declines.

Price of Other Fuel: Additionally, the study comes to the conclusion that all other variables estimated in the model, such as the cost of alternative fuel sources, have a substantial impact on wood usage. In order to analyze household usage of kerosene, charcoal, and firewood, Lee (2013) calculated three distinct Tobit models. One finding of this study is that since kerosene and firewood are typically interchangeable, the price of kerosene is found to be positively correlated with the utilization of firewood. The study also discovers a favorable relationship between the consumption of kerosene and the price of firewood. The same study found that a continued increase in the price of firewood encourages households in both urban and rural areas to switch to nonsolid

fuels. Mensah and Adu (2013); and Schunder, T., & Bagchi-Sen, S. (2019) made a similar case, finding that the price of firewood had a favorable impact on household fuel switching to cleaner energy. That is to say, more households switch to greener energy sources as the price of firewood rises.

2.4.2 Socio-Demographic Factors of Households

The type and structure of a household's sociodemographic characteristics affect the way they switch between fuels and how much they utilize it. These variables include the household marital status, education level, age, gender, and gender distribution (the proportion of men to women in the household). The household uses less clean energy when the proportion of female to male household members rises. Previous research have established the veracity of this claim (Rosenthal, et al. 2018; Suliman, 2010; Heltberg, 2005).

Marital Status: According to Laureti and Secondi (2012), compared to a household with only one person, households with couples and children tend to consume more coal and wood and less oil and electricity. Similar to this, Nnaji et al. (2012) found that when the household head is married, households likely to consume less kerosene in comparison to firewood. On the other hand, a logit analysis by Danlami et al. (2016) discovered a favorable link between the adoption of cleaned fuels and the gender of the household head. The likelihood of adopting cleaned fuel is higher in married households than in other households.

Gender of the Household Head: Additionally, Mensah and Adu (2013) discovered that male head of household discourages other households from adopting clean energy. On the premise that the many energy options available to households are arranged in an ordered fashion, they employed an ordered probit model to examine the factors that

influence household energy switching from a non-cleaned source to the highest potential cleaned source. Similar findings were made by Suliman (2010), who discovered that having a male household head enhances the likelihood that biogas, straws, and animal dung will be used as the primary fuel source for cooking. Similar to this, a logit analysis by Danlami et al. (2016) revealed a negative correlation between a male family head and the adoption of a cleaned fuel source by the household. Conclusively, a household led by female has higher chances of accepting clean fuel by about 3% compared to the male headed households.

Age of the Household Head: The adoption of clean energy was found to be negatively correlated with the age of the household head (Ifegbesan, et. al., 2016; Nlom & Karimove, 2014; Mensah & Audu, 2013; Suliman, 2010). When the head is older, households adopt less clean energy sources. According to Nnaji et al. (2012), households with older household heads tend to utilize more charcoal than they use firewood. Eakins (2013) carried out a study to evaluate the factors influencing household energy use using OLS model. The analysis's findings showed that homes with a head who is 55 years of age or older often spend more on oil and electricity than other households. Petersen (1982) carried out a study to look at the factors influencing variation in household energy usage using the same OLS model. The age of the respondents was discovered to be one of the factors that significantly influences how much energy is used in homes. Similar to this, OLS regression by Osiolo (2010) for household fuel wood expenditure in Kenya revealed that household heads that are 40 years of age and older often burn more firewood than other household heads. OLS was also utilized by Risseuw (2012) to calculate the factors influencing household charcoal spending in Mozambique. According to the study's findings, only the respondents' age

was shown to be statistically significant, which has a detrimental effect on household charcoal spending. Suliman (2010) came to the conclusion that families' use of cleaner cooking fuels was negatively correlated with the age of the head of the family.

The adoption of renewable energy is generally less as one becomes older as the head of the family. The household head's age has a detrimental impact on the adoption of more renewable energy, according to Mensah and Adu's (2013) research. According to Nlom and Karimove's results and conclusions, family heads are less likely to switch to cleaner energy the older they are (2014). On the other hand, Ozcan et al. (2013) came to the conclusion that the age of the head of the family has a positive link with the use of natural gas and liquid fuel in place of firewood, and a negative relationship with the use of dung and plant residue as firewood, respectively.

Level of Education: The adoption of clean energy is positively correlated with the household head educational level. The higher the educational level of household, the more he understands its harmful effects of adopting unclean energy and vis versa. Previous investigations (Meng, et al. 2019; Nlom & Karimove, 2014; Eakins, 2013; Mensah & Audu, 2013; Ozcan et al., 2013; Laureti & Secondi, 2012) confirmed that this claim was accurate. According to a study by Oyekale et al. (2012) using a probit model in Oluyole local government area, Oyo state, the likelihood that a household will utilize firewood decreases with the level of education of the household head. Additionally, Nnaji et al. (2012) used a multinomial logit model to analyze the factors influencing household energy decisions in rural Enugu State. The study demonstrates that a household's adoption of more charcoal at the expense of firewood consumption is influenced by the household head's educational level. Similar to this, Maryam (2011) uses a multinomial logit model to examine the variables impacting families' energy

choices in Nigeria's Gombe state. The study claimed that the use of kerosene instead of firewood is related to the education level of the housewife and the higher education level of the household head.

Additionally, Eakins (2013) carried out a study to evaluate the factors that influence Irish home energy usage. The predicted household expenditures from six distinct OLS models came from a variety of sources. The analysis's findings showed that a higher level of education causes a reduction in the amount of coal and turf that households use for energy. According to Lee (2013), household electricity use is negatively impacted by educational attainment, and the likelihood that households will switch from kerosene to electricity increases with household head education. Additionally, the three separate Tobit models used to analyze household use of kerosene, charcoal, and firewood reveal a correlation between education level and increased use of all three energy sources. Osiolo (2010) estimated the factors influencing household wood fuel expenditure in Kenya using OLS regression. According to the survey, households with a head with only a primary education typically use more firewood than other households. According to Pundo and Fraser (2006), households are more likely to use charcoal as an energy source than firewood when both the husband and wife have higher educational levels. Meanwhile, Heltberg (2003) discovered that households use more non-solid fuels when their education level is higher. In Jimma town, Ethiopia, Abebaw (2007) did a study to look at the factors that influence the use of home fuel wood. According to the study, the household head's education degree has a direct negative impact on how much fuel wood is consumed. Furthermore, Heltberg (2005) discovered that households in both urban and rural settings are more likely to accept LPG alone than wood and LPG when the head of the family is more educated. Additionally, Mekonnen and Kohlin (2008) in

agreement with Heltberg (2005) came to the conclusion that the level of education of the household head encourages households to embrace non-solid fuels and discourages them from using a combination of solid and non-solid fuels. Similarly, a multinomial logit study by Braun (2009) revealed a correlation between higher household head education and increased use of gas and decreased adoption of solid fuel and electricity. A study on the variables influencing households' decisions on their primary cooking fuel in Sudan was done by Suliman (2010). This study found that households using cleaner energy are encouraged by education levels at both the primary and secondary levels (LPG, biogas, kerosene and charcoal). Similar to Braun (2009), Laureti and Secondi (2012) came to the conclusion that households with a head who completed a degree adopt more electricity and less LPG or coal-wood when compared to households where the head only completed a diploma. Based primarily on the presumption that the various energy options available to households are arranged in an ordered manner, Mensah and Adu (2013) and Nlom and Karimove (2014) examined the factors that influence household energy switching from uncleaned to the highest possible cleansed source using ordered probit models. Both studies demonstrate that when the head of the household has greater education, the household switches to cleaner energy.

2.4.4 Exogenous (Supply) Factor

The exogenous factor are the significant group of factors that affects fuel selection. Although it is outside of the purview of households, this factor significantly affects the fuel choice made by households. For instance, the availability of a specific energy source can influence how much energy is consumed at home.

Availability of Energy Source (Supply): Energy sources that are accessible, affordable, and close by are frequently chosen by households for their consumption

needs. According to empirical research, Mensah and Adu (2013) discovered a favorable correlation between home energy use and the availability of the relevant energy. Access to firewood reduces the likelihood of switching to the use of cleaner energy while a consistent supply of LPG improves that likelihood. Heltberg (2005) made the case that households' usage of traditional biomass as their primary fuel source declines when they gain access to affordable electricity for this reason. In a similar line, Abdurrazak et al. (2012) discovered that families continuously increase their consumption of biomass fuel over time due to its accessibility and affordability. Onoja (2012) used the two-stage least square method to analyze the variables affecting the demand for fuel and wood in the Nigerian state of Kogi. The results showed that when the supply of firewood is far from the homes, the amount of firewood consumed by the families tends to go down. Similar to this, Link et al. (2011) examination of a logit model showed that families are more likely to use firewood as a source of energy when it is readily available and nearby than they would be otherwise. Additionally, Heltberg (2003) discovered that homes with electricity typically use more non-solid fuel than households without power. Furthermore, a probit study by Osiolo (2010) revealed that the lack of substitutes for wood fuel in rural areas led to a favorable influence on the distance to wood fuel sources.

2.5 Literature review

There exist several household energy use and consumption empirical studies, which has conducted in both developed and developing countries across the globe. As such, there has been some identified gaps and limitations. For example, some studies on household energy consumption (e.g. Austin, 2011; Wang et. al., 2011; Svoboda and Br, 2013; Pourazarm and Cooray, 2013; Inglesi-lotz and Blignaut, 2011; Reiss and White, 2014;

Ziramba and Kavezeri, 2012; Njenga et al. 2019) ignored other factors, such as the usage of wood and other fuels, such as kerosene and LPG, as sources of household energy consumption, in opposition to concentrating exclusively on household electricity energy consumption. In addition, some studies such like Jumbe and Angelsen, 2010; Naibbi and Healey, 2013; Onoja and Emodi, 2011, only focuses on fuel wood analysis as a source of energy for households while also neglecting other energy sources such as kerosene, electricity and gas.

Additionally, other studies like that of Michael (2001) and Gallini et. al. (2001) only focused their analysis on household consumption using LPG, while neglecting other energy sources like electricity, kerosene and wood. Relatively, Braun (2009), Laureti and Secondi (2012), and Hanemann et. al. (2013) mainly concentrated their research on space heating, which is only one aspect of energy use in homes. This indicates that the majority of earlier research on home energy use, in both developed and developing nations, has tended to be narrowly focused, addressing certain facets and dimensions of household energy demand while ignoring others, as previously mentioned. Furthermore, there are some discrepancies that exist in the findings and conclusions of previous studies on household fuel use. For instance, research by Oyekale et al. (2012), Lee (2013), Nlom and Karimove (2014), among others, established a correlation between household income and firewood use. On the other hand, certain investigations, like those by Mekonon and Kohlin (2008), Onoja (2012), and Song et al. (2012), discovered that this association was unfavorable. However, studies by Couture et al. (2011) and Jingchao and Kotani (2011) found no connection between household firewood use and income. This means that generalizing the findings from a certain region might be incorrect because of uniqueness in socio-economic, cultural, and

environmental variables. As a result, researching household energy in a new area adds nothing new to the body of knowledge. Additionally, studies by Nnaji et al. (2012), Onoja (2012), Ganchimeg and Havrland (2011), as well as others, discovered a favorable correlation between the household head's age, educational level, household size, and housing size. However, research by Song et al. (2012), Jumbe and Angelsen (2010), and Heltberg (2005) revealed that these associations were inherently harmful. Furthermore, quite a number of previous studies not consider the cost benefit analysis of household energy, specifically cooking energy. Because in most developing countries household tend to make use of energy based on cost, household income, availability and general preference (Ogwumike et al., 2014).

According to the Relative Income Hypothesis (RIH), a well-established economic theory of consumption, the consumption of a household is most influenced by that of its immediate neighbor. According to RIH, a household's spending decisions also take into account the relative consumption patterns of its neighbors. That is, households typically have higher criteria for communal consumption, and as a result, the majority of their consumption habits are influenced by this behavior. As a result, for consumption behavior, there is an interdependency between households and the close neighbor. However, inspite of the usefulness of this conclusion to policy makers; previous studies on household energy use as not yet in-cooperated such hypothesis (i.e. as it connects to household energy utilization) in their analysis.

Even yet, a number of research, particularly those conducted outside of Nigeria (Jeuland, et al., 2015; Eakins, 2013; Lee, 2013; Couture et al., 2012; Osiolo, 2010; Mekonnen & Kohlin, 2009), have utilized a broader component of econometrics to household energy choice analysis. On the other hand, none of these studies have been

carried out in Nigeria. the majority of studies in Nigeria The studies by Abdulrazak et al. (2012), Onoja (2012), Nnaji et al. (2012), Oyekale et al. (2012), and Maryam (2011) are purely descriptive in character or estimations of household cooking preferences based on a particular area.

As such, household energy demand study that makes use of various and different econometric models would make a major contribution to existing literature. Conclusively, this study would contribute to existing body of literature in the following ways: Firstly, this is the first study that would make use of micro data in Niger-Delta, Nigeria. Has it would not only analyze family's energy choice and demand, but with use of wider aspect of econometric models, the study comes with a unique pattern that is different existing relevant studies in the Country (Nigeria).

Second, using Niger-Delta Nigeria as a case study, the study would broaden the scope of earlier investigations that have looked at a variety of aspects of household energy consumption, including the cost-benefit analysis of cooking fuel and the consumption of LPG, kerosene, firewood, and electricity. Thirdly, by estimating the comprehensive variables that have not previously been studied collectively, this study will fill in the gaps. In this, the income hypothesis in relation to household energy use would be tested. Finally, an interactive variable would be developed to ascertain how neighborhood energy choices affected the environment in homes.

2.6 Summary of Literature review

Although there are several empirical research on home energy use and consumption carried out in various regions in both developed and developing countries, there are significant gaps and limitations that have been noted. For example, some studies on household energy use (e.g., Meng, et al. 2019; Austin, 2011; Wang et al., 2011;

Svoboda & Br, 2013; Pourazarm & Cooray, 2013; Inglesi-lotz & Blignaut, 2011; Reiss & White, 2014; Ziramba & Kavezeri, 2012) ignored other factors such burning wood and other fuel usage in favor of concentrating solely on the electrical component of residential energy use. Likewise, other studies, like those by Michael, Gallini et al. (2001), Verhallen and Raaij (1981), and Schmalensee and Stoker (1999), limited their analysis to household LPG use and consumption while ignoring the use of alternative energy sources, such as electricity, fuel wood, and kerosene. The sole aspect of household energy usage that Laureti and Secondi (2012), Braun (2009), and Hanemann et al. (2013) focused on in their studies was space heating. These studies demonstrated that the majority of earlier research on household energy usage, both in developed and developing nations, had a narrow scope, covering only some of the characteristics and dimensions of household energy demand while ignoring others, as was mentioned above. Additionally, there are discrepancies between the findings and recommendations of earlier studies on household energy use. For instance, certain studies (Oyekale et al., 2012; Lee, 2013; Nlom & Karimove, 2014 Troncoso, K., & da Silva, A. S. 2017) discovered that household use of firewood and income have a substantial positive association. However, several investigations, including those by Mekonon and Kohlin (2008), Onoja (2012), and Song et al. (2012), discovered a negative association. While it was found by Couture et al. (2011) and Jingchao and Kotani (2011) that there is no connection between household firewood usage and income. This implies that due to socioeconomic, cultural, and environmental differences, the conclusions and findings from one study from a certain place cannot be generalized to another area. Therefore, researching home energy use in a different region adds to the body of knowledge already available. Meanwhile, studies by Nnaji

et al. (2012), Ganchimeg and Havrland (2011), and Onoja (2012) found that factors including household size, age of the household head, level of education of the household head, and others were positively correlated with household fire wood use (2012). Heltberg (2005), Jingchao and Kotani (2011), Song et al. (2012), and others found these connections to be unfavorable. Furthermore, some investigations, such those by Jumbe and Angelsen (2010) and Laureti and Secondi (2012), came to the conclusion that there is no correlation between these factors and household fuel-wood usage. The same was true for other household energy sources, such as kerosene, electricity, and LPG, where some studies (Ding, et al. 2017; Cecelski, et al. 2015; Fan & Hyndman, 2010; Souza et al., 2009) came to the conclusion that there was a positive relationship, while others (Mehetre, et al. 2017; Singh, et al. 2017; Petersen, 2002; Westly, 1989; Helden et al., 2001) discovered a negative relationship, and still others (Puzzolo, et al. 2019; Hu, et al. 2017; Ward, 2001; Terza, 2001) discovered there was no relationship. This warns that because home energy consumption patterns and styles vary from one location to another, the conclusions and findings of studies on household energy use conducted in one area cannot be drawn from and/or generalized to other dissimilar areas. As a result, a study on home energy use that takes a new area into account adds to the body of current literature.

Furthermore, none of the studies carried out in the Nigerian context have wider econometric application, despite the fact that some earlier studies (Eakins, 2013; Lee, 2013; Couture et al., 2012; Osiolo, 2010; Mekonnen & Kohlin, 2009) did use these techniques to analyze household energy choice outside the context of Nigeria. The majority of studies conducted in the Nigerian setting, including those by Abdurrazak et al. (2012), Desalu et al. (2012), Nnaji et al. (2012), Onoja (2012), Oyekale et al. (2012),

and Maryam (2011), only estimated one model to analyze household cooking fuel choice for some specific localities. As a result, a study on household energy demand that uses a variety of econometric models adds to the body of knowledge already available in the field.

In a summary, this study made the following contributions to the literature: firstly, it is the first study to use household micro-data in the Niger Delta Region of Nigeria in order to analyze households' energy demand and choice as well as to apply econometric models of cost-benefit in a wider range of contexts. This gave the study a distinctive pattern compared to the few other relevant studies that have been conducted in the entire nation (Nigeria). Second, the study covered numerous aspects of household energy consumption (such as the aspects of cooking fuel, the consumption of firewood, kerosene, and electricity), using the Niger-Delta region, which is a region of the country that produces crude oil, as the area of the study. This expanded the study's scope beyond that of the majority of earlier studies.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Research Design

Research design is a framework that shows how the objective of a study, its philosophy, its methods, its analytical techniques, and its strategies of inquiry connect. (Creswell 2009). Based on application, two broad types of research exist (pure and applied research); this study is applied research. In applied research, the primary aim of the study is not to introduce new science principles or theories; rather existing knowledge and theories are used to develop new complex. This study is an attempt to use the existing theories and principles to develop new tool for the assessment of cost and benefits of household cooking energy in the Niger-Delta region of Nigeria. According to expectations, the research will produce findings that can be promptly implemented. In order to build a strategy framework for household cooking energy usage, the goal is to come up with recommendations for best practices.

In respect to the objectives a study, four basic types of research approach exist: exploratory, descriptive, explanatory, and correlational. The exploratory research approach is used to investigate a problem which is not clearly defined. Additionally, exploratory research aims to elucidate how and why two components of a situation or phenomena are related, associated, or interdependent. (Department of city and Regional Planning; 2018). One of the primary objectives of this studies is to be able to estimate the relationship between the cost (direct and indirect) and benefit (user, fuel, and cooking system) of household cooking energy; hence, the exploratory research design is adopted for the study. It is conducted to have a better understanding of the existing problem.

Furthermore, the research design approach of a study can also be viewed from the dimension of data required for the study. Three basic research design approach exist depending on the types of data required for the study: quantitative, qualitative, and mixed method. This study is predicated on quantitative research design approach. Quantitative research is all about quantifying relationships between variables using descriptive or an experimental study. A quantitative approach is one in which the researcher uses postpositive claims to develop knowledge (cause and effect thinking, reduction to specific variables and hypotheses and questions, usage of measurement and observation, and the test of theories), uses descriptive inquiry strategies like surveys or experiments, and gathers data on predetermined instruments that produce statistical data.

This study adopts the descriptive study approach for data gathering. Descriptive studies are sometimes known as observational studies since you watch the subjects without doing anything else with them. (Creswell, 2018). Although different types of descriptive research approach exist (case series, cross-sectional, prospective or cohort (longitudinal), and case control (Hopkins, 2000); the descriptive approach for the study is the cross-sectional. Cross-sectional studies investigate the associations between variables of interest in a sample of subjects by conducting a single test. The quality of evidence supporting a cause-and-effect link between variables varies between the different designs. The weakest are cases and case series. A carefully planned case-control or cross-sectional study can offer solid proof that there is no association. However, if a relationship is found in such a study, it usually just provides suggestive evidence of a causal association. Therefore, a cross-sectional or case-control study is an excellent place to start when determining if it is worthwhile to move on with better

designs. Hence, the cross-sectional descriptive study approach was employed for data gathering in this study.

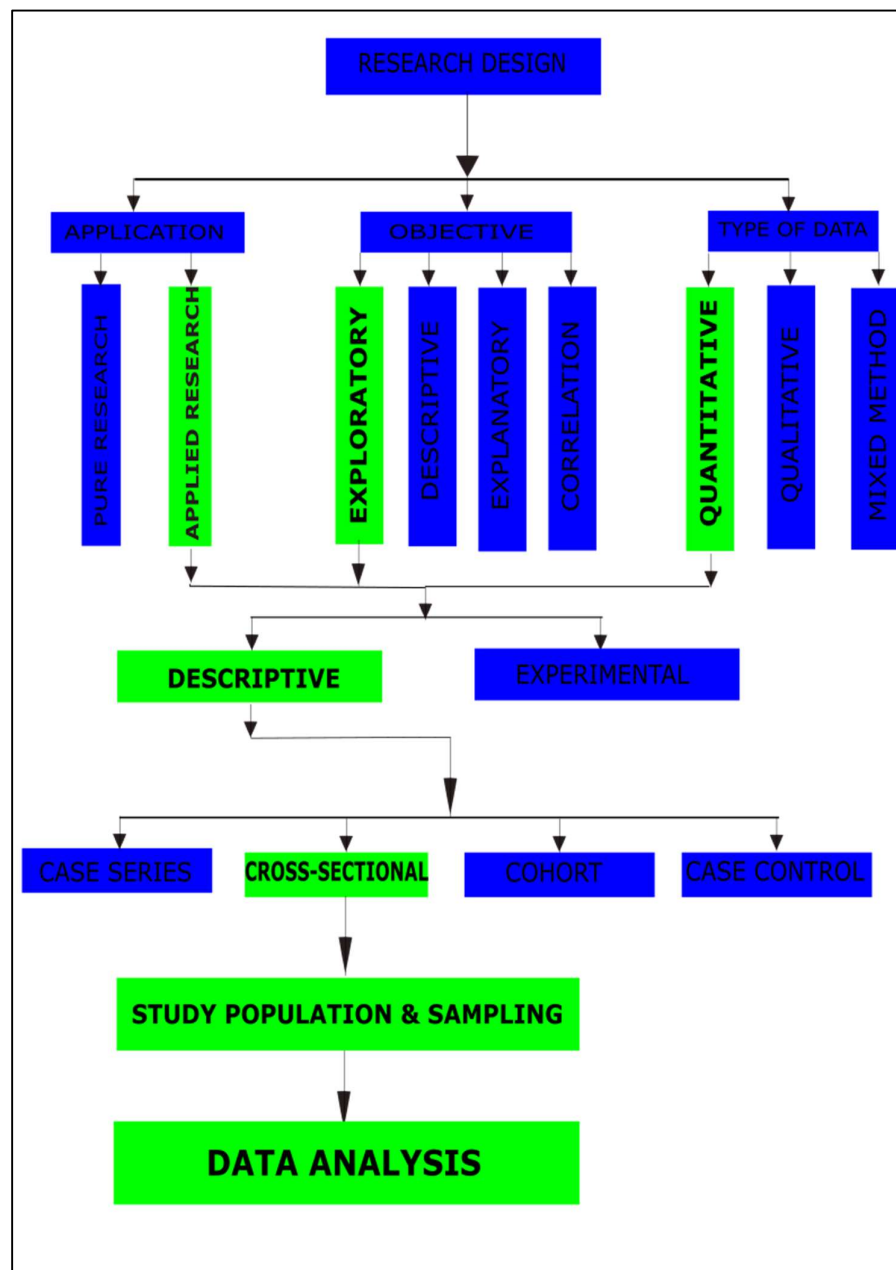


Figure 1 Research design of the study

3.2 Types of Data Required

This section deals with the different types of information in the form of data that were needed for the study to be carried out. The data gathered for this study were harvested from both the primary and secondary data source. For example, primary data were collected directly at the level of the household on types of energy used for cooking. On the contrary, census data and other literature were gathered from secondary data used for this study.

3.2.1 Sources of Data

Based on the research design, primary quantitative data were gathered directly households in the Niger Delta region. The primary data collected were categorized under five thematic areas.

The summary of primary data collected for this study is highlighted below:

- i. Socioeconomic Characteristics: This includes gender, literacy level, marital status, household size, occupation and age of respondents,
- ii. Primary and alternative cooking energy type (e.g. electricity, charcoal, LPG, Fuelwood, and Kerosene) among others.
- iii. Cost of Household Cooking energy: Direct cost (capital, operation, maintenance), and indirect cost (pollution and waste)
- iv. Benefits of Household Cooking energy: This include users benefits, fuel benefits, and benefits of the cooking system
- v. Determinants of household cooking energy option: This include .

Secondary sources of data that were explored to provide documented and statistical data on demographic data, documented literature, administrative maps of the state, and neighbourhood boundary.

3.3 Sample Frame

3.3.1 Sample frame

According to Cresswell (2003), A sample frame is a collection of people or organizations that have certain features that allow the researcher to identify and examine them. Selecting the appropriate group to analyze as a target population is crucial in social research. This study investigates the cost and benefit of household cooking energy, in the Niger-Delta Region. Therefore, the unit of measurement for the study is the household. Therefore, the sample frame for the study is total population of household within the state capitals of all the ten States in the Niger Delta Region of Nigeria. The Niger Delta States in Nigeria are: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers State. To estimate the household population in the State capitals, the study relied on the 2006 National Population Census data of ten to estimate the projected population of the States Capital. The 2006 population census figures for the states were projected at 2.31% growth (NPC, 2019) to arrive at an estimated population of people in the respective states of the Niger Delta region. The projected population was further divided by the national average household size of six reported in the National Population Commission report of 2019.

$$P_n = P_o (1 + r)^n$$

(1)

Where: P_b = Population sought; P_o = Population base year; r = Annual growth rate; n = No of year to project

Therefore, with a base population of 31,224,587, the study arrived at an estimated population of 41,972,607 at a growth rate of 2.3% and an estimated household population of 6,995,434 at an average household size of six.

Table 1 Sample Frame

States	2006 Population (X0)	Projected 2022 Population (Xt)	Household size(i.e. Xt/6)
Abia	2,833,99	4,148,36	69,139.3
Akwa Ibom	3,920,208	5,738,349	956,391.5
Bayelsa	1,703,358	2,493,353	415,558.8
Cross River	2,888,966	4,228,831	704,805.2
Delta	4,098,391	5,999,171	999,861.8
Edo	3,218,332	4,710,952	785,158.7
Imo	3,934,899	5,759,854	959,975.6
Ondo	3,441,014	5,036,911	839,485.2
Rivers	5,185,420	7,590,350	1,265,058.3
Total	31,224,587	41,972,607	6,995,434.40

Source: National Population Commission, 2022

3.3.2 Sample Size

In order to determine a sample size that will serve as a good representative for the sample frame for the study, the Taro –Yamane sample size formula was adopted. The mathematical expression of the formula is expressed in equation 2. The sample size was determined by using the estimated number of households in the study area and a margin error of 3% and confidence level of 97%.

$$n = \frac{N}{1 + N(e)^2} \quad \text{eq}$$

2.

where n= sample size; N = finite population; e = level of precision (0.10%)

The applying the equation, the study arrived at an estimated sample size of 1111 households. The representative sample size for each state was also determined from the ratio of each state capitals population to the total population of all the Niger Delta States. The sample size ranges from a minimum of 11 in Abia State to a maximum of 201 in Rivers State.

Table 2 Sample Size of the Study

States	2006 Population (X0)	Projected 2022 Population (Xt)	Household size(i.e. Xt/6)	% pop	No of questionnaire
Abia	2,833,99	4,148,36	69,139.30	1.00	11
Akwa Ibom	3,920,208	5,738,349	956,391.50	13.7	152
Bayelsa	1,703,358	2,493,353	415,558.80	5.9	66
Cross River	2,888,966	4,228,831	704,805.20	10.1	112
Delta	4,098,391	5,999,171	999,861.80	14.3	159
Edo	3,218,332	4,710,952	785,158.70	11.2	125
Imo	3,934,899	5,759,854	959,975.60	13.7	152
Ondo	3,441,014	5,036,911	839,485.20	12	133
Rivers	5,185,420	7,590,350	1,265,058.30	18.1	201
Total	31,224,587	41,972,607	6,995,434.40	100.00	1,111

Source: Researcher's Lab work, 2022

3.4 Sampling Technique

There are two basic types of sampling: probability sampling and the non-probability sampling (Elfil and Negida, 2017). Probability sampling is a sampling technique where a researcher chooses samples from a larger or homogeneous population using a method based on probability theory. A participant must be selected at random in order for them to be considered a probability sample (Bhardwaj, 2019). Hence, since the population of the study is homogeneous, the probability sampling technique was adopted. According to Bhardwaj (2019), five types of probability random sampling technique exist (simple, stratified, cluster, systematic, and multistage). However, three sampling technique was

adopted in the course of this study. The Cluster, Stratified, and random sampling technique was adopted in this study, and hence the multi-stage sampling technique. The Niger Delta region was divided into ten clusters, using the ten State capitals. Therefore, each of the state capital were identified as individual clusters for this study. Secondly, in each of the State capitals, the state capital was divided into strata based on density, and hence the stratified sampling technique. Therefore, the capitals were divided into low, medium, and high density to ensure that every strata of the capital is adequately accounted for, since neighbourhood density has a correlation with fuel type consumed due to economic differentials. Lastly, the households were randomly selected for sampling within each of the stratas of the state capital.

3.5 Instruments for Data Collection

Data for any research are collected following a well-structured procedure that will ensure the right data is collected at the right time and for the right purpose using the appropriate instrument. Therefore, the instrument used for data collection for this study is the questionnaire, digital camera and direct observation.

3.5.1 Questionnaire

Quantitative data were collected through the use of a well-structured questionnaire. The main objective of the questionnaire was to obtain a quantitative insight into the cooking energy choice, pattern, cost and benefit, in the Niger Delta region. The questionnaire was developed into four (4) sections. The first section had questions on demographic and socio-economic characteristics of households; the second section covers aspect on the primary and alternative energy choice, while the third section covers aspect on the cost and benefits of the preferred household cooking energy choice. The last section addresses issues of factors that influence household primary cooking energy choice.

Some of the questions were closed ended or open ended, while other item was developed in likert scale format.

3.5.2 Piloting of questionnaires

Before distributing the questionnaire, a pilot study was thought to be appropriate in order to critically evaluate the tool and make sure it was working properly.

Therefore, the initial questionnaire was pilot tested with 50 households; that is five in each of the ten states capitals. This was done in order to review the questionnaire, find any issues that might occur with the respondents' comprehension or interpretation of the questions, and determine the causes of any confusion. This made it easier to evaluate the questionnaire's length, convenience of use, and clarity and gave the chance to make any necessary changes that would have impacted the instrument's quality. The 50 questionnaires were subjected to a reliability test using Cronbach Alpha to determine the internal consistency of the instrument before final production of large numbers and survey.

3.6 Data Analysis

This section would be discussed based on the objectives of the research

3.6.1 Assess the socio-economic characteristics of household that uses different cooking energy sources in Niger-Delta Region, Nigeria

The data on the socio-economic attributes of respondents in this study was analyzed using simple descriptive statistics. The descriptive statistics helps to describe, summarize and organize the data into potable form for easy comprehension. The descriptive statistics employed include simple frequencies and percentage.

3.6.2 Examine the household choice of primary and alternative cooking energy, and their characteristics

The data on the primary and alternative household cooking energy in this study was analyzed using simple descriptive statistics. The descriptive statistics helps to describe, summarize and organize the data into potable form for easy comprehension. The descriptive statistics employed include simple frequencies and percentage. The inferential statistics (t-test) was also employed to describe the variation in pattern of household energy use and consumption

3.6.3 Examine cost and benefits of household cooking energy and their characteristics.

In this study, the decision on household cooking energy based on the cost and benefits of the different household cooking energy available to the people is imperative. Therefore, using a sound logical process is essential while making decisions. Analytical Hierarchy Process (AHP) is one of the most significant of the numerous related approaches suggested by scholars and/or practitioners. The AHP is a Multi-Criteria Decision Approach (MCDA) initially developed by Saaty (1977). It combines biophysical, social, and economic goals to provide broader management decision-making criteria. Decision-makers can also come up with alternate options and evaluate the relative importance of various factors thanks to it. Utilizing it when making decisions involves four main processes. First, a hierarchical model of the decision problem is created, consisting of Goals, Objectives, and Alternatives. Because it places more emphasis on the decision makers' preference structures and can logically handle challenging decisions between complex and confusing alternatives, the AHP method has drawn a lot of attention (Clayton and Wright (1993), Saaty and Cho (2001).

According to Blair et al. (2002), Bennett and Saaty (1993), and Azis (1990), there have been numerous successful applications in a wide range of fields, including resource allocation, financial management, enterprise outsourcing selection, vulnerability studies, etc.

The cost-benefit analysis of household cooking energy will be conducted in this study using the AHP. As a result, two distinct hierarchies one for cost and one for benefit were be created. The expected benefits decision make up the criteria for the benefits hierarchy. As a result, a pairwise comparison was used to weight the criteria. Similar to this, the expected cost of household cooking energy was used to develop the cost hierarchy. The alternatives were evaluated in relation to how expensive or advantageous they are (higher priority reflects higher cost and vice versa). The 9-point continuous Saaty scale (Table 3) were used to determine the appropriate weights for each attribute and factor, and the weights were then normalized using the AHP.

Table 3 Scale of Relative Importance

Relative Importance	Definition Description	Description
1	Equal importance	The objective is influenced equally by factors of cost and benefit.
3	Moderate importance	One factor may slightly favor another
5	Strong importance	One factor is strongly favored over another by experience and judgment.
7	Very strong importance	One factor in decision-making is given strong preference over another, and its dominance is demonstrated in practice.
9	Extreme importance	The strongest possible orders of validity support one decision factor over another.
2, 4, 6 and 8	Intermediate values between adjacent judgment	when giving in is necessary

Saaty (2008)

3.6.4 Factors that influences household's choice of primary cooking energy

Finding the underlying factors (subsets of variables) from which the observed variables were generated is the goal of the exploratory technique known as factor analysis (FA), which is used on a set of observed variables (Figure 2). For instance, factors like household size, accessibility, energy cost, level of literacy, and others can affect how much energy a household uses to cook. The variables that have been observed are the questions' responses. The factors are the underlying, driving factors. The correlation matrix of the variables that were observed is subjected to factor analysis. The weighted average of the initial variables is a factor. The main objectives of factor analysis are to identify each factor as representing a particular theoretical factor and to facilitate the interpretation of the data. As a result, a lot of factor analysis reports are made to help with factor interpretation. Therefore, factor analysis will be used in this study to pinpoint and compile the main variables affecting household cooking energy.

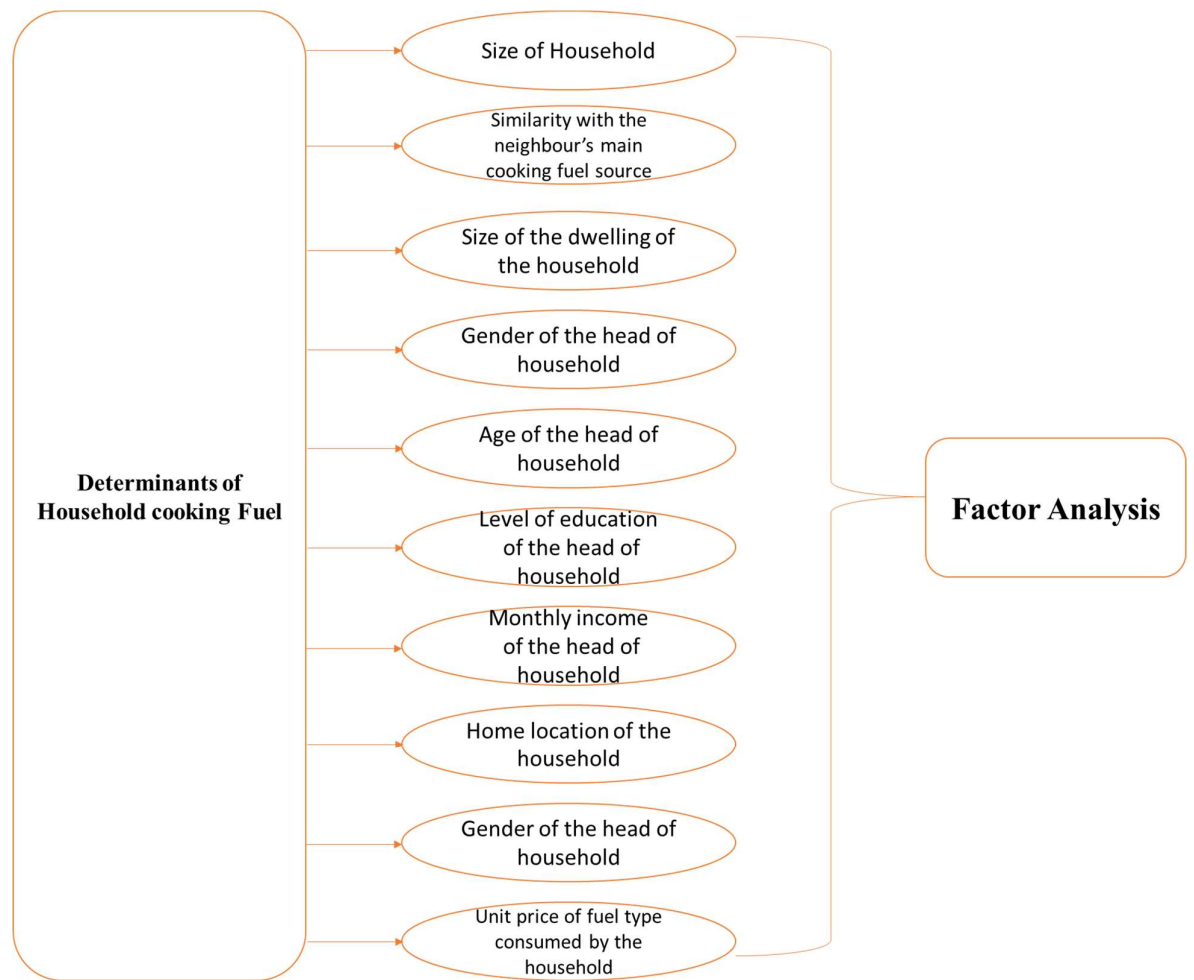


Figure 2 Analysis of determinants of households' Cooking Fuel Choice

Source: Modified from Danlami et al. (2019)

CHAPTER 4 RESULTS

4.1 Socioeconomic Attributes of Respondents

4.1.1 Age of Household Head

The age distribution of household heads for the study ranges from 25 years to above 65 years old. The study shows that household heads within the age bracket of 36-45 years old accounted for 22%, while those within the age bracket of 25-35 years and 46-55 years accounted for 20% respectively (Table 4). Older household heads within the age bracket of 56-65 years and above 65 years accounted for 19% respectively. The age of respondents play significant role in the choice of household cooking energy. Older generations often tend to adhere to traditional cooking methods they are familiar with, which may involve the use of biomass fuels such as firewood, charcoal, or animal dung. This preference is influenced by the cultural significance attached to specific cooking methods and fuels. Younger generations, however, may be more open to adopting alternative cooking technologies and fuels due to exposure to modern practices and environmental concerns.

Table 4 Age of Household Head

Age of HH	Frequency	Percent
25-35	219	20
36-45	245	22
46-55	224	20
56-65	214	19
Above 65	209	19
Total	1111	100

Table 5 shows the variation in age distribution of household heads. The result recorded a t-value of 68.708; df (1110), and a p-value (<.001). This shows that there is significant

variation in the age distribution of household heads in the study area. Hence, it is expected that there may be significant variation in the choice of household cooking energy within the study area since different age groups are likely to adopt different energy types keeping all other variables constant.

Table 5 Variation in Age of Household Heads

	t	df	p	Mean Difference
Age of HH	68.708	1110	< .001	2.931

Note. For the Student t-test, the alternative hypothesis specifies that the mean is different from 0.

4.1.2 Gender Distribution of Respondents

The gender distribution of household heads in the study area is depicted in Figure 3. Male household heads accounted for 64%, while female household head accounted for 36%. This is in line with the culture and tradition of the people and Africans in particular. Although natural order in this area recognizes the male as the household head, however, there are instances where the women become household head either as a result of death of the husband (male) or as a result of divorce or separation. In many societies, women have historically been responsible for cooking and household chores. As a result, their preferences and choices regarding cooking energy are often influential. Traditional biomass fuels like firewood, crop residues, or animal dung are commonly associated with women's responsibilities for gathering fuel and cooking. Therefore, women may have a stronger influence on the choice of cooking energy within the household.

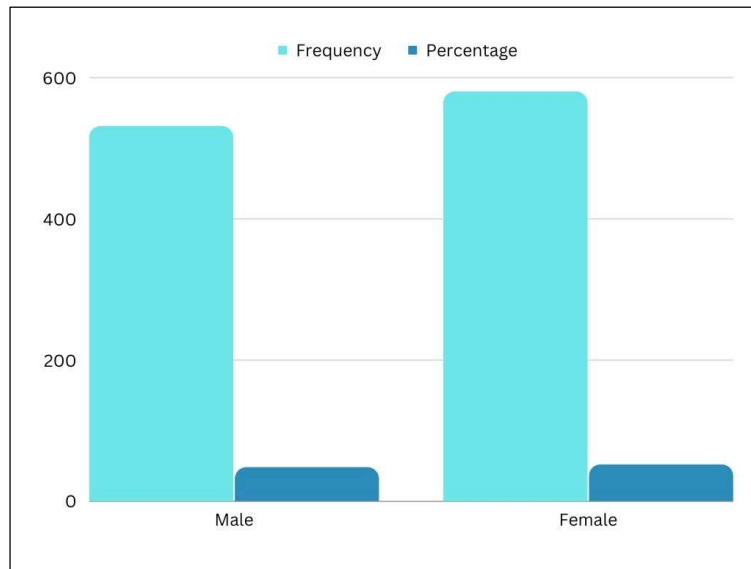


Figure 3 Gender of Household Head

4.1.3 Marital Status of Respondents

There are 111 respondents in the sample who are widow(er), accounting for 10% of the total. This indicates that a portion of the population has lost their spouse and is now single due to the death of their partner (Table 6). The majority of the respondents, 589 individuals or 53%, fall under the "Married" category. This indicates that more than half of the respondents are currently in a marital relationship. Singles accounted for 24% involving 267 respondents, this group of respondents have never been married or are not currently married. They may be in relationships or living independently.

Table 6 Marital Status of Respondents

Marital Status	Frequency	Percent
Widow(er)	111	10
Divorced	144	13
Single	267	24
Married	589	53
Total	1111	100

4.1.4 Occupational Distribution of Respondents

The largest category in Table 7 is "Trader/Business," with 292 individuals, making up 26% of the sample. This category includes individuals engaged in trading activities or running their own businesses. They include persons involved in various sectors such as retail, wholesale, or small-scale entrepreneurship. The category of "Artisan/Service Provider" consists of 288 individuals, representing 26% of the sample. This group comprises individuals involved in skilled trades, manual labor, or service-oriented professions. Examples include carpenters, plumbers, electricians, hairstylists, and other similar occupations.

The data shows that 251 individuals, accounting for 23% of the sample, are categorized as "Civil servants." This group includes individuals employed by the government or public sector organizations. Civil servants work in various fields such as administration, education, healthcare, law enforcement, and other government-related roles. The category of "Private Employee" includes 280 individuals, making up 25% of the sample. This group consists of individuals who work in the private sector, typically for companies or organizations. Private employees can be found in diverse industries such as finance, technology, manufacturing, services, and more.

Table 7 Occupational Distribution of Respondents

Occupation	Frequency	Percent
Trader/Business	292	26
Artisan/Service Provider	288	26
Civil servant	251	23
Private Employee	280	25
Total	1111	100

Table 7 provides an overview of the occupational distribution within the given sample. Occupation can influence income levels, which, in turn, may impact the choice of cooking energy. Individuals in higher-paying occupations, such as traders/business owners and private employees, may have more financial resources to invest in cleaner and more efficient cooking technologies. On the other hand, individuals in lower-paying occupations, such as artisans/service providers and civil servants, may have more limited financial means and may rely on traditional biomass fuels due to affordability. Individuals in different occupations may have varying levels of awareness and access to alternative cooking energy sources. Those in more urban or developed areas, such as private employees and civil servants, may have greater exposure to modern cooking technologies and fuels. They may also have better access to infrastructure and services, making it easier to adopt cleaner cooking options. Conversely, individuals in rural or less developed areas, such as artisans/service providers and traders/business owners, may have limited awareness or availability of alternative cooking energy sources.

4.1.5 Literacy Level of Respondents

Table 8 provides information on the literacy level distribution among a sample of 1,111 households. The data shows that 215 individuals, accounting for 19% of the sample, have attained primary education. This category typically indicates completion of primary education, which provides basic reading, writing, and numeracy skills. Respondents who had attained "Secondary education" consists of 237 individuals, representing 21% of the sample. This group includes individuals who have completed secondary education, which generally covers a wider range of subjects and provides a higher level of literacy and numeracy skills.

NCE/OND: The data shows that 217 individuals, making up 20% of the sample, have an educational qualification of NCE (National Certificate in Education) or OND (Ordinary National Diploma). These qualifications typically represent completion of specialized vocational or technical programs beyond secondary education.

Furthermore, 216 individuals, accounting for 19% of the sample had attained HND/B.Sc. This group comprises individuals who hold higher education degrees such as a Higher National Diploma (HND) or Bachelor of Science (B.Sc). These qualifications indicate completion of undergraduate programs in various fields of study. The data shows that 226 individuals, representing 20% of the sample, have pursued post-graduate studies beyond their undergraduate degrees. This category includes individuals who have obtained Master's degrees, Doctorates, or other advanced qualifications. Higher levels of literacy are often associated with better access to information, which can lead to increased awareness of modern cooking technologies and fuels. Individuals with higher literacy levels, such as those with HND/B.Sc or post-graduate studies, may be more informed about the benefits of cleaner and more efficient cooking energy options. They may be more likely to adopt such technologies in their households.

Table 8 Literacy Level of Respondents

Literacy level	Frequency	Percent
Primary	215	19
Secondary	237	21
NCE/OND	217	20
HND/B.Sc	216	19
Post-Graduate Studies	226	20
Total	1111	100

Literacy level can be correlated with socioeconomic status, which can influence the choice of cooking energy. Higher literacy levels, along with higher educational qualifications, may indicate better job prospects and income levels. Individuals with higher socioeconomic status are more likely to have the financial resources to invest in cleaner cooking technologies, while those with lower literacy levels may have limited financial means and may rely on traditional biomass fuels.

Higher levels of education and literacy are often associated with increased environmental consciousness. Individuals with higher literacy levels may have a better understanding of the environmental impact of traditional cooking fuels and may be more inclined to adopt cleaner and sustainable cooking energy sources.

Table 9 Variation in Literacy Level of Respondents

	t	df	p	Mean Difference
Literacy level	70.776	1110	< .001	3.001

Note. For the Student t-test, the alternative hypothesis specifies that the mean is different from 0.

The variation in literacy level of respondents is presented in Table 9. The calculated t-value is 70.776. The t-value measures the difference between the mean of the sample and a hypothetical population mean, taking into account the variability within the sample. A higher t-value indicates a larger difference between the sample mean and the hypothesized mean. This was therefore a clear indication that conducting the study in the facility was relevant..

Based on the results, the one-sample t-test suggests a statistically significant difference in the literacy level of the sample compared to the hypothetical population mean. The extremely low p-value indicates that the observed difference is unlikely to have occurred by chance alone. This suggests that the sample has a significantly higher literacy level than the hypothesized population mean.

4.1.6 Household Size

Table 10 provides information on the distribution of household sizes within a sample of 1,111 households. The data shows that 259 households, representing 23% of the sample, have less than three persons. This category includes small households with one or two members. The category of "3-6 Persons" consists of 314 households, making up 28% of the sample. This group represents households with a moderate number of members, typically including nuclear families with parents and children or extended families with additional relatives.

The data shows that 275 households, accounting for 25% of the sample, have between seven and ten persons. This category includes larger households with multiple generations or extended families living together. The category of "Above 10 Persons" includes 263 households, representing 24% of the sample. This group consists of the largest households with more than ten members, which could include multiple generations, extended families, or communal living arrangements. The data suggests a diverse range of household sizes, with a significant portion falling within the 3-6 persons and 7-10 people's categories.

It's important to consider that household size can impact cooking energy choices as well. Larger households may require more cooking energy to meet their daily needs, potentially influencing the choice of cooking technologies and fuels. Additionally, cultural practices, income levels, and geographic location can also influence cooking energy preferences within households of different sizes.

Table 10 Household Size of the Respondents

Household Size	Frequency	Percent
< 3 Persons	259	23
3-6 Persons	314	28
7-10 Persons	275	25
Above 10 Persons	263	24
Total	1111	100

4.2 Household Cooking Energy Alternatives

4.2.1 Primary Household Cooking Energy

Table 11 provides an overview of the primary cooking energy sources used by households in Niger-Delta region of Nigeria. It highlights the dominance of LPG as a cleaner and more efficient cooking energy option, followed by charcoal, fuelwood, kerosene, and electricity. The most widely used primary cooking energy source in the Niger-Delta region is LPG (Liquefied Petroleum Gas), with 630 households accounting for 57% of the sample. LPG is a cleaner and more efficient alternative to traditional biomass fuels and kerosene. The Nigerian government has implemented various initiatives to promote LPG adoption, leading to its increasing popularity, particularly in urban areas and among wealthier households.

The result shows that 144 households, representing 13% of the sample, use charcoal as their primary cooking energy source. Charcoal is a commonly used biomass fuel derived from wood, and it has been traditionally popular due to its affordability and accessibility in many parts of Nigeria.

These findings reflect the ongoing transition from traditional biomass fuels to modern and cleaner cooking energy sources in the country, driven by factors such as government policies, availability, affordability, and access to infrastructure.

Table 11 Primary Cooking Energy

Primary Cooking Energy	Frequency	Percent
Charcoal	144	13
Electricity	91	8
Fuelwood	127	12
Kerosene	119	10
LPG	630	57
Total	1111	100

Furthermore, 127 households, making up 12% of the sample, use fuelwood as their primary cooking energy source. It is commonly used in rural areas where biomass resources are more readily available. Kerosene accounted for 10% of the sample, which primarily use kerosene for cooking. Kerosene stoves or lamps have been a traditional cooking energy source, although its usage has declined in Nigeria in recent years due to safety concerns and the increasing popularity of cleaner alternatives. The category of household using "Electricity" consists of 91 households, accounting for 8% of the sample. These households primarily rely on electric stoves or cookers for their cooking needs. Electricity as a cooking energy source is typically more prevalent in urban areas or households with reliable access to electricity.

4.2.2 Household Alternative Cooking Energy

The result presented in Table 12 provides information on the frequency and percentage distribution of alternative energy options for household cooking in the Niger-Delta

region of Nigeria. These options include charcoal, electricity, fuelwood, kerosene, and LPG (Liquefied Petroleum Gas).

The result as presented in Table 12 reveals that charcoal is the most commonly used alternative energy source, with 37% of households relying on it for cooking. This finding suggests that charcoal remains a popular choice due to its affordability and accessibility, especially in areas where other energy options may be limited. Fuelwood is also utilized by 13% of households, reflecting the continued reliance on traditional biomass fuels. The result also shows that electricity is used by 17% of households, indicating the presence of reliable electricity access in certain areas or among specific socioeconomic groups. LPG, a cleaner and more efficient energy option, is chosen by 14% of households. This demonstrates the successful efforts in promoting LPG adoption and highlights the potential for further growth and transition to cleaner cooking energy sources.

Table 12 Alternative Energy Option

Energy	Frequency	Percent
Charcoal	411	37
Electricity	189	17
Fuelwood	144	13
Kerosene	214	19
LPG	153	14
Total	1111	100

In addition, 19% of households still rely on kerosene for cooking. This finding suggests the ongoing usage of kerosene as an alternative energy source, although its popularity has decreased over time. The distribution of alternative energy options presented in Table 12 has implications for policy-making and sustainability efforts. The dominance

of charcoal and fuelwood highlights the need for initiatives to address the environmental and health impacts associated with traditional biomass fuels. The promotion of cleaner energy options like LPG and electricity can contribute to reducing indoor air pollution, deforestation, and associated health risks.

4.2.3 Volume of Fuelwood Consumed per Month

The study assessed and highlights the volume of fuelwood consumed by households in Niger-Delta region of Nigeria, providing insights into the quantity of fuelwood consumed for cooking purposes. Table 13 categorizes the volume of fuelwood usage into four ranges: less than 300 kg, 300-500 kg, 500-1000 kg, and above 1000 kg. The table indicates that 19% of households use less than 300 kg of fuelwood, 45% use between 300-500 kg, 29% use between 500-1000 kg, and 7% use above 1000 kg. The variations in fuelwood volume usage may be influenced by socioeconomic factors such as income levels, household size, and geographic location. For example, larger households may require more fuelwood for cooking, while households with limited income may rely on smaller volumes due to affordability constraints.

Table 13 Volume of Fuelwood Consumed Per Month

Volume Fuelwood	Frequency	Percent
Less than 300 Kg	24	19
300-500 Kg	57	45
500-1000kg	37	29
Above 1000kg	9	7
Total	127	100

The distribution of volume of fuelwood has important implications for the environmental impact of fuelwood usage. Higher volumes of fuelwood consumption

indicate a greater demand for biomass resources, which can lead to deforestation, habitat loss, and environmental degradation. This suggests the need for sustainable fuelwood management practices and initiatives to promote alternative cooking energy sources.

4.2.4 Volume of LPG Consumed per Month

The volume of LPG usage by households per month were categorized into four ranges: less than 5 kg, 5-10 kg, 11-15 kg, and above 15 kg. The result as presented in Table 14 highlight the volume of LPG consumed by households in the Niger-Delta region of Nigeria, providing insights into the quantity of LPG consumed for cooking purposes. The result indicates that 6% of households use less than 5 kg of LPG, 28% use between 5-10 kg, 48% use between 11-15 kg, and 19% use above 15 kg. The distribution of LPG volume suggests varying levels of LPG access and consumption patterns among households. Higher volumes of LPG usage indicate a greater reliance on LPG as the primary cooking energy source, which can be attributed to factors such as affordability, availability, and awareness of the benefits of LPG.

Table 14 Volume of LPG Consumed per Month

Volume LPG	Frequency	Percent
Less than 5 Kg	36	6
5-10 Kg	175	28
11-15 Kg	300	48
Above 15 Kg	119	19
Total	630	100

4.2.5 Volume of Kerosene Consumed per Month

The volume of kerosene usage on monthly basis was categorized into four; less than 20 liters, 20-30 liters, 31-40 liters, and above 40 liters. Out of the total 119 households surveyed, 19 households (16%) reported using less than 20 liters of kerosene for cooking per month. This indicates a relatively small volume of kerosene usage among these households. Similarly, 31 households (26%) reported using 20 to 30 liters of kerosene. This range represents a moderate volume of kerosene usage among these households. However, the majority of households, 65 in total (55%), reported using 31 to 40 liters of kerosene. This range signifies a higher volume of kerosene usage among these households compared to the previous categories. Only 4 households (3%) reported using more than 40 liters of kerosene. This indicates a relatively small proportion of households consuming a larger volume of kerosene for cooking purposes. Overall, the data suggests that the majority of households surveyed use moderate to higher volumes of kerosene, with 55% falling within the 31-40 liters range.

Table 15 Volume Kerosene Consumed Per Month

Volume Kerosene	Frequency	Percent
Less than 20 Litres	19	16
20 - 30 Litres	31	26
31 - 40 Litres	65	55
Above 40 Litres	4	3
Total	119	19

4.2.6 Distance Travelled to Cooking Energy Source

The result presented in Table 16 provides information on the distance travelled by households to collect or acquire cooking energy in the Niger-Delta region of Nigeria.

Out of the total 1111 households surveyed, 198 households (18%) reported having to travel less than 1000 meters to access cooking energy sources. This indicates that a relatively small proportion of households have easy access to cooking energy within a short distance.

Overall, the data suggests that a significant proportion of households have to travel moderate distances (1001-3000m) to access cooking energy sources. However, a notable number of households also face the challenge of traveling longer distances (3001-5000m and above 5000m). This information provides insights into the accessibility of cooking energy sources for households and can be valuable for understanding the spatial dynamics and challenges associated with energy access in Nigeria.

Table 16 Distance Travelled to Energy Cooking Source

Distance Travelled	Frequency	Percent
less than 1000m	198	18
1001-3000m	425	38
3001-5000m	324	29
Above 5000m	164	15
Total	1111	100

4.3 Weight Factor of Household Cooking Energy

4.3.1 Weight Factor for Cost of Household Cooking Energy

The study assessed the cost of household cooking energy on household. The cost was divided into two categories, which is the direct cost and the indirect cost. The influence of direct and indirect cost on the total cost of household cooking energy was examined and the result is presented in Table 17. The direct cost refers to the immediate expenses

incurred by households for purchasing or acquiring the cooking energy source. According to the Table, LPG and electricity have the highest direct cost at 0.9 (90%), followed by charcoal, fuelwood, and kerosene, which all have a direct cost of 0.8 (80%). This indicates that LPG and electricity are relatively more expensive in terms of direct costs compared to other energy sources.

The indirect cost represents the additional expenses or consequences that are not directly related to the purchase of the cooking energy source but are associated with its usage. Table 17 shows that LPG and electricity have the lowest indirect cost at 0.1, indicating that they have fewer additional expenses or consequences. On the other hand, charcoal and kerosene have an indirect cost of 0.2, while fuelwood has the highest indirect cost at 0.3. This suggests that fuelwood has relatively higher additional expenses or consequences compared to other energy sources. The total cost represents the sum of the direct and indirect costs. The total cost for household cooking energy sources is 0.82 (82%), with a corresponding indirect cost of 0.18 (18%). This indicates that the indirect costs account for a relatively smaller proportion of the total cost compared to the direct costs.

Table 17 Weight Factor for Cost of Household Cooking Energy

Energy Type	Direct Cost	Indirect Cost
Charcoal	0.8	0.2
Fuelwood	0.7	0.3
LPG	0.9	0.1
Kerosene	0.8	0.2
Electricity	0.9	0.1
Total	0.82	0.18

These findings provide insights into the cost considerations associated with different cooking energy sources. LPG and electricity have higher direct costs but lower indirect costs, suggesting that they may have a more predictable and stable cost structure. Charcoal and kerosene have slightly lower direct costs but higher indirect costs, while fuelwood has the highest indirect cost among the energy sources examined. It is important to note that the costs presented in the table are based on the specific context of the study and may vary depending on factors such as location, market conditions, and energy efficiency measures.

4.3.1.1 Weight Factor for Direct Cost of Household Cooking Energy

The study identified three categories of factors that influence the direct cost of household cooking energy for the study. The categories are capital cost, operational cost, and maintenance cost. Table 18 provides cost-related information for different cooking energy sources. The capital cost refers to the initial investment required to acquire the necessary equipment or infrastructure for using a particular cooking energy source. According to the table, LPG has the highest capital cost at 0.36, followed by electricity at 0.28. Charcoal has the lowest capital cost at 0.12, while fuelwood has the lowest at 0.04. Kerosene falls in the middle range with a capital cost of 0.2. Operation costs refer to the ongoing expenses associated with using a specific cooking energy source. The table shows that electricity has the highest operation cost at 0.36, followed by LPG at 0.28. Fuelwood and kerosene have the same operation cost of 0.2, while charcoal has the lowest operation cost at 0.04.

Table 18 Weight Factor for Direct Cost of Household Cooking Energy

Cooking Energy	COST				Overall
	Capital	Operation	Maintenance	Transport	
Charcoal	0.12	0.04	0.24	0.20	0.15
Fuelwood	0.04	0.12	0.05	0.12	0.08
LPG	0.36	0.28	0.14	0.28	0.27
Kerosene	0.2	0.2	0.33	0.36	0.27
Electricity	0.28	0.36	0.24	0.04	0.23

Maintenance costs represent the expenses incurred in maintaining and repairing the equipment or infrastructure used for cooking. According to the table, kerosene has the highest maintenance cost at 0.33, followed by electricity at 0.24. Charcoal has a maintenance cost of 0.24, while fuelwood has the lowest maintenance cost at 0.05. LPG falls in the middle range with a maintenance cost of 0.14. Transportation costs refer to the expenses associated with transporting the cooking energy source to the households. Table 18 shows that kerosene and LPG have the highest transportation cost at 0.36 and 0.28, respectively. Charcoal and fuelwood have lower transportation costs of 0.20 and 0.12, respectively. Electricity has the lowest transportation cost at 0.04.

The overall costs represent the combined capital, operation, maintenance, and transportation costs for each cooking energy source. The table indicates that kerosene and LPG have the highest overall costs at 0.27. Electricity has an overall cost of 0.23, while charcoal has a slightly higher overall cost of 0.15. Fuelwood has the lowest overall cost at 0.08. These findings highlight the variations in costs associated with different cooking energy sources, taking into account not only the capital, operation, and maintenance costs but also the transportation costs. It is important to consider these

factors when assessing the affordability and sustainability of different cooking energy options.

4.3.1.2 Weight Factor for Indirect Cost of Household Cooking Energy

Table 19 provides information on the indirect costs associated with different types of cooking energy sources, specifically related to pollution, waste, and overall indirect costs. The pollution cost represents the indirect costs associated with the environmental pollution caused by using a particular cooking energy source. According to Table 19, charcoal has the highest pollution cost at 0.28, followed by fuelwood at 0.36. Kerosene has a pollution cost of 0.2, while LPG and electricity have lower pollution costs at 0.12 and 0.04, respectively.

The waste cost refers to the indirect costs related to the generation and disposal of waste produced during the use of a cooking energy source. The table shows that fuelwood has the highest waste cost at 0.58, followed by charcoal at 0.26. Kerosene has a waste cost of 0.12, while LPG and electricity have lower waste costs at 0.02. The overall indirect costs represent the combined pollution, waste, and other indirect costs associated with each cooking energy source. According to the table, fuelwood has the highest overall indirect cost at 0.47, followed by charcoal at 0.27. Kerosene and LPG have lower overall indirect costs of 0.16 and 0.07, respectively. Electricity has the lowest overall indirect cost at 0.03. These findings highlight the variation in indirect costs associated with different cooking energy sources, particularly in terms of pollution and waste. Charcoal and fuelwood tend to have higher indirect costs due to their impact on pollution and waste generation. On the other hand, LPG and electricity have relatively lower indirect costs in these aspects.

Table 19 Weight Factor for Indirect Cost of Household Cooking Energy

Type of Cooking Energy	INDIRECT COST		
	Pollution	Waste	Overall
Charcoal	0.28	0.26	0.27
Fuelwood	0.36	0.58	0.47
LPG	0.12	0.02	0.07
Kerosene	0.2	0.12	0.16
Electricity	0.04	0.02	0.03

4.3.1.3 Weight Factor for Total Cost of Household Cooking Energy

According to the Table 20, LPG has the highest direct cost at 0.27, followed by kerosene at 0.27. Electricity has a direct cost of 0.23, while fuelwood has the lowest direct cost at 0.08. Charcoal falls in the middle range with a direct cost of 0.15. For indirect cost, the table shows that fuelwood has the highest indirect cost at 0.47, followed by charcoal at 0.27. Kerosene has an indirect cost of 0.16, while LPG and electricity have lower indirect costs at 0.07 and 0.03, respectively.

Therefore, the overall costs represent the combined direct and indirect costs for each cooking energy source. According to the Table 20, fuelwood has the highest overall cost at 0.28, followed by charcoal at 0.21. Kerosene and electricity have lower overall costs of 0.22 and 0.13, respectively. LPG falls in the middle range with an overall cost of 0.17. It is evident that fuelwood has the highest total cost due to its relatively high indirect costs. Charcoal, kerosene, and electricity have moderate total costs, while LPG has the lowest total cost among the options presented.

Table 20 Weight Factor for Total Cost of Household Cooking Energy

Type of Cooking Energy	TOTAL COST		Overall
	Direct Cost	Indirect Cost	
Charcoal	0.15	0.27	0.21
Fuelwood	0.08	0.47	0.28
LPG	0.27	0.07	0.17
Kerosene	0.27	0.16	0.22
Electricity	0.23	0.03	0.13

4.3.2 Weight Factor for Benefits of Household Cooking Energy

The benefits of household cooking energy was assessed through the prism of three critical factors; the user, the fuel and the cooking system.

4.3.2.1 Weight Factor for Benefits Derived by Users from Household Cooking Options

Table 21 presents the level of benefits derived by users from different household cooking energy options, specifically in terms of health benefits, time savings, and overall benefits. The health benefits represent the positive impacts on users' health resulting from the use of a particular cooking energy source. According to the table, electricity has the highest health benefit score at 0.36, followed closely by LPG at 0.28. Kerosene and charcoal have moderate health benefits, both scoring 0.20. Fuelwood has the lowest health benefit score at 0.04.

The time savings indicate the extent to which users can save time by using a specific cooking energy source. Table 21 shows that electricity has the highest time saving score at 0.28 (28%), followed by LPG at 0.36 (36%). Charcoal and kerosene have the same time saving score of 0.20 (20%), while fuelwood has the lowest time saving score at 0.04 (4%). The overall benefits represent the combined positive impacts on health and

time savings experienced by users. According to the table, LPG and electricity have the highest overall benefit scores of 0.32 (32%), indicating that they provide substantial benefits in terms of both health and time savings. Charcoal and kerosene have an overall benefit score of 0.20 (20%), while fuelwood has the lowest overall benefit score at 0.04 (4%). These findings suggest that electricity and LPG offer the most significant benefits to users in terms of health, time savings, and overall benefits. These energy sources tend to have higher scores in all three categories, indicating that they have a positive impact on users' well-being and convenience. On the other hand, fuelwood consistently scores lower in all categories, indicating fewer benefits in terms of health and time savings.

Table 21 Weight Factor for Benefits Derived by User from Household Cooking Energy

Type of Cooking Energy	USER		
	Health	Time	Overall
Charcoal	0.12	0.12	0.12
Fuelwood	0.04	0.04	0.04
LPG	0.28	0.36	0.32
Kerosene	0.20	0.2	0.20
Electricity	0.36	0.28	0.32

4.3.2.2 Weight Factor for Benefits Derived from Household Cooking Energy

Table 22 presents the assessment of different cooking energy options based on their fuel-related benefit, including sustainability, availability and supply, and an overall assessment. Sustainability refers to the environmental impact and long-term viability of a cooking energy source. In Table 22, electricity and LPG receive relatively high sustainability scores of 0.36 and 0.28, respectively. This suggests that these energy

sources have lower environmental impacts compared to others. According to a study by Mulugetta et al. (2017), LPG is considered a more sustainable cooking energy option compared to traditional biomass fuels like charcoal and fuelwood. LPG emits lower levels of greenhouse gases, reduces indoor air pollution, and minimizes deforestation. The study also assessed the benefits derived from fuel relating to ease of access and level of supply of household cooking energy option. Fuelwood receives the highest score of 0.36, indicating its wide availability. Charcoal and kerosene also have relatively high scores, while electricity and LPG have lower scores. In a study by Barnes *et al.* (2013), it was found that in rural areas of Nigeria, fuelwood is the most readily available cooking energy source due to the abundance of forests and wood resources. However, overreliance on fuelwood can lead to deforestation and depletion of natural resources.

The overall assessment combines the sustainability and availability and supply scores to provide a comprehensive evaluation of the cooking energy source. Table 22, LPG has the highest overall score of 0.24, followed by charcoal, fuelwood, kerosene, and electricity. According to the International Renewable Energy Agency (IRENA), LPG is considered a cleaner and more versatile cooking energy option. It is easily transportable, has a stable supply chain, and offers convenience to users. However, it is important to ensure the affordability and accessibility of LPG for all segments of the population. These results highlight the trade-offs and considerations associated with different cooking energy options. While LPG and electricity generally perform well in terms of sustainability, other factors such as availability and supply play a significant role. Fuelwood, despite having sustainability concerns, remains widely available in

certain regions. It is essential to consider a holistic approach when evaluating cooking energy options, taking into account social, economic, and environmental factors.

Table 22 Weight Factor for Benefits Derived from Household Cooking Energy

Type of Cooking Energy	FUEL		
	Sustainability	Availability and Supply	Overall
Charcoal	0.12	0.28	0.2
Fuelwood	0.04	0.36	0.2
LPG	0.28	0.2	0.24
Kerosene	0.2	0.12	0.16
Electricity	0.36	0.04	0.2

4.3.2.3 Weight Factor for Benefits Derived from Cooking Energy System

The result presented in Table 23 presents the benefits of household cooking energy based on the characteristics of their cooking systems, including ease of maintenance, ease of operation, safety, and an overall assessment. In the Table, charcoal and fuelwood receive similar scores for ease of maintenance (0.13 and 0.13, respectively), suggesting that they may be relatively moderate to maintain. LPG and electricity have higher scores, indicating that their cooking systems generally require less maintenance, hence, they are easy to maintain. According to a study by Ogundari et al. (2019), LPG cooking systems are known for their ease of maintenance compared to traditional cooking systems like charcoal and fuelwood. LPG stoves require minimal cleaning and have fewer parts that may wear out or require replacement.

Table 23 Weight Factor for Benefits Derived from Cooking Energy System

Type of Cooking Energy	Cooking System			
	Ease of Maintenance	Ease of Operation	Safety	Overall
Charcoal	0.13	0.16	0.32	0.20
Fuelwood	0.13	0.03	0.11	0.09
LPG	0.26	0.28	0.04	0.19
Kerosene	0.22	0.25	0.25	0.24
Electricity	0.26	0.28	0.29	0.28

In Table 23, LPG, electricity, and kerosene receive relatively high scores for ease of operation, indicating that their cooking systems are generally user-friendly. Charcoal and fuelwood have lower scores, suggesting that they may require more effort and time to operate effectively. A study by Okafor and Olaniyi (2020) found that LPG cooking systems are preferred by households in Nigeria due to their ease of operation. LPG stoves offer instant ignition, precise temperature control, and consistent heat output, making them convenient for cooking activities. Charcoal has the highest safety score (0.32), indicating that it is perceived as relatively safe. Electricity and Kerosene also receive moderate safety scores. Fuelwood and LPG have lower safety scores, suggesting that they may pose more safety risks. In a study by Akadiri et al. (2017), it was found that fuelwood cooking systems, although widely used, can contribute to indoor air pollution and present a higher risk of accidental fires. Electricity is considered as a safer alternatives, as they do not produce smoke or open flames.

The overall assessment combines the scores for ease of maintenance, ease of operation, and safety to provide an overall evaluation of the cooking systems associated with each energy option. Electricity receives the highest overall score (0.28), followed closely by

kerosene (0.24). LPG and charcoal have moderate overall scores, while fuelwood has the lowest overall score. According to a study by Nwafor et al. (2021), electricity cooking systems are perceived as highly efficient, convenient, and safe, making them a preferred option for urban households in Nigeria. However, the study also highlights the challenges related to electricity access and affordability, which can limit its adoption in Nigeria, and the Niger delta region in particular. These results highlight the trade-offs and considerations associated with different cooking energy options in terms of their associated cooking systems. Factors such as maintenance requirements, ease of operation, and safety play a crucial role in user satisfaction and overall usability. It is essential to consider the specific needs, preferences, and context of households when assessing the suitability of different cooking energy options.

4.3.2.4 Overall Weight Factor for Benefits of Household Cooking Energy

Table 24 presents the total benefits of different household cooking energy options based on three dimensions: user benefits, fuel benefits, and cooking system benefits. This study assesses the benefits experienced by users of each cooking energy option. In Table 24, electricity, LPG, and kerosene receive high scores for user benefits, indicating that they provide significant advantages to the users. Fuelwood and charcoal have relatively lower scores in this category. A study by Okoye and Onwuanaku (2018) found that LPG and electricity cooking systems offer numerous user benefits, such as improved cooking efficiency, reduced cooking time, and better cooking outcomes. These benefits result in enhanced user satisfaction and convenience.

In Table 24, LPG receives the highest score (0.24) for fuel benefits, followed by electricity, charcoal, fuelwood and kerosene. According to a report by the Energy Commission of Nigeria (2020), LPG is considered a clean and efficient fuel with high

energy content. It produces minimal smoke, reduces indoor air pollution, and contributes to a healthier cooking environment compared to traditional fuels like charcoal and fuelwood.

Table 24 Total Benefits of Household Cooking Energy

Type of Cooking Energy	TOTAL BENEFITS			
	User	Fuel	Cooking System	Overall
Charcoal	0.12	0.2	0.2	0.17
Fuelwood	0.04	0.2	0.09	0.11
LPG	0.32	0.24	0.19	0.25
Kerosene	0.2	0.16	0.24	0.20
Electricity	0.32	0.2	0.28	0.27

Cooking system benefits focuses on the advantages provided by the cooking systems associated with each energy option. Table 24, electricity receives the highest score for cooking system benefits, indicating that it offers significant advantages in terms of cooking system efficiency and performance. LPG and kerosene also receive relatively high scores, while charcoal and fuelwood have lower scores. A study by Adewale et al. (2020) highlighted the benefits of electricity cooking systems, such as precise temperature control, consistent heat output, and the availability of various cooking features. These benefits contribute to improved cooking experiences and enable the preparation of a wide range of dishes.

The overall assessment combines the scores for user benefits, fuel benefits, and cooking system benefits to provide an overall evaluation of each cooking energy option. In the table, electricity and LPG receive the highest overall scores of 0.27 and 0.25 respectively, indicating that they offer the most comprehensive benefits to users across different dimensions. Charcoal, kerosene, and fuelwood have lower overall scores. A

study by Ugwoke and Onoja (2019) compared the overall benefits of different cooking energy options in Nigeria. They found that electricity and LPG were favored due to their multiple benefits, including improved cooking efficiency, reduced cooking time, lower health risks, and environmental friendliness.

4.3.3 Benefit-Cost Ratio of Household Cooking Energy Alternatives

The total cost and benefits of household cooking energy alternatives provides the order of preference of household cooking energy but may not provide a true picture of the household cooking energy usage. Figure 4 shows the benefits-cost ratio of household cooking energy.

The benefit-cost ratio for fuelwood is relatively low, indicating that the overall benefits derived from using fuelwood as a cooking energy option may not outweigh the associated costs. This suggests that fuelwood may have limitations in terms of economic efficiency and value for money. Research by Alao et al. (2019) explored the economic implications of fuelwood use in Nigeria. They highlighted that fuelwood consumption can contribute to deforestation, land degradation, and adverse health effects due to indoor air pollution. These factors may negatively impact the benefit-cost ratio of fuelwood as a cooking energy option.

The benefit-cost ratio for charcoal indicates that for every unit of cost invested in charcoal as a cooking energy option except fuelwood, there is an estimated return of 0.81 units in terms of overall benefits. While charcoal has a positive benefit-cost ratio, it is relatively lower compared to other energy options in Figure 4. This result corroborate the findings of Akinbami and Adeyemi (2017), the study analyzed the economic costs and benefits of charcoal as a cooking energy option in Nigeria. They found that while charcoal is relatively inexpensive, it has drawbacks such as

environmental degradation and health risks associated with indoor air pollution. Kerosene had a benefit-cost ratio of 0.91. The benefit-cost ratio for kerosene suggests that the overall benefits of using kerosene as a cooking energy option are relatively close to the associated costs. While it is positive, it falls short compared to options like LPG and electricity. A study by Idris et al. (2018) examined the economic viability of kerosene as a cooking energy source in Nigeria. They found that kerosene use has declined in recent years due to its high cost, health risks, and limited availability. These factors may contribute to a moderate benefit-cost ratio for kerosene.

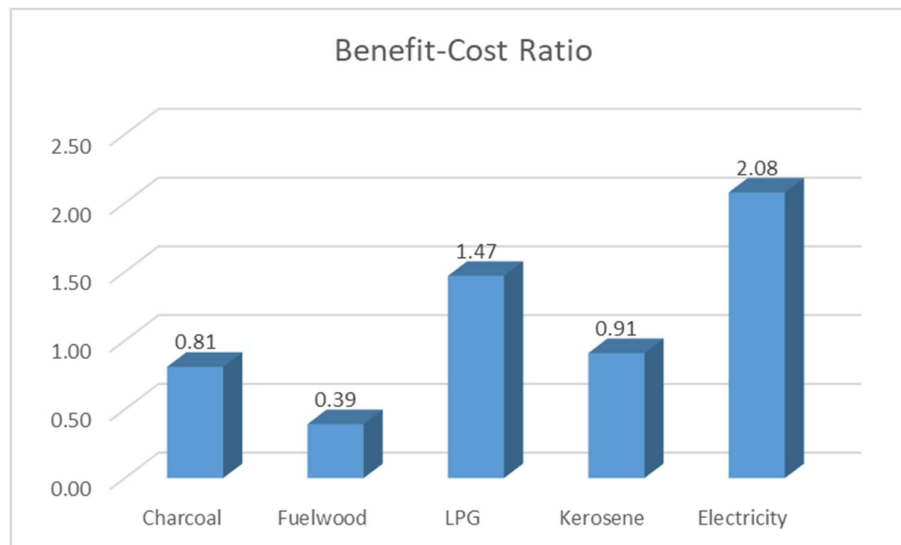


Figure 4 Benefits-Cost Ratio of Household Cooking Energy

LPG stands out with a relatively high benefit-cost ratio of 1.47, indicating that the overall benefits derived from using LPG as a cooking energy option surpass the associated costs. LPG is considered a cost-effective option in terms of the value it provides to users. Several studies, including one by Emodi and Okolie (2020), have shown that LPG offers economic advantages, such as reduced cooking time, increased

cooking efficiency, and improved health outcomes. These factors contribute to a higher benefit-cost ratio for LPG.

Electricity stands out with the highest benefit-cost ratio of 2.08 among the other energy options assessed in this study. This indicates that the overall benefits derived from using electricity as a cooking energy option far outweigh the associated costs, making it a highly efficient and cost-effective choice. Studies, such as the one by Okafor et al. (2018), have emphasized the economic advantages of electricity as a cooking energy option. Electricity offers precise temperature control, convenience, and versatility in cooking, resulting in higher benefits and a favorable benefit-cost ratio. However, the supply of electricity is in very low supply in Nigeria, and the Niger Delta region, hence, may hinder the adoption of electricity as a cooking energy options for low income households.

4.4 Factors that influences household's choice of primary cooking energy

To determine the factors that influence household choice of primary cooking energy, the principal component analysis was carried out. The result presented in Table 25 indicates the outcome of a Chi-squared test conducted on a model. The Chi-squared test is a statistical test that determines whether or not two category variables have a significant connection.

The test produces a Chi-squared value, degrees of freedom (df), and a p-value. The Chi-squared value obtained is 1537.475, which represents the test statistic. The degrees of freedom indicate the number of categories that can vary freely in the analysis. In this case, the model has 2 degrees of freedom. The p-value is $< .001$, which is less than the conventional threshold of significance (typically set at 0.05 or 0.01). This indicates that the association between the variables in the model is statistically significant.

Table 25 Model Summary Table for PCA

Chi-squared Test	Value	df	P
Model	1537.475	2	< .001

In addition, the result from the Principal Component Analysis (PCA) presented in Table 26 shows the component loadings for each variable in the analysis. Component loadings signify the association between the variables and the principal components extracted from the data. The study revealed that affordability has a high loading (0.762) on the first principal component (RC1), indicating a strong positive relationship between affordability and the overall variation explained by RC1. This suggests that affordability plays a significant role in influencing household's choice of primary cooking energy. For example, in regions where biomass fuels like charcoal or fuelwood are cheaper than alternative options like LPG or electricity, households may opt for biomass fuels due to their affordability. Government policies and Incentives has a high loading (0.599) on RC1 as well, indicating that government policies and incentives are positively associated with the factors influencing cooking energy choices. This can include subsidies, tax incentives, or programs promoting the use of clean cooking technologies. Such policies and incentives can make certain energy sources more attractive and accessible to households.

Health and Safety has a notable loading (0.767) on RC2, indicating that households consider the potential health risks associated with different cooking energy options. For instance, the use of traditional biomass fuels like charcoal or fuelwood can lead to indoor air pollution, which can have adverse health effects. Therefore, households may prioritize cleaner and safer cooking energy alternatives to protect their health and well-

being. Energy Efficiency also shows a significant loading (0.625) on RC2, suggesting that households value energy-efficient cooking technologies. Efficient stoves or appliances can reduce the consumption of fuel and lower energy costs, making them appealing options for households.

Table 26 Component Loadings

	RC1	RC2	RC3	RC4	Uniqueness
Affordability	0.762				0.424
Government policies and Incentives	0.599				0.600
Health and Safety		0.767			0.392
Energy Efficiency		0.625			0.422
Availability and Accessibility			0.879		0.273
Infrastructure and Technology			0.431		0.715
Cooking needs and Preferences				0.766	0.395
Environmental Impact				-0.676	0.489

Note. Applied rotation method is promax.

Availability and Accessibility loaded highly (0.879) on RC3, suggesting that households consider the availability and accessibility of cooking energy options. They are likely to choose energy sources that are easily accessible in their geographical location or have a well-established distribution network. Infrastructure and Technology also loaded on RC3. The moderate loading (0.431) implies that the presence of suitable infrastructure and appropriate cooking technologies is a factor influencing households' cooking energy choices. For example, access to piped natural gas or electricity infrastructure may influence their decision.

Cooking needs and Preferences has a high loading (0.766) on RC4, indicating that households' specific cooking needs and personal preferences play a role in their choice of cooking energy. Factors such as the type of cuisine, cooking techniques, and cultural

preferences can influence their decision. Environmental Impact has a negative loading (-0.676) on this component, indicating an inverse relationship with other variables. It suggests that households' consideration of the environmental impact of their cooking energy choices may differ from other factors in the analysis. They may prioritize environmentally friendly options, such as renewable energy sources, to minimize carbon emissions and ecological footprint. The uniqueness values indicate the amount of variance in each variable that is not explained by the extracted components. Higher uniqueness values suggest that the variable is less correlated with other variables in the analysis.

Table 27 presents the characteristics of the components derived from both the unrotated and rotated solutions of the principal component analysis (PCA). The eigenvalue represents the amount of variance explained by each component. In the unrotated solution, Component 1 has an eigenvalue of 1.119, Component 2 has an eigenvalue of 1.101, Component 3 has an eigenvalue of 1.043, and Component 4 has an eigenvalue of 1.028. These eigenvalues indicate the relative importance of each component in explaining the variance in the data. Higher eigenvalues suggest greater explanatory power.

The proportion of variance explains the proportion of total variance in the data accounted for by each component. In the unrotated solution, Component 1 explains 14.0% of the variance, Component 2 explains 13.8%, Component 3 explains 13.0%, and Component 4 explains 12.8%. These values indicate the relative contribution of each component to the overall variance in the data.

Cumulative Proportion of Variance: The cumulative proportion of variance in the rotated solution shows the cumulative amount of variance explained by the

components. In the rotated solution, the cumulative proportion of variance for Component 1 is 13.8%, for Component 2 is 27.3%, for Component 3 is 40.3%, and for Component 4 is 53.6%. The cumulative proportion of variance provides insights into the total amount of variance explained by the components as they are added sequentially.

Table 27 Component Characteristics

	Unrotated solution			Rotated solution		
	Eigenvalue	Proportion var.	Cumulative	SumSq. Loadings	Proportion var.	Cumulative
Component 1	1.119	0.140	0.140	1.106	0.138	0.138
Component 2	1.101	0.138	0.277	1.076	0.135	0.273
Component 3	1.043	0.130	0.408	1.044	0.130	0.403
Component 4	1.028	0.128	0.536	1.064	0.133	0.536

Sum of Squared Loadings: The sum of squared loadings represents the total amount of variance in the observed variables accounted for by each component. In the rotated solution, Component 1 has a sum of squared loadings of 1.106, Component 2 has a sum of squared loadings of 1.076, Component 3 has a sum of squared loadings of 1.044, and Component 4 has a sum of squared loadings of 1.064. These values indicate how well the variables are represented by each component.

Overall, the result shows that the four factors explained 53.6% of the total variance. The study also revealed that affordability, Health and safety, availability and accessibility, and cooking needs and preference were the primary factors driving household cooking energy choice in the Niger Delta region. The path diagram for the PCA is presented in Figure 5.

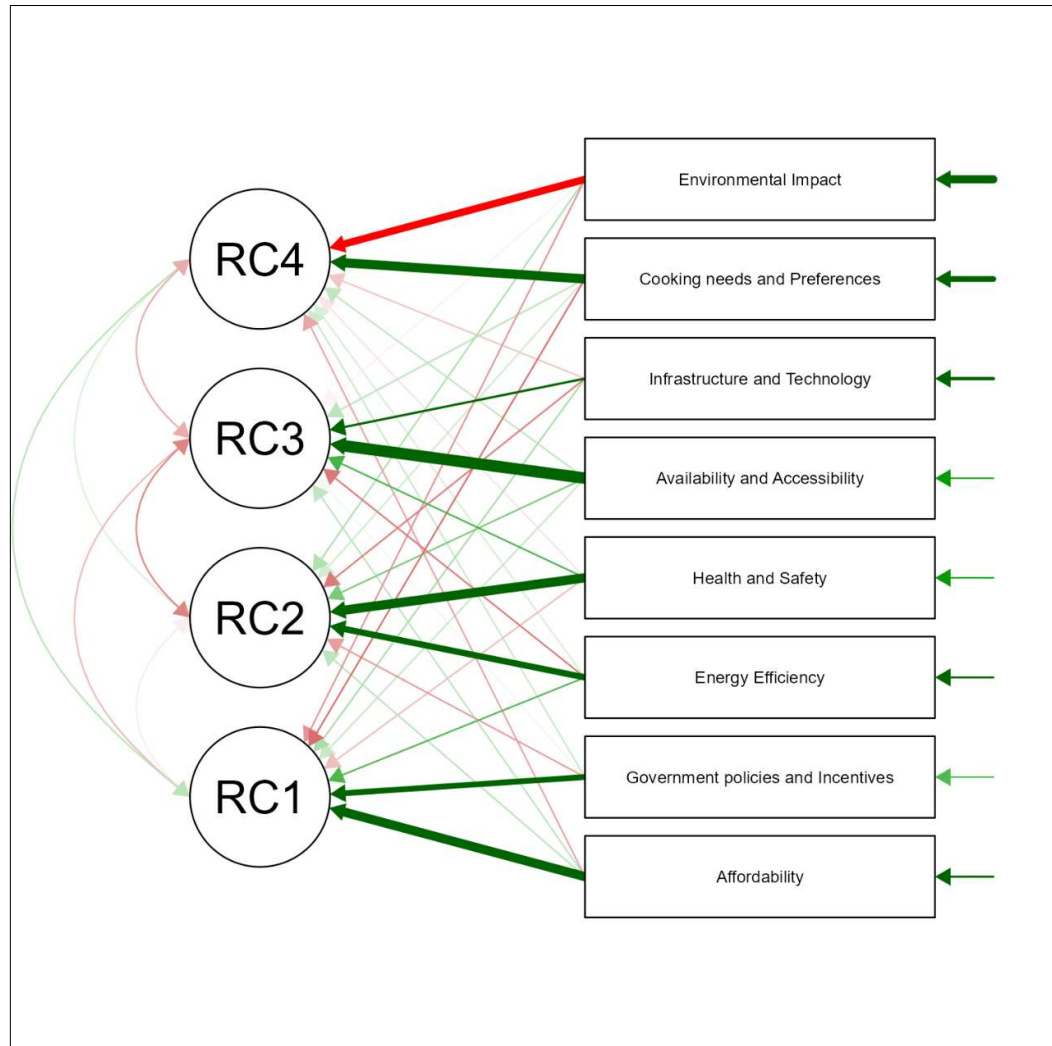


Figure 5 The path diagram for PCA.

4.5 Summary of Findings

The thesis titled "Assessment of Cost and Benefits of Household Cooking Fuel in Niger-Delta Region Nigeria, with a View of Developing a Framework for Sustainable Consumption" aimed to evaluate the costs and benefits associated with household cooking fuel options in the Niger-Delta region of Nigeria. The ultimate goal was to develop a framework that promotes sustainable consumption practices in the context of cooking fuel.

The study conducted a comprehensive cost analysis of different cooking fuel options, including charcoal, fuelwood, LPG, kerosene, and electricity. It considered various cost factors such as capital investment, operation, maintenance, pollution, and indirect costs. The findings revealed significant variations in the costs among different fuel types, with LPG and electricity being relatively more expensive options compared to charcoal and fuelwood.

The thesis also examined the benefits derived from each cooking fuel option. It assessed the benefits in terms of health, time savings, user satisfaction, environmental impact, sustainability, and availability and accessibility. The results demonstrated that electricity and LPG offered substantial benefits, including improved health outcomes, time savings, and reduced environmental impact. However, charcoal and fuelwood had lower benefits, particularly in terms of health and environmental considerations.

The study calculated the benefit-cost ratio for each cooking fuel option. The benefit-cost ratio is a measure of the net benefits derived from a particular cooking fuel option relative to its cost. The results showed that electricity had the highest benefit-cost ratio, indicating that it provided significant benefits compared to its cost. LPG and kerosene also had favorable benefit-cost ratios, while charcoal and fuelwood had lower ratios.

The study employed Principal Component Analysis (PCA) to analyze the underlying factors influencing households' cooking fuel choices. The PCA identified key components related to affordability, government policies and incentives, health and safety, energy efficiency, availability and accessibility, infrastructure and technology, cooking needs and preferences, and environmental impact. The findings from the PCA provided insights into the interrelationships among these factors and their relative importance in shaping households' decision-making process.

In conclusion, the findings of the thesis highlighted the complex dynamics of household cooking fuel choices in the Niger-Delta region of Nigeria. The cost and benefit analysis, along with the proposed framework for sustainable consumption, can serve as valuable inputs for policymakers, energy planners, and stakeholders in designing strategies to promote sustainable and affordable cooking fuel options. The study underscores the importance of considering multiple factors, such as affordability, health and safety, energy efficiency, and environmental impact, in ensuring a transition towards sustainable consumption practices in the household cooking sector.

CHAPTER 5 CONCLUSION AND DISCUSSION

5.1 Conclusion

This study investigates household cooking energy choices in the Niger-Delta region, integrating economic and social dimensions with a framework rooted in various economic theories, including Random Utility Theory, Theory of Demand, Cost-Benefit Analysis (CBA) and Relative Income Hypothesis (RIH). These frameworks help explain the observed preferences for cooking fuels, highlighting the role of affordability, availability, government policies, and health and environmental impacts in shaping household decisions.

The Random Utility Theory helps explain the variability in household preferences for cooking fuels. According to this theory, households make decisions based on the expected utility derived from each option, factoring in elements like convenience, health risks, and environmental sustainability. The findings align with this theory: electricity and LPG, which offer better utility in terms of user satisfaction, health outcomes, and efficiency, are preferred by households with better access to these resources. Households that can afford LPG (57%) and electricity tend to derive higher utility from their convenience, lower health risks, and reduced environmental impact.

The study also shows that 18% of households travel less than 1000 meters to acquire their cooking energy, while others must travel much farther, which directly affects their utility calculation. Households that have to travel longer distances are more likely to opt for fuels like charcoal or fuelwood, where transportation costs are lower, despite their lower overall benefits. This reflects the multidimensional utility households consider in energy choices, not just cost or environmental impact, but also ease of access and cultural familiarity.

The Theory of Demand further contextualizes the findings, showing how consumption patterns for cooking energy shift in response to changes in price, availability, and household income. The study reveals that 28% of households use 5-10 kg of LPG per month, and 19% use above 15 kg, indicating that as household incomes rise, so does the demand for cleaner and more efficient cooking fuels. Similarly, as LPG becomes more available through government interventions, the demand increases due to its perceived value, cleaner combustion, and time efficiency, as noted in the study's high benefit-cost ratio for LPG.

However, fuelwood (45% using 300-500 kg) remains in high demand among lower-income households due to its low cost and wide availability. This finding highlights the inelastic nature of demand for traditional fuels in rural and low-income areas, where price remains the dominant factor influencing consumption choices. The PCA results corroborate this by identifying affordability (0.762) and availability (0.625) as key drivers of demand for cooking energy, emphasizing that cleaner energy options like LPG and electricity require affordability and infrastructure improvements to increase their demand.

Cost-Benefit Analysis (CBA) and Household Cooking Energy

The application of Cost-Benefit Analysis (CBA) provides a useful tool to assess the economic trade-offs between different cooking fuels. Key findings reveal that LPG (57%) and electricity offer the highest benefit-cost ratios, with electricity scoring 2.08 and LPG 1.47, due to factors like improved cooking efficiency, health benefits, and reduced environmental harm. This aligns with CBA principles, as households derive greater utility from energy options with higher net benefits relative to their costs. Conversely, charcoal (37% as an alternative energy source) and fuelwood, although

cheaper (with lower direct and indirect costs), present lower benefit-cost ratios, reinforcing the classic trade-off between affordability and long-term benefits like health and sustainability.

The volume of LPG consumption further supports the CBA perspective. Households using between 11-15 kg per month (48%) demonstrate a growing reliance on LPG, driven by a perceived balance between cost and significant benefits such as time savings, cleaner air quality, and ease of access. However, affordability, as evidenced by the significant loadings in the Principal Component Analysis (0.762), remains a primary determinant of choice, particularly in rural areas where the upfront costs of LPG or electricity are barriers to adoption.

The Relative Income Hypothesis (RIH) explains how income differences shape household energy preferences, as revealed in the study. Higher-income households, particularly in urban areas, are more inclined to adopt LPG and electricity due to their higher disposable income, enabling them to absorb the higher capital and operational costs associated with these cleaner energy options. For example, households using LPG (57%) reflect this dynamic, as wealthier segments have better access to infrastructure and resources that make LPG more viable. In contrast, lower-income households lean towards fuelwood (13%) and charcoal, where the cost is minimal but at the expense of health and environmental quality.

The study's finding that 45% of households consume between 300-500 kg of fuelwood per month supports the RIH, showing a reliance on more affordable, albeit less efficient, energy options among lower-income groups. These households may face economic constraints, forcing them to prioritize immediate affordability over long-term benefits. The strong loading of government policies (0.599) in PCA emphasizes how subsidies

or financial incentives could shift these choices, encouraging a transition toward cleaner fuels.

Toward Sustainable Energy Transitions

The study demonstrates the need for a holistic approach to promoting cleaner energy transitions in the Niger-Delta region. Government policies that reduce the upfront cost of LPG and electricity, combined with infrastructure improvements, can address the demand-side constraints identified in this study. The Relative Income Hypothesis suggests that income-based subsidies could be effective, while the CBA highlights the long-term benefits of LPG and electricity. Furthermore, addressing accessibility challenges (as noted in the distance households travel to acquire energy) could increase the adoption of cleaner fuels.

In summary, the findings, supported by CBA, RIH, Random Utility Theory, and the Theory of Demand, reveal that while LPG and electricity offer significant health, environmental, and economic benefits, affordability and accessibility remain critical barriers. A sustainable transition toward cleaner energy sources will require targeted government policies, financial incentives, and infrastructure investments to make these options viable for a broader range of households in the Niger-Delta region.

In conclusion, the thesis provides a comprehensive assessment of the costs and benefits of household cooking fuel options in the Niger-Delta region of Nigeria. The proposed framework for sustainable consumption, derived from the analysis, offers a practical approach for policymakers and stakeholders to promote sustainable cooking fuel choices. By considering factors such as affordability, government policies, health and safety, energy efficiency, availability and accessibility, infrastructure and technology, cooking needs and preferences, and environmental impact, a more sustainable and

inclusive cooking fuel sector can be developed in the Niger-Delta region. The findings of this study contribute to the existing knowledge on sustainable energy consumption and can guide policy interventions and decision-making processes in the region and beyond.

To guide sustainable consumption practices, the thesis proposed a framework based on the analysis of cost, benefits, and underlying factors influencing households' cooking fuel choices. The framework emphasized the importance of considering various factors, including affordability, government policies and incentives, health and safety, energy efficiency, cooking needs and preferences, availability and accessibility, infrastructure and technology, and environmental impact. By incorporating these factors into decision-making processes, policymakers and stakeholders can develop strategies to promote sustainable and affordable cooking fuel options in the Niger-Delta region.

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Appendix

Appendix A

Consistency ratio for MCDA

Cost and Benefits	CR	R.I
Direct Cost		
Capital	0.082	1.12
Operation	0.071	1.12
Maintenance	0.093	1.12
Transport	0.056	1.12
Indirect Cost		1.12
Pollution	0.077	1.12
Waste	0.065	1.12
User Benefits		1.12
Health	0.085	1.12
Time	0.089	1.12
Benefits from Cooking Energy System		1.12
Sustainability	0.055	1.12
Avaialbility	0.064	1.12
Benefits from Cooking Energy System		
Ease of Maintenance	0.051	1.12
Ease of Operation	0.063	1.12
Safety	0.091	1.12

Multinomial Test

	χ^2	df	p
Multinomial	215	4	< .001

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1. **Total Hydrocarbon Content in Water and Sediment at Effluent Discharge Points into the New Calabar River, Rivers State, Niger Delta, Nigeria.** Journal of Scientific and Engineering Research, 2021, 8(5):1-6 2021
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