ASSESSING FACTORS THAT INFLUENCE HOUSEHOLD FUELSTACKING BEHAVIOUR WITHIN RURAL HOUSEHOLDS IN THE GONANI VILLAGE, LIMPOPO PROVINCE, SOUTH AFRICA

by

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submitted in accordance with the requirements

for the degree of

MASTER OF SCIENCE

in the subject

ENVIRONMENTAL MANAGEMENT

at the

UNIVERSITY OF SOUTH AFRICA

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FEBRUARY 2023

DEDICATION

Mama and Papa you have fostered in me a passion for learning. I sincerely hope I have made you proud as I dedicate this to you.

DECLARATION

I, Nkhensani Tiyani Precious Sithole, hereby declare that this dissertation, which I am submitting for the Master of Environmental Science degree at the University of South Africa, is my original work and that, to the best of my knowledge and belief, I have not previously submitted it for a degree at this or another institution.

I attest that all information contributed by other authors has been accounted for in the dissertation. I attest that while quoting from a published source, I have paraphrased and cited the original text. When precise words from a source were used, quotation marks and a citation to the source were included.

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Signature:  Date: February 2023

ACKNOWLEDGEMENTS

Gratitude is extended to the following persons and organizations.

Lord, it has taken me nearly six years to get here, but I have finally arrived! Indeed, even the smallest amount of faith may move mountains! Your will has brought me to a place where your grace will sustain me.

Dr. K. Semenya, your consistent support, insightful analysis, and encouraging comments over the past two years are highly appreciated. You are an incredible Supervisor, and I am grateful to have embarked on this master's journey with you. Thank you to the student funding M & D Bursary at UNISA for funding this research.

Thank you to the Xikundu Tribal Authority and Nduna Gonani for granting permission to record the stories of the villagers of Gonani Village. Hani Tsakani, you are God-sent. I appreciate everything about you and everything you've done to aid my academic advancement. Thank you and your staff for assistance with the collection of my data. To Scelo Masondo, thank you for assisting with the data analysis.

Mama and Papa, thank you for everything you've done for me and all the sacrifices you've made in order for me to be who I am and where I am now. It is not assumed as a given. I adore and value you both.

The assistance provided by my siblings is not taken for granted. To my nieces and nephews, I hope you learn something from this! To my family and friends, thank you for the support.

I am grateful to be able to call you my son, Olwethu. Thank you for being patient when mother could not play because she had to write, or for snuggling with me on the couch as I typed. I hope Mommy has made you proud.

EXECUTIVE SUMMARY

Energy is crucial to human survival since it sustains all kinds of life. Traditional/dirty/solid energy sources have given way to modern/clean energy sources in the evolution of energy sources. Some experts have noted that as a family's income rises, it is not uncommon for them to switch from utilizing traditional fuels to cleaner fuels, which can be viewed as the energy ladder. Other experts, however, feel that households do not fully leave traditional fuels when their income grows, but rather use a combination of fuels. Despite the fact that poor houses are now electrified, there is still a reliance on conventional energy sources. Even though households might convert to cleaner fuels, they continue to rely on traditional fuels, according to studies. This study aimed to determine the factors that influence the fuel storage behavior of households in Gonani village, Limpopo Province. This study was meant to help add to the knowledge gap about the factors that influence household behavior in Limpopo Province and South Africa as a whole, for which there is limited literature. A systematic questionnaire which was provided to 70 participants was utilized to study energy use patterns and the factors that determine the utilization of certain energy sources for household needs. Furthermore, observations were conducted with 25 (n=36%) of the participants to further understand the fuel stacking behaviour and probe the reasoning behind fuel stacking behaviour. Despite all the participants (n=100%) having access to electricity, households continue to rely on traditional fuels such as firewood for domestic needs such as cooking and water heating, as cooking with electricity is not viable. Furthermore, although the physical capital of the participants was assessed as part of the study, it can be asserted that the physical capital does not have an influence on households' choice of fuel. It is also evident from this study that both economic and non-economic factors (culture) influence household energy decisions and that energy reliance, energy poverty, indigenous knowledge, preferences, and lack of access to free basic electricity are the causes for households' usage of firewood. In summary, the study demonstrates that, due to socioeconomic and cultural considerations, rural households do not climb the energy ladder but instead use numerous fuels simultaneously.

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LIST OF ABBREVIATIONS AND ACRONYMS

BI	Business Intelligence
COPD	Chronic Obstructive Pulmonary Disease
DMRE	Department Mineral Resources and Energy
FAO	Food and Agriculture Organization
FBAE	Free Basic Alternative Energy
FBE	Free Basic Electricity
IEA	International Energy Agency
IDP	Integrated Development Planning
LPG	Liquefied Petroleum Gas
NEP	National Electrification Programme
RDP	Reconstruction and Development Programme
SASSA	South African Social Security Agency
SEA	Sustainable Energy Africa
SDG	Sustainable Development Goal
VDM	Vhembe District Municipality
WHO	World Health Organization

CHAPTER 1 BACKGROUND

1.1. Introduction

There are several uses for energy, with household energy being the most important. Energy is required for human living. Households consume energy for transportation, communication, recreation, cleaning, sanitation, and cooking. Energy usage varies with nation and level of affluence (Roser, 2021). High- and middle-income households use energy sources like electricity, natural gas, and ethanol (WHO, 2018). Modern energy sources are also referred to as clean energy or non-solid fuels. Households with low and very low incomes continue to rely on solid fuels or dirty fuels like coal, charcoal, firewood, crop waste, and manure for their energy needs. Modern sources of energy are more effective and environmentally friendly than conventional fuels, they are also crucial for a country's socioeconomic progress (Stanslaus, 2021).

Energy poverty refers to the absence of access to modern, sustainable energy sources. According to the World Bank (2010), energy poverty is characterized by insufficient, inappropriate, unreliable, and environmentally hazardous energy sources. According to Rosner (2021) saw the development of the Sustainable Development Goals (SDGs) by the United Nations in an effort to ensure peace and prosperity for all people. In total, there are seventeen goals. SDG 7 was created to ensure that all people have equitable access to affordable, reliable, and sustainable energy because it recognizes that a lack of access to modern energy can hinder human and economic development. According to the SDG 7 summary, approximately one billion people lack access to electricity, which severely restricts their economic potential (Rosner, 2021).

Traditional fuels are used since there are readily available and low cost. The gathering of firewood results in deforestation, which has made using traditional fuels a global problem. Furthermore, the burning of traditional fuels in inefficient stoves releases dangerous gases that eventually lead to environmental deterioration and indoor air pollution. According to Parere (2018) and WHO (2021). The burning of solid fuels indoors exacerbates health problems such respiratory conditions and diseases. Over 2.9 billion people in rural areas still use solid (traditional) fuels such wood, branches, twigs, animal dung, coal, gas,

and kerosene for household tasks in spite of these health risks such as respiratory disorders, stroke and asthma (Kojima, 2022, Makonese, *et al*., 2017 & Stanslaus, 2021). Burning solid fuels causes rural households' social issues, such as impacts on health for the rural households, in addition to environmental ones. The gathering, processing, and transporting of traditional fuels is time consuming, which places additional limitations on opportunities for productive work and education, particularly for women and children, support gender inequality in rural areas (Sole, 2015).

SDG 7 aims to give everyone access to affordable, dependable, sustainable, and clean energy sources in recognition of the need for equal access to energy. Governments are encouraged by the SDG 7 goal to launch efforts and programs that aid households in switching from biomass fuels to cleaner fuels (Ochieng, 2020). Nevertheless, despite the success of some initiatives, households still use traditional fuels on occasion. They have, however, incorporated modern technology while retaining more traditional ones. (Imran & Ozcatalbaş, 2016 & Yadav *et al*., 2021) discovered that, contrary to the energy ladder hypothesis, households' energy choices, behaviors, and transitions do not adhere to a linear switching process from one energy fuel to another. Instead, households will gradually migrate to alternative fuels or will amass and use a variety of fuels, using conventional fuels for chores like cooking and contemporary fuels for recreation. Utilizing several fuels or blending various fuels is known as fuel stacking. Numerous studies have emphasized the significance of socioeconomic factors in determining whether households depend on one fuel or a combination of fuels (Makonese *et al*., 2017 & Chaudhuri,2021). Power access, household size, educational attainment, and wealth index are only a few examples of socioeconomic characteristics.

In South Africa, where the government has established free basic electricity programs to help impoverished rural households cope with high electricity costs, rural electrification has attracted a lot of attention (Makonese, 2012 & Meyer, 2021). Rural households still use traditional fuels like firewood for cooking and heating as well as kerosene for lighting, which has negative effects on the environment, human health, and society (Stanslaus 2021 & WHO, 2021). The goal of this study is to identify the variables that that influence people's fuel use patterns in relation to fuel stacking in Gonani, Vhembe District Municipality, Limpopo. The interaction of cultural factors that affect the choice and use of energy sources is also examined in this study. This study was informed by the results of research done in Mexico and India, which showed the importance of focusing not only on the energy ladder but also on the cultural

factors that affect fuel selection behavior (Masera *et al*., 2000; Joon *et al*., 2009). Similar to that, this study looked into how cultural influences might influence fuel stacking habits in the Limpopo hamlet of Gonani.

1.2. Problem statement

According to the Vhembe District Municipality (VDM) Integrated Development Plan (IDP) for 2020–2021, 93% of homes in the Vhembe District have access to electricity. Despite high rates of household electrification, most homes still utilize traditional fuels for heating, lighting, and cooking. The absence of suitable electrical appliances makes this worse. The use of conventional fuels contributes to indoor air pollution, a serious public health concern that can result in conditions like pneumonia, stroke, ischemic heart disease, COPD, and lung cancer (WHO, 2022). There have been about 3,4 million fatalities as a result of these diseases (WHO, 2022). Rural women and children make up the majority of this population (Medina *et al*., 2019). In addition, traveling long distances to gather firewood puts women and children in danger of being attacked by wild animals or raped (Longe, 2021). The use of kerosene, animal manure, and firewood leads to interior and outdoor air pollution, changes to the forest's conservation status, and deforestation (Maeleka, 2016). These energy sources can produce pollution that starts in the kitchen, moves to other areas of the house, and eventually ends up outside.

There are many reasons why households prefer to use multiple types of energy, according to earlier studies by Smith and Pillarsetti (2017), Uhunamure (2017), and Semenya and Machete (2019). Nevertheless, their outcomes vary. For instance, while Smith and Pillarsetti (2017) discovered that even when superior technology, in this case electricity, are made available, people do not immediately accept them, Semenya and Machete (2019) link the utilization of energy sources to indigenous and social perceptions. According to Uhunamure (2017), fuel replacement is not feasible in low- and middle-income countries. The findings of the research stated above indicate that households stack fuels and do not always give up the most traditional fuels. Consequently, the goal of this study is to understand fuel stacking behavior in the Limpopo community of Gonani.

1.3. Rationale and significance of the study

Energy is vital for supporting human existence in all of its forms, including daily food, necessary domestic energy, and the energy we require to live (DoE, 2016; Maseleka, 2019). Despite the electrification of impoverished homes, there is still a reliance on conventional energy sources, which has detrimental effects

on the environment and human health due to indoor pollution as well as increasing carbon emissions and the logging of forests (Kimutai *et al*. 2019).

Due to the reduction in biomass energy supply brought on by agricultural practices, fuelwood collecting, and other resource exploitation (Idiata *et al*. 2013), people now have to work harder to find fuelwood and frequently travel great distances to acquire it. The type of energy sources used by households has changed for a number of reasons, not just the scarcity of biomass resources. Other considerations include the amount and volatility of energy prices, household income, socioeconomic status, household size and structure, gender, and cultural influences (Heltberg, 2005; Kimutai *et al*. 2019).

The energy ladder and fuel stacking are two theories for the energy transition. According to the energy ladder theory, as a household's income rises, they should convert to more modern energy sources (Uhunamure *et al*., 2017). The utilization of various fuel kinds is referred to as "energy stacking." Despite having the option to transition to cleaner fuels, households continue to utilize traditional fuels for domestic purposes because of social issues (Masera *et al*., 2000; Gatama and Planning, 2017; Kimutai *et al*., 2019). Households also use a variety of fuels to increase their energy security.

Studies have shown that low and middle-income countries do not experience fuel switching or substitution. Instead, households utilize a range of fuels (Sepp, 2014; Hoffman, 2015; Uhunamure *et al*., 2017; Semenya and Machete, 2019). There are relatively few studies on the causes of household fuel stacking, leaving a void in the literature, even though many studies indicate that families are not giving up on their traditional energy systems and fuel options. (Ochieng *et al*., 2013; Medina *et al*., 2019; Ruiz-Mercado and Masera, 2015; Gordon and Hyman, 2012). As a result, the study can help fill in the knowledge gaps about the causes of fuel stacking behavior while also enhancing energy policy for households in the Vhembe District of Limpopo.

1.4. Research aim and objectives

The main aim of the study was to assess factors that influence household fuel-stacking behaviour within rural households in the Gonani Village, Limpopo Province, South Africa.

From the research aim, the following objectives for the study have been formulated:

i. Determining the types of fuels that are being used in households;

ii. Examining the role of income in types of fuel being used;
iii. Examining the role of culture in types of fuel being used; and
iv. Identifying the role of family size in fuel choices.

1.5. Chapter outline / Research outline

This dissertation consists of five chapters and is organised as follows:

- Chapter 1: Provides a background and overview of stacking behaviour of fuels. The problem statement of the study has been defined. It also contains a rationale for the research study and the objectives that have been formulated for the study,
- Chapter 2: Contains a summary of the literature reviewed. Literature on South African energy sector, household energy use patterns, energy poverty, energy transition and energy stacking, and factors determining household energy use were reviewed.
- Chapter 3: This chapter introduces the study area. The research methodology used has been defined. The research methodology includes the research design and a description of the methods used for sampling and data collection. In addition, this chapter explains the ethical considerations that were made for this study.
- Chapter 4: This chapter analyses and presents the data collected. In addition, the results were discussed in detail.
- Chapter 5: This chapter presents the results of the study and the limitations encountered. Recommendations are made where appropriate, particularly with regard to future research on stacking behaviour.

CHAPTER 2 LITERATURE REVIEW

2.1. Introduction

Despite the fact that energy is regarded as the foundation of human survival, not everyone has access to sufficient and inexpensive energy sources. Energy accessibility is unmistakably and frequently related to the advancement of society and the economy. As a result, less developed nations get the worst energy services, which increases starvation, bad lifestyles, and restricted access to jobs and education. Approximately 1 billion people globally, mostly in Africa and South Asia, lack access to electricity, according to the IEA World Energy Outlook (2018).

It should be mentioned, though, that in places like East Asia and Latin America, where power infrastructure growth has increased access to energy, the situation has greatly improved. Significant advances in access to electricity have also been observed in nations including Indonesia, Bangladesh, Kenya, and Ethiopia. "Despite this development, it is projected that 2.7 billion people globally do not have access to clean cooking facilities, forcing them to rely on solid fuels like biomass, coal, and kerosene as their main source of cooking fuel" (IEA World Energy Outlook, 2018). Although attempts are being made to meet the SDG 7 target, obstacles like geography prevent this goal from being accomplished. Rural areas require electricity, but grid power supply is constrained since it is frequently impossible financially and logistically to bring electricity to rural communities.

To strive and accomplish SDG 7, programs have been developed. For instance, The World Bank has created a $50 million Clean Cooking Fund. This fund intends to hasten the switch to contemporary cooking energy sources by using the World Bank Group and other financial resources including private sector investments. Unfortunately, although being widely considered as successful, programs like this have not yet been able to totally wean households off of using conventional stoves and fuels. However, the World Bank (2020) found that stove and fuel stacking is typical across all cookstove projects in a recent systematic review.

In Brazil, the 1970s saw the conversion of cooking fuel, yet LPG stoves are still utilized alongside firewood burners, according to Coelho and Goldemberg (2013). Although there are more clean fuel options accessible in the Kathmandu Valley of Nepal, the continuous usage of solid fuels due to the time requirements involved with fuel collection contributes to energy poverty (Sunil, Prasad & Lohani, 2020). Nearly all of the households participating in a successful LPG program in Mexico have reported continuing to use firewood for cooking (Troncoso *et al*., 2019). A massive LPG replacement program for electric stoves in rural India did not have an impact on the switch from conventional wood stoves as the primary cooking technology (Banerjee, 2016).

Numerous studies have been conducted that show households do not entirely abandon their previous technology and fuels (Gordon & Hyman, 2012; Medina *et al*., 2019; Ruiz-Mercado & Masera, 2015). Fuel stacking, according to Banerjee *et al.* (2016) and Coelho & Goldemberg (2013), is a rationing and backup plan for clean fuels. This might be as a result of accessibility or affordability. Other research have linked household variables, like family size, to fuel-stacking behavior. According to Ochieng *et al*., there are various motivations for fuel stacking choices, and this technique is environment-specific (2020).

Even though rural Indian households have access to modern energy, research undertaken in some parts of India examined how they stack various fuels. The study emphasized the importance of socioeconomic factors in determining whether households rely on a single fuel or a variety of fuels, such as biomass or kerosene over LPG for cooking (Choudhuri, 2021). According to the study, an increase in household size, an increase in the age of the household head, and an increase in education levels all have an impact on fuel-stacking behavior. Despite a successful fuel transition program, LPG is still used in households in Indonesia in addition to traditional fuels (Thoday *et al*. 2018).

Although Tanzania has a variety of energy sources, such as natural gas, hydropower, and solar energy, the majority of Tanzanians still utilize firewood and charcoal since it is less expensive than modern energy sources for domestic tasks like cooking. Concerns regarding deforestation and harm to Tanzania's forests arise from the usage of solid fuels (2021). The utilization of solid fuels varies by region in Tanzania. Since forests are typically found in rural regions, firewood is readily available to households. Additionally, there is no tax on firewood, which encourages households to use it more frequently than charcoal. Despite having access to electricity, households in Tanzania, according to a study by Choumert, Motel, and Le

Roux (2017), still chose charcoal and firewood as their primary sources of energy for cooking. This is due to the expense of upgrading infrastructure when shifting energy sources.

Approximately 80% of the study region in Ethiopia had access to grid energy in 2022, according to a study there (Tucho *et al.*, 2022). Participants in the survey voiced complaints about both the frequent power outages and the erratic grid electricity supplies. Because of this, households frequently use firewood and charcoal as their primary sources of energy for cooking. However, more than 98 % of respondents said they used electricity for lights. The devices, however, are probably only available to people with a private electricity connection (Tucho *et al.*, 2022).

Despite the introduction of electricity, research by Madubansi and Shackleton (2007) in South Africa indicated that around 90% of rural families still utilize firewood for domestic functions like cooking. According to a study done in Potchefstroom by Ateba, Prinsloo, and Fourie (2018), high-income and low-income households had different fuel preferences. Households with higher incomes typically use more advanced energy sources than those with lower incomes. Low-income households use kerosene for cooking, firewood for cooking, and electricity for lighting while high-income households use electricity for lighting, cooking, and space heating. Additionally, socioeconomic characteristics like family size, educational attainment, and the household head determine decision; for example, larger households choose biomass for heating and LPG for cooking (Ateba, Prinsloo & Fourie, 2018).

Sole (2016) asserts that residents in Soshanguve, Gauteng, South Africa, have simple access to and a large range of fuel options. The availability of fuelwood in backyards or surrounding bushland has an impact on how much is used by homes. According to study participants, using firewood helps to preserve cultural history and is a part of their roots and heritage. Everyone who participated in the survey acknowledged having access to power, which is provided to the neighborhood on behalf of Eskom. They primarily utilize electricity for lighting and television since they view it as a finite energy source that shouldn't be wasted. As a result, the study's participants opt to use other fuels in addition to electricity.

In the Thulamela Municipality of Limpopo, Altein, Botsoleni, Makovha, and Thenzehni were the sites of research carried out by Uhunamure in 2017. According to the report, villages have access to both electricity and firewood as sources of energy. Even though the communities had access to electricity, they

primarily used firewood because both forms of energy are crucial. The study came to the conclusion that "a variety of socioeconomic characteristics, including household income, education level, occupation, household size, employment, accessibility, location, and cooking preferences, had an impact on the usage of firewood relative to electricity."

2.2. Energy ladder vs fuel stacking

Scientists have two primary theories to explain home energy preferences. The energy ladder and fuel stacking are two of these hypotheses. Below is an analysis of both theories.

2.2.1. Energy ladder

Science explains home energy preferences and the energy transition process using two key hypotheses. These hypotheses consist of fuel stacking and the energy ladder (refer to **Figure 2.1**). The following analyzes both theories.

Stage 1: Traditional fuels are heavily used by households as their main energy source. These households, which fall into the category of being poor or extremely poor, cannot afford contemporary fuels.

Stage 2: Households start using fuels like kerosene, coal, and charcoal as their income rises.

Stage 3: In this stage, households start using cleaner, more advanced energy sources for residential requirements like lighting and cooking, such as LPG and electricity.

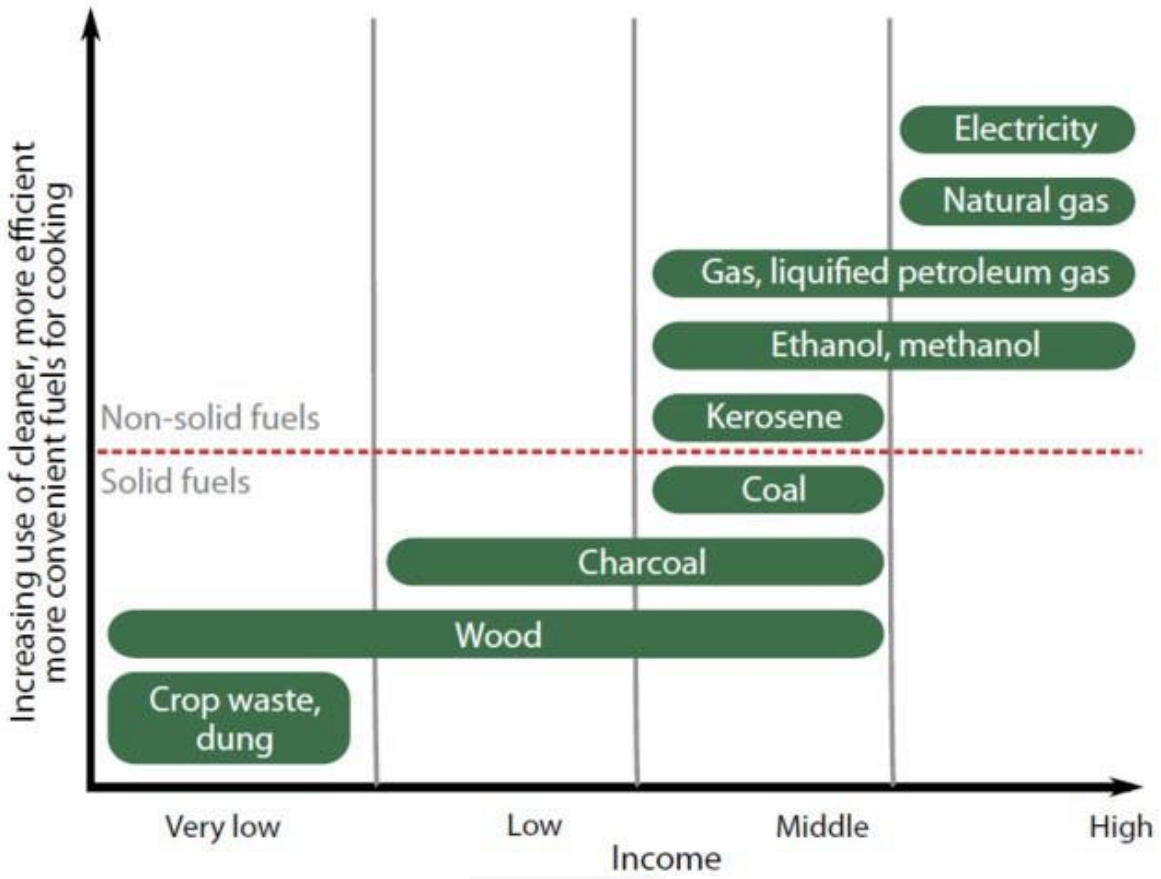

Figure 2.1: The energy ladder theory (Paunio, 2018)

The energy ladder is substantiated by a 1987 study by Hosier and Dowd, who looked at urban Zimbabwean families. The study came to the conclusion that these households tended to convert from wood to kerosene and electricity as income increased. Similar to this, higher-income households in Burkina Faso chose for natural gas as their energy source (Ouedraogo, 2006). As household income rises in Nigeria, kerosene, natural gas, and electricity replace traditional fuels (Baiyegunhi and Hassan, 2014).

Empirical research has shown that household fuel choice is significantly influenced by income (Van der Kroon *et al*., 2018; Baek *et al*. 2020). The energy ladder concept, however, has been challenged by other studies, which have discovered that household fuel choice is influenced by a variety of socioeconomic characteristics, including age, gender, education level, and employment status. Researchers further point out that the energy shift is not a progressive process, which casts doubt on the concept. Nevertheless, a number of fuels are employed concurrently.

According to research done in Maun, Botswana, not all households adhere to the energy ladder model because most use fuelwood for reasons unrelated to their degree of income (Hiemstra *et al*., 2008). An increase in income may potentially result in an increase in demand for conventional fuels, according to Kebede (2002) and Uhunamure (2017).

2.2.2. Fuel-stacking theory

Fuel stacking theory contends that household energy decisions, actions, and transitions, particularly in low and middle-income countries, do not correspond to an energy ladder theory-explained linear switching process from one energy source to another (Uhunamure, 2017). Households diversify their energy profile by employing a variety of fuels rather than transitioning from traditional fuels to modern fuels. The primary driver of fuel stacking is unrelated to rising income (see **Figure 2.2** below for a diagram depicting fuel stacking theory).

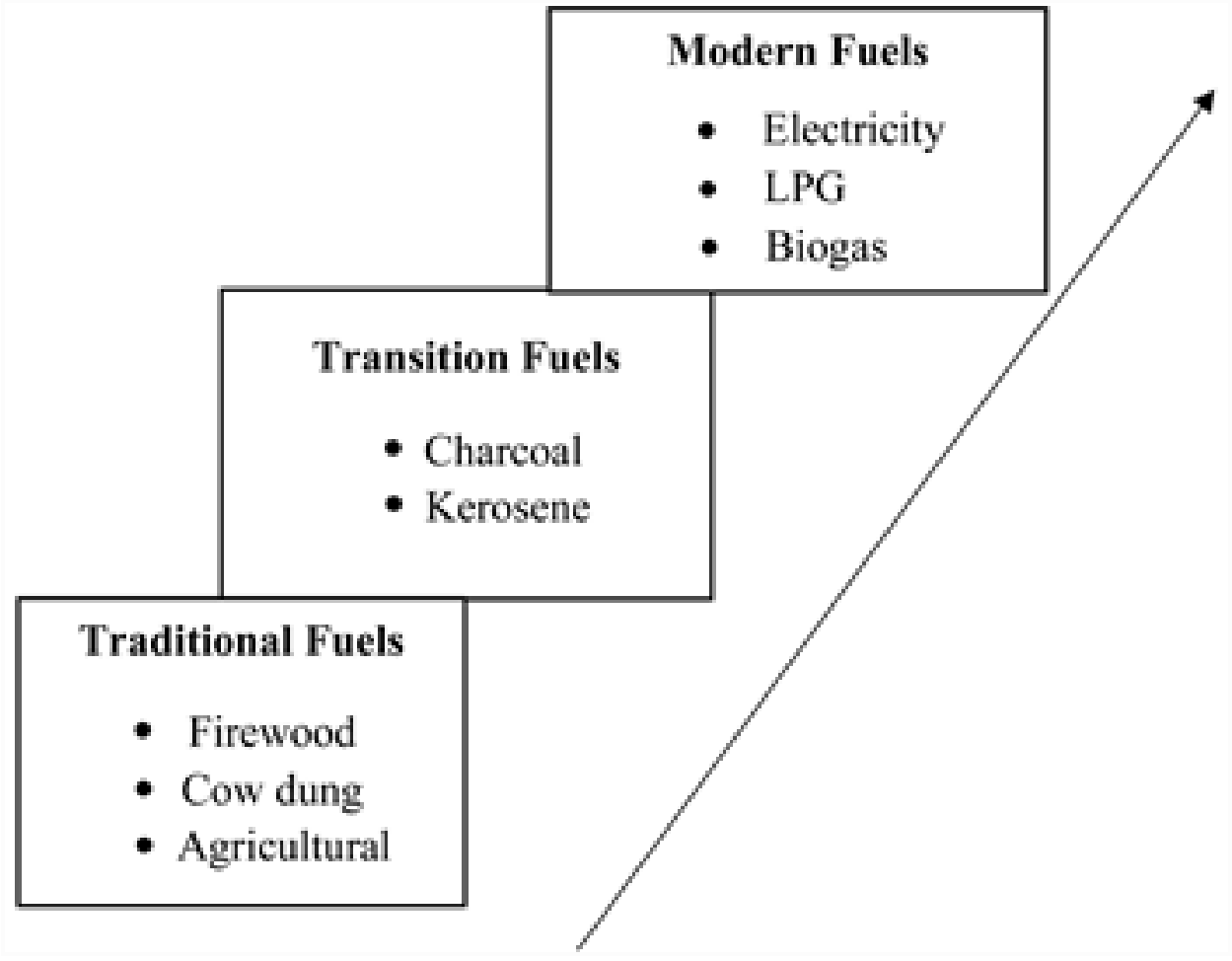

Figure 2.2: Diagram depicting the fuel-stacking theory (Source: Sole, 2015)

The fuel stacking behavior investigates why families choose alternatives other than those given by the energy ladder theory. Availability and accessibility of energy sources, family size, the high cost of electric appliances, heightened safety precautions, a risk mitigation strategy, and the work status of the head of the household are all factors (Sole, 2015). These factors can affect a household's propensity to move from traditional to modern fuels. In addition, according to the fuel stack hypothesis, various energy sources are utilized in complex ways for a given purpose. According to Sole (2015), the transition to contemporary fuels should be considered as a supplement to old fuels, not as a replacement for them.

Different homes often meet their energy needs with fuels such as coal, firewood, kerosene, LPG, solar energy, and electricity. Many studies suggest that homes in low and middle-income countries utilize a combination of fuels rather than contemporary energy sources (Uhunamure, 2017; Van der Kroon *et al*., 2018 & Baek *et al*. 2020). According to Masera *et al*. (2000) and Heltberg (2005), the varying fuel consumption patterns of various households are the result of complex interactions among economic, social, and cultural factors. Domestic usage of various fuels has become commonplace, and the introduction of contemporary fuels does not necessitate the replacement of traditional fuels.

It is essential, when assessing fuel stacking, to examine the many reasons why households utilize energy sources. These include, among others, cooking, lighting, heating, and entertainment. Additionally, households use energy for social purposes.

2.2.3. Factors influencing fuel choices

A household's decision to utilize a specific fuel is influenced by a number of factors. These factors include household income, family size, the high cost of electrical appliances, cultural preferences, fuel availability, cooking, and consumption patterns. In addition, economic considerations (such as household income) and non-economic factors (gender, level of education, type of dwelling, age of household, distance to fuel source, and access to electricity) influence fuel selection (Sepp, 2014).

2.2.3.1. Economic factors

Initially, the economic activity category was believed to be the most influential factor in a household's choice of fuel source.

It is believed that household income has a significant impact on fuel selection, as family income levels and fuel selection are closely associated. According to Faisal *et al*. (2013), the baseline for energy fuel selection is household income. According to a study conducted in Ethiopia, the use of power and charcoal grows with income. This shows that households with higher incomes prefer cleaner fuels than those with lower incomes who rely on fuelwood and crop wastes (Wassie *et al.* 2021). This result is supported by the findings of Katutsi *et al.* (2020), who found that households with higher average monthly earnings use contemporary fuels, whereas households with lower average monthly incomes rely on traditional fuels.

Even wealthy homes with access to electricity have not abandoned the use of firewood and agricultural leftovers, despite the fact that the usage of firewood as a primary energy source diminishes as income rises. In addition to contemporary energy sources, people continue to utilize traditional fuels in lesser quantities. This is due to the unreliability and irregularity of modern energy sources as well as the dependability of traditional energy sources. Additionally, flavor preferences, fuel availability, and household customs may influence burning behavior (Wassie *et al*. 2021).

According to a study conducted by Uhunamure (2017) in Thulamela Municipality, persons with lower incomes spend more time gathering firewood to meet their energy demands. People with a middle income rely primarily on conventional energy sources but have shifted to more contemporary energy sources.

2.2.3.2. *Non-economic factors*

In prior studies of household fuel choice, primarily economic factors were utilized to examine fuel choice patterns; however, non-economic factors have become increasingly prominent in fuel choice research. The non-economic aspects of fuel selection are covered in the following section.

2.2.3.2.1. Age

The age of members in a family influences the choice of fuel. Jaiswal & Meshram (2021) and Tchereni (2013) concluded that the age of the head of the home determines the fuel choice of the household.

According to the study of fuel use in Ghana undertaken by Kwakwa and Wiafe (2013), rural families reported a negative correlation between age factors and the choice of using fuelwood. This is also supported by research conducted in Guatemala, which found that elderly households are more likely than younger ones to utilize firewood for cooking. Older household heads favor traditional cooking fuels, but younger household heads choose modern cooking fuels (Katutsi *et al*., 2020).

According to a study conducted by Nlom & Karimov (2014) in Northern Cameroon, the age of the household head has a negative correlation with the use of clean fuels. According to a study conducted in Uganda, as household heads age, they resort to traditional fuels out of habit (Katutsi *et al*, 2020).

2.2.3.2.2. Gender

In patriarchal society, women are typically expected to undertake the majority of housework, including cooking and cleaning. Gender has a significant impact on fuel selection. According to Ateba (2018), in households where the man is the primary breadwinner and decision maker, the costs and benefits of clean cooking fuels may be neglected. Furthermore, culture and tradition may discourage female-headed households from embracing contemporary energy technologies.

Because female-headed homes tend to be poor and less able to afford power connections or cleaner fuels, women choose to cook with charcoal and firewood. Due to cultural and legal constraints imposed on women, female-headed households may also be disadvantaged. In remote locations in Tanzania, households led by women are more likely to store fuel (Negesse. *et al.* 2020). In contrast to female-headed families, male-headed households are more likely to utilize LPG and kerosene for cooking than firewood, according to Ogwumike *et al*. (2014).

Zhang and Hassen (2014) and Wu *et al.* (2017) found from their research that female-headed households prefer traditional fuels or a combination of fuels. Female-headed households are more aware of the dangers of utilizing traditional fuels. Moreover, women decided to utilize enhanced biomass stoves

because they conserve fuel. This suggests that households led by women are concerned with cost savings.

2.2.3.2.3. Education

It is assumed that the level of education of the head of the household influences the choice of fuel in the home. According to a study undertaken in Ghana by Karakara (2019), educated people are more likely to have better occupations and earn more salaries than illiterate people. Additionally, educated persons may be aware of the health risks linked with traditional fuel use.

This is confirmed by Mensah and Adu's (2014) and Ogumike *et al* (2014).'s findings that education enhances the likelihood of utilizing clean fuels. According to a study by Katusi (2020), the household head's level of education is likely to impact the selection of modern and transitional fuels over traditional fuels. Higher household education levels may result in increased household income, improved taste, and fuel knowledge. Additionally, households with a high level of education are likely to have more time to collect firewood. The study found that household heads with a college education were more likely to utilize contemporary fuels, but those with a basic education were more likely to use traditional fuels.

2.2.3.2.4. Marital status

The FAO (1997) defines a person's marital status as being either married, single, or divorced. Relationship status influences fuel selection. According to FAO (1997) and Maseleka (2019) discovered that married couple households cook more frequently than single and divorced households. This indicates that they choose readily available and inexpensive energy sources, such as firewood. This is supported by a study conducted in Kenya by Baek *et al.* (2020), which indicated that married households tend to have higher expenses than single households and, as a result, must rely on cheaper fuels.

2.2.3.2.5. Employment status

Employment status is crucial for gauging the economics and energy consumption of a society (Uhunamure, 2017). The link between income and employment status is very substantial. Due to affluence, employed households are more likely to consume contemporary energy, such as electricity.
Employed and self-employed households utilize contemporary energy sources to some extent, but unemployed households rely more on conventional fuels (Uhunamure, 2017).

2.2.3.2.6. Household size

A household's energy use and fuel choice are determined by its size. It may also indirectly encourage households to engage in energy switching and stacking (Kowsari and Zerriffi, 2011; Ateba, 2016). Mensah and Ado (2013) and Tchereni (2013) found that household size had a negative effect on the likelihood of households utilizing clean fuels as opposed to conventional fuels. Smaller households are more likely to use clean fuels, while larger households are more likely to use traditional fuels.

According to a study by James *et al*. (2020), the number of basic cooking fuels consumed rises with the size of the household but reaches a maximum. The first increase can be attributed to family members being available to collect firewood. It is also corroborated by the findings of Zhang *et al.* (2014), Ado *et al.* (2016), Muller (2016), and Wu *et al.* (2017), who found that a bigger household size is connected with a greater likelihood of using firewood as the major cooking fuel.

In contrast, Ouedraogo (2006) and Ogwumike *et al.* (2014) discovered a correlation between household size and LPG consumption. Increasing household size can increase the amount of food that must be cooked, necessitating increased cooking energy.

2.2.3.2.7. Distance to fuel source

According to a study conducted in Ethiopia, the choice of fuel for families diminishes with distance from the fuel source. According to a study conducted in Malawi by Jumbe and Angelson (2007), the distance to a fuel source is one of the most significant drivers of fuel selection.

Rural communities in low and middle-income countries have access to numerous energy sources, including woody and non-woody biomass, coal, charcoal, and liquefied petroleum gas (Uhunamure, 2017). This permits the use of one or more of these fuels for home activities such as cooking, water heating, space heating, and lighting.

According to Semenya and Machete (2019) and FAO (2017), distance determines the availability of fuel. Accessibility and availability of fuel have a significant impact on household fuel selection.

2.2.3.2.8. Socio-cultural preferences

Household energy choices are linked to socio-cultural preferences, such as wealth, religious belief and cultural beliefs. One of the many factors that prevent a shift towards cleaner energy fuels is cultural preferences and acceptance. According to Nissing & Van Blottnitz (2010), cultural choice and preferences may result in fuel stacking rather than shifting to safe energy sources. Low-efficiency and polluting fuels may be used due to local practices, even though they may be modern energy sources that are available for use.

Girls learn to cook at a young age by actively engaging and observing their mothers and grandmothers, according to Ndege (2007). Adult women can therefore embrace this method of cooking. According to studies by Joon *et al*. (2009) and Uhunamure (2017), rural households prefer cooking with firewood because they believe it has a superior flavor. In addition, consumers have preconceived notions regarding a product and whether or not they will use it. Cooking with firewood is culturally significant since it displays a woman's higher status and superior cooking skills (Tamire *et al*., 2018).

2.2.3.2.9. Type of dwelling

The type of dwelling may be a housing complex or a rented or owned single residence. These arrangements are likely to affect the household's choice of fuel for cooking and lighting (Rahut *et al.*, 2014). Consider the number of rooms, the shared nature of the home, the expense of upkeep, the lighting, and the materials used for the walls, floors, and roof. According to the data analysis, the usage of firewood is more prevalent than the use of electricity.

2.3. Conclusion

Although certain scholars such as Faisel *et al.* (2013) and Wassie *et al.* (2021) have concluded that fuel stacking behaviour is associated with economic factors such as a family's income levels. Other scholars have attributed fuel stacking behaviour to non-economic factors such as age, gender, family size and marital status etc. (Nlom & Karimov, 2014; Ateba, 2018; Katutsi *et al*., 2020). From the review of literature, it can be deduced that there are a wide range of factors that influence fuel-stacking behaviour. Fuel stacking behaviour is not only influenced by economic factors and the need for energy security; however, it is also influenced by cultural and social factors (Nissing & Van Blottnitz, 2010; Uhunamure, 2017).

CHAPTER 3 RESEARCH METHODOLOGY

3.1. Description of Study Area

Gonani Village is a small community within the bigger community of Xikundu. It is located in Limpopo's Collins Chabane Local Municipality (Vhembe District Municipality). Gonani village is located at 22°49'35.52" S / 30°47'21.83" E and is comprised of approximately 85 homesteads and 425 people. It is governed by an induna chief who is subordinate to Chief Xikundu. It is situated in the northeast of South Africa, approximately 100 kilometers from Zimbabwe and 20 kilometers from the Punda Maria Gate of Kruger National Park. 6 to 7 kilometers separate the community of Gonani from the nearest paved road. Gonani village is the most impoverished of the eleven communities in Xikundu. Refer to **Figure 3.1** for Google's location map:

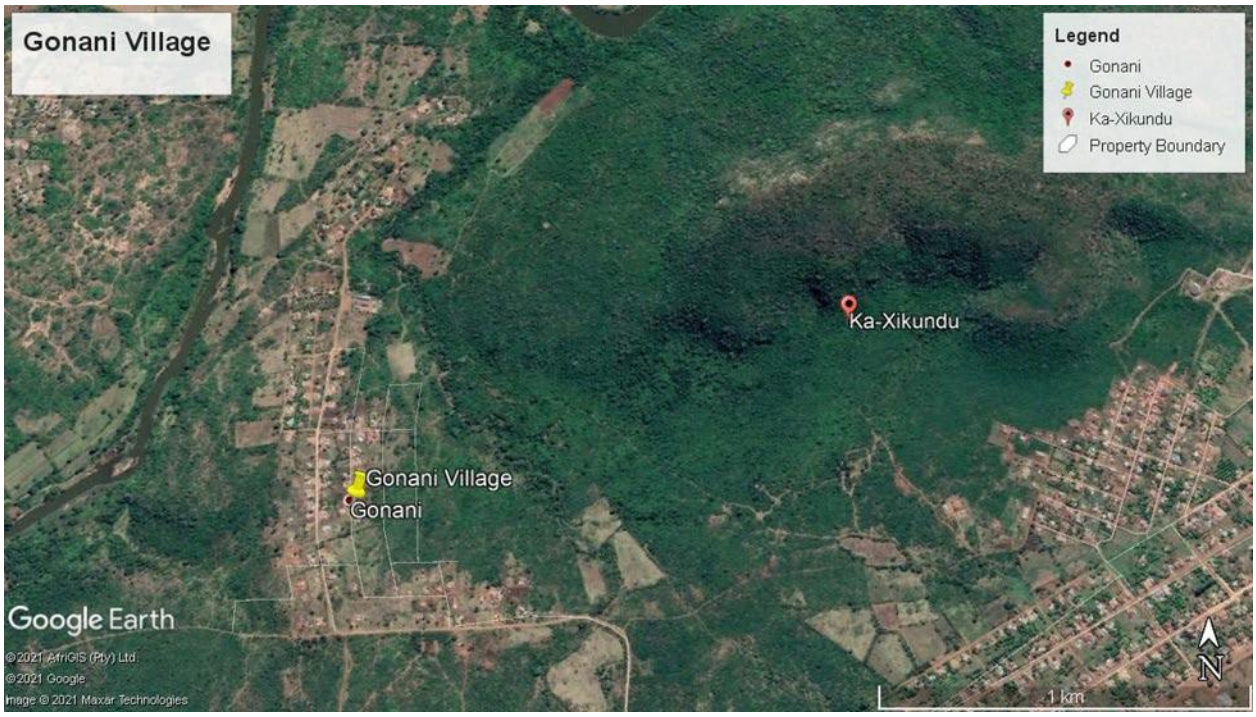

Figure 3.1: Gonani Village location - Google Location (Source: Google Earth)

Figure 3.2: Gonani Village location (indicated in by the red star) (Source: SA Places)

3.1.1. Energy

Approximately, 93% of families in Vhembe District Municipality have access to electricity, while 4.06 % do not, according to the Vhembe District Municipality IDP Review (2020). This implies that Eskom and Vhembe District Municipality are doing a good job ensuring that all homes in the district have access to energy as electricity providers.

The Lambani Substation provides electrical service to the study area. However, the substation faces issues such as transformer theft, cable theft, illegal connections, meter tampering, and bypassing 93% of families in Vhembe District Municipality have access to electricity, while 4.06 % do not, according to the Vhembe District Municipality IDP Review (2020).

3.2. Sample size

The formula for calculating sample sizes is simplified by Yamane (1967). This algorithm yields a 95 % confidence level and a 5 % error margin. In Gonani village, there are approximately 85 homes and 425 inhabitants. This is how the sample size was calculated:

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

Where;

"N is the population size, n is the sample size, and e is the error margin."

Therefore;

$$nn = \frac{85}{1 + 85(0.05)^2}$$

$$= \frac{85}{1 + 0{,}2125}$$

= 70 households

According to Freund and Williams (1983), Nyakiriri (2009), and Maseleka (2019), a statistical base size equal to or larger than 30 is acceptable. This sample size takes into account the risk of non-response (which might be as high as 40 to 45 %), which could be due to respondents limited financial resources, the nature of the survey, and the time required to complete it.

3.3. Sampling

The research employed convenience sampling. This method of sampling utilizes respondents who are easily located for the researcher, as the community was accessed through preexisting relationships. There was no pattern to the collection of responses. According to Saunders *et al*. (2012), this method has the advantage of being able to collect data in a short amount of time and is one of the most cost-effective sampling techniques.

3.4. Study Design

This study employs a descriptive research approach and is expected to give statistical data as well as information on the types of fuels utilized and the reasons for fuel selection. This study employed a cross sectional study design by using both qualitative and quantitative methods to ensure that it was conclusive and exhaustive.

3.4.1 Qualitative approach

McMillan and Schumacher (1997) define qualitative research as a method of gathering data through face-to-face interviews with selected individuals in their familiar environments in order to determine whether socioeconomic and cultural factors influence their experiences and behaviors. It is a blended strategy that combines an interpretive and naturalistic approach to the topic (Denzin and Lincoln, 2011). Through in-depth interviews, focus group discussions, observation and content analysis, visual techniques, and personal stories, the qualitative approach investigates human experiences comprehensively.

According to Denzin and Lincoln (2011), qualitative research enables the researcher to find themes from the participants' points of view and comprehend the meanings and interpretations they assign to behaviors, events, or objects. The qualitative method was suitable for this study since it allowed the researcher to investigate the perspectives of the participants through observations and interviews. This study employed a narrative inquiry as its methodology. This instrument was utilized because to its interpretative nature. According to Deem (2002), narrative inquiry entails the use of themes, vocabulary, and research methods that do not empower participants but do acknowledge their silenced voices and employ the researcher as a storyteller. According to Sole (2015), narrative inquiry focuses on how individuals or groups interpret the events and acts of their life. Due to the importance of socioeconomic factors, household features, and cultural aspects on fuelling behaviors, this methodology was well suited for the study. Using the narrative

inquiry, the researcher was able to determine the fuel stacking motivations of the participants.

3.4.2 Quantitative approach

Various authors have varying definitions of quantitative research (Leedy, 2011; Cohen, *et al*., 2011). This form of research entails the gathering, evaluation, and analysis of numerical data collected through experiments or surveys using organized or unstructured questionnaires (Leedy, 2011).

Using the participant questionnaire, quantitative data were collected, analyzed, and interpreted for this study. Three components were included in the questionnaire: Included demographic information such as age, gender, nationality, level of education, income, occupation, household size, etc. The second segment addressed the respondents' energy sources, such as firewood, electricity, kerosene, cow manure, etc. The third and last portion addressed the type of energy consumption (cooking, heating, space heating, lights, etc.).

3.5. Data collection

Primary and secondary data collection approaches were employed for the research. Observations, questionnaires, and interviews were employed to obtain primary data. Articles, theses, dissertations, journals, websites, and books constituted secondary sources of information. Three methods were utilized to collect data, namely, a pilot study, administering an observation checklist and administering interviews via a questionnaire.

3.5.1. Pilot study

In December 2021, a preliminary site visit (pilot study) was held in the selected hamlet, allowing for an assessment of the study area's breadth and observation of existing conditions. At this point, communication with the local chief was made. A series of questions were developed to elicit information from village leaders through direct conversations. Among the data gathered from local leaders were the following: How many houses have access to electricity, and what types of traditional fuels are used? This phase also allowed for the recruitment of resident assistants to assist with fieldwork. With the assistance of two field assistants, the primary fieldwork was undertaken in June 2022.

3.5.2. Observation

Observations may be either open or hidden. Overt observation is when participants are aware they are being observed, whereas covert observation is when participants are unaware, they are being studied (Cohen *et al*., 2011). Overt observations are advantageous because individuals are more likely to behave normally when they are unaware of being observed.

Nonetheless, open observations were undertaken for ethical concerns. Cohen *et al*. (2011) also point out that observations can be direct or indirect. Indirect observations may utilize recording equipment such as cameras, whereas direct observations require the presence of the observer. This investigation involved both direct and indirect observations. Observations included accompanying participants while they gathered firewood in the forest. Participants opened their homes to the researcher. The researcher observed the participants preparing lunch and those that went out to collect firewood. During the observations discussions were had with the participants. The Observation Checklist that was used has been attached as **Appendix C**.

3.5.3. Questionnaire

There were both closed and open-ended questions on the surveys. Closed-ended questions provide the respondent with a list of options from which he or she must select the one that most accurately represents his or her facts or opinions. The use of closed-ended inquiries is prevalent when requesting background information and statistical data. This study favored the use of open-ended questions since they allowed respondents to make longer responses.

Closed-ended questions included straightforward inquiries on gender, age, family size, and education level. Participants' comprehension of the sorts of energy sources and the social, environmental, and health challenges related with traditional fuels was enhanced through the use of open-ended questions. The Questionnaire that was provided to the participants has been attached as **Appendix D**.

3.5.4. Literature

Articles, thesis, dissertations, journals, websites, and books, both published and unpublished, were used to collect secondary data. A literature study was done to evaluate residential energy consumption patterns and factors impacting fuel selection. In addition, past studies were referenced in order to comprehend fuel

storage patterns in Africa, South Africa, and the province of Limpopo.

3.6. Data analysis

The first step in the data analysis phase was to ensure that all questionnaires were completed correctly. With the help of a qualified statistician and business intelligence developer (BI), the QlikView tool was used to log and code the data. This tool is useful because it is very flexible, has a rich visual interface, and allows the user to clearly see relationships between data (Schuette, 2013). The initial step of the data analysis phase consisted of ensuring that all surveys were accurately filled out.

The data was logged and coded with the assistance of a competent statistician and business intelligence (BI) developer using the QlikView tool. This tool is important because it is very adaptable, has a visually rich interface, and enables the user to perceive data relationships clearly (Schuette, 2013).

3.6.1. Descriptive statistics

Descriptive statistics represent the fundamental attributes of a study's data. In conjunction with a simple graphical analysis, it summarizes the sample and measures and offers a foundation for quantitative data analysis. Descriptive statistics were selected because they are used to offer quantitative descriptions in a format that can be manipulated. Moreover, it facilitates the meaningful simplification of vast quantities of data (William, 2021).

3.6.2. Frequency distribution

Frequency distribution represents study findings with %ages, graphical representations, line graphs, pie charts, histograms, and bar graphs (Allen, 2017). The frequency distribution was utilized to ease the socioeconomic examination (age, gender, education level, income level, employment, and family size, etc.).

3.7. Data validity and reliability

3.7.1. Validity

In qualitative research, validity refers to the suitability of instruments, processes, and data. Whether the research question is appropriate for the desired outcome, the choice of technique is appropriate for addressing the research question, the design is effective for the methodology, and sampling and data

analysis are appropriate (Leung, 2015).

3.7.2. Reliability

Reliability is the exact duplicability of a process and its outcomes. In qualitative research, consistency in reliability is required (Leung, 2015). To guarantee the validity of the interviews, comparable questions were posed to each participant. The questionnaire was designed to ask multiple-choice questions; for instance, only five types of energy sources were provided. In addition, tables detailing the precise uses of the energy sources and the kind of household consumption were provided.

3.8. Ethical considerations

A set of moral standards proposed by an individual or group is the definition of ethics (De Vos, 2002). When investigating human participants, researchers must carefully evaluate the ethical consequences of their work. Throughout the study, ethical problems such as the obligation to preserve the respondents' privacy and dignity, protection from physical or psychological harm, and a respectful attitude toward participants and their houses were examined. Before the research was conducted, consent from the ethics committee of CAES UNISA (reference number: 2021/CAES HREC/158) was acquired. Refer to Appendix B for the ethical clearance approval.

3.8.1. Permission to conduct the study

The Xikundu Tribal Authority was requested to provide permission to undertake the research. A UNISA-approved letter of approval was drafted and presented to the tribal authority (**Appendix E**). Before beginning the trial, participants provided their informed consent (**Appendix F**). Participants were told about the research project. In addition, participants were given consent forms to certify that they understood the nature of their involvement.

3.8.2. Informed consent

According to Hakim (2000), research involving human participants must get written informed consent. The participants were informed of the nature of the study and provided with the option to participate. Participants were also informed that they might withdraw from the study at any moment.

3.8.3. Right to privacy

The right to privacy entails maintaining private information that is not ordinarily meant for others to watch or analyze (De Vos *et al*., 2011). Participants' privacy and identities must be respected. Participants' privacy was protected, and anonymity was enforced throughout the duration of the research process.

CHAPTER 4 RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents the findings of the questionnaires distributed to research participants. The chapter begins with a discussion of the study participants' collected data, followed by a summary of characteristics of the data. This chapter investigates the effect of economic and noneconomic factors on energy source preference. The majority of results presented in this chapter are displayed in graph or table format. The data were analyzed using the methods of research outlined in Chapter 3. This chapter focuses primarily on the quantitative findings and briefly on the qualitative findings of this study. The results are presented in the same order as the literature review, with economic factors mentioned first, followed by non-economic variables. This allowed the researcher to evaluate the probability of a relationship between each element and the energy source independently of other variables. This allowed the researcher to determine which factors had the greatest impact on the fuel choice of households.

4.2. Pilot study

Time was spent with the Induna (Village Headman) and two field assistants during the pilot project. It was observed that firewood is stored in homes. The overseer linked these customs to rites of passage, as married ladies believe that cooking with firewood demonstrates that they are well-mannered. It is also tied to culture, as parents, grandparents, and even great-grandparents have all cut firewood.

The first field assistant indicated that his family was financially stable. His mother continues to cook with firewood because she believes the flavor is superior. His aunt, who resides in the same home, utilizes either an electric or a gas stove. Additionally, they rely on electricity for light and amusement, as they have three televisions and a variety of other electrical gadgets that allow them to live comfortably.

The second field assistant indicated that she is unemployed, and her son provides for the family. She stated that she used electricity for all of her household needs. However, she routinely stockpiles firewood as a contingency plan because load shedding can leave her without electricity for up to three days at a time.

Based on the results of the pilot study it was determined that a set of questions need to be asked to the

participants as there seems to be continued use of firewood based on generational knowledge transfer and contingency plans. Therefore, the researcher aimed at understanding whether the participants are aware of the negative impacts of firewood harvesting.

4.3. Results

During the survey questionnaire phase of the study, 70 participants were provided with a translated questionnaire. The two field assistants joined the researcher to assist with any complicated dialect that may occur during the survey questionnaire phase.

Table 4.1: Study descriptives

Variable	Frequency (n)	Frequency (%)
Gender:		
Male	27	39
Female	43	61
Age:		
18 – 25	3	4
26 – 40	18	26
41 - 45	20	29
46 - 60	26	37
>60	3	4
Education level:		
No schooling	-	-
Foundation Phase (Grade R – Grade 3)	32	46
Intermediate Phase (Grade 4 – Grade 6)	25	36
Secondary Phase (Grade 7 – Grade 12)	12	17
Higher Certificate	-	-

Tertiary Education	1	1
Employment status:		
Employed	3	4
Part-Time	3	4
Self-Employed	4	6
Unemployed	60	86
Income source:		
Social Grant	62	89
Salary	8	11
Marital status:		
Cohabit	28	40
Widow/Widower	18	26
Married	12	17
Single	11	16
Divorced	1	1
Family size:		
1 – 2	16	23
3 – 4	16	23
5 – 6	23	32
7 – 8	11	16
9 – 10	4	6

Using the chi-square test for independence, the probability and association between energy source selection and factors influencing energy source selection were determined. To prove the hypotheses, the test computes the p-value, also known as the significance level. If the p-value exceeds 0.05, the hypothesis is rejected and there is no link between the variables.

Table 4.2 to **Table 4.7** display the probability and association between the energy source used for cooking, water heating, space heating, and lighting and the factor that has the greatest impact on the environment.

Table 4.2: Relationship between the gender of families and their choice of energy source

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Gender					
Gender	Female	43	0	0	1
	Male	27	0	0	
Choice of water heating energy source in relation to Gender					
Gender	Female	43	0	0	1
	Male	27	0	0	
Choice of space heating energy source in relation to Gender					
Gender	Female	5	0	38	0.928
	Male	4	0	23	
Choice of lighting energy source in relation to Gender					
Gender	Female	19	1	15	0.119
	Male	12	0	23	

According to **Table 4.2**, the p-value is greater than 0.05, indicating that there is no correlation between energy source selection and household income.

Table 4.3: Relationship between the age of families and their choice of energy source

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Age Group					
Age Group	25-45	18	0	0	1
	45-65	52	0	0	
Choice of water heating energy source in relation to Age Group					
Age Group	25-45	18	0	0	1
	45-65	52	0	0	
Choice of space heating energy source in relation to Age Group					
Age Group	25-45	3	0	15	0.855

	45-65	6	0	46	
Choice of lighting energy source in relation to Age Group					
Age Group	25-45	9	0	9	0.738
	45-65	22	1	29	

The p-value is greater than 0.05, showing there is no correlation between age and household energy consumption.

Table 4.4 demonstrates the correlation between the household's choice of energy source and their degree of education.

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Education Level					
Highest Qualification	Grade R - 3	32	0	0	1
	Grade 4 - 6	25	0	0	
	Grade 7 - 12	12	0	0	
	Tertiary	1	0	0	
Choice of water heating energy source in relation to Education Level					
Highest Qualification	Grade R - 3	32	0	0	1
	Grade 4 - 6	25	0	0	
	Grade 7 - 12	12	0	0	
	Tertiary	1	0	0	
Choice of space heating energy source in relation to Education Level					
Highest Qualification	Grade R - 3	4	0	28	0.280
	Grade 4 - 6	2	0	23	
	Grade 7 - 12	2	0	10	
	Tertiary	1	0	0	
Choice of lighting energy source in relation to Education Level					
Highest Qualification	Grade R - 3	9	1	22	0.210
	Grade 4 - 6	13	0	12	

	Grade 7 - 12	8	0	4	
	Tertiary	1	0	0	

Table 4.4 reveals that the p-value is greater than 0.05, indicating that there is no correlation between energy source selection and household income.

Table 4. 5: Relationship between participants' choice of energy source and their employment status

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Employment Status					
Employment Status	Employed	3	0	0	1
	Self-employed	4	0	0	
	Part-time	3	0	0	
	Unemployed	60	0	0	
Choice of water heating energy source in relation to Employment Status					
Employment Status	Employed	3	0	0	1
	Self-employed	4	0	0	
	Part-time	3	0	0	
	Unemployed	60	0	0	
Choice of space heating energy source in relation to Employment Status					
Employment Status	Employed	2	0	1	0.181
	Self-employed	0	0	4	
	Part-time	0	0	3	
	Unemployed	7	0	53	
Choice of lighting energy source in relation to Employment Status					
Employment Status	Employed	2	0	2	0.987
	Self-employed	2	0	1	
	Part-time	1	0	2	
	Unemployed	26	1	33	

There is no correlation between energy sources and household/family size, as seen in **Table 4.5.**

Table 4.6: Relationship between energy source selection and monthly family income of participants

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Source of Income					
Source of Income	Salary	8	0	0	1
	Grant	62	0	0	
Choice of water heating energy source in relation to Source of Income					
Source of Income	Salary	8	0	0	1
	Grant	62	0	0	
Choice of space heating energy source in relation to Source of Income					
Source of Income	Salary	2	0	6	0.552
	Grant	7	0	55	
Choice of lighting energy source in relation to Source of Income					
Source of Income	Salary	4	0	4	0.893
	Grant	27	1	34	

According to **Table 4.6**, the p-value is greater than 0.05, indicating that there is no correlation between energy source selection and household income.

Table 4.7: Relationship between energy source selection and marital status in households

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Marital Status					
Marital Status	Co-habit	28	0	0	1
	Single	11	0	0	
	Widow\Widower	18	0	0	

	Divorced	1	0	0	
	Married	12	0	0	
Choice of water heating energy source in relation to Marital Status					
Marital Status	Co-habit	28	0	0	1
	Single	11	0	0	
	Widow\Widower	18	0	0	
	Divorced	1	0	0	
	Married	12	0	0	
Choice of space heating energy source in relation to Marital Status					
Marital Status	Co-habit	2	0	26	0.940
	Single	1	0	10	
	Widow\Widower	3	0	15	
	Divorced	0	0	1	
	Married	3	0	9	
Choice of lighting energy source in relation to Marital Status					
Marital Status	Co-habit	18	0	10	0.223
	Single	4	0	7	
	Widow\Widower	5	1	12	
	Divorced	0	0	1	
	Married	4	0	8	

Table 4.7 reveals that the p-value is greater than 0.05, indicating that there is no correlation between energy source selection and household income.

Table 4.8: Relationship between energy source selection and family size of participants

Variables	Attributes	Energy Sources			P-value
		Firewood	Electricity	None	
Choice of cooking energy source in relation to Family Size					
Family Size	1-2	16	0	0	1
	3-4	16	0	0	

	5-6	23	0	0	
	7-8	11	0	0	
	9-10	4	0	0	
Choice of water heating energy source in relation to Family Size					
Family Size	1-2	16	0	0	1
	3-4	16	0	0	
	5-6	23	0	0	
	7-8	11	0	0	
	9-10	4	0	0	
Choice of space heating energy source in relation to Family Size					
Family Size	1-2	1	0	15	0.917
	3-4	2	0	14	
	5-6	3	0	20	
	7-8	3	0	8	
	9-10	0	0	4	
Choice of lighting energy source in relation to Family Size					
Family Size	1-2	8	0	8	0.847
	3-4	8	0	8	
	5-6	8	1	14	
	7-8	6	0	5	
	9-10	1	0	3	

There is no correlation between energy sources and household/family size, as seen in **Table 4.8.**

4.4. Discussion

4.4.1. Gender of participants

Literature indicates that gender may impact the selection of energy source. Therefore, the participants' gender was established. The gender of participants was determined in order to comprehend how gender effects fuel storage behavior. **Table 4.1** depicts the gender distribution of the participants. 61 % of the participants are female (n=43), whereas 39 % are male (n=27), according to a study of the data. Females

are primarily accountable for home dynamics and the type of energy source utilized. In patriarchal society, women are often expected to handle the majority of household duties, such as cooking and cleaning. Gender has a significant impact on fuel preference. Because female-headed households are more likely to be poor and less able to afford power connections or cleaner fuels, women prefer charcoal and firewood for cooking. Despite the fact that the majority of respondents are female, there is no association between gender and respondents' preferred energy source.

4.4.2. Participants age group

To identify the age of the participants, two (2) age categories were developed. Seventy participants were older than 18 years of age, with the majority (74 %) between 45 and 65 years of age, followed by 25 to 45 years of age (26 %). The age distribution was utilized to determine whether or not age influenced energy selection.

The literature indicates that the age of a household affects its choice of fuel. Older households are more likely to cook with firewood than younger households. According to Makhado (2006), Venda and Tsonga elders hold the cultural idea that porridge cooked with firewood tastes better than porridge cooked using electricity. This is corroborated by this study, since one male participant remarked that stove-prepared meal did not taste as well as food cooked on a three-legged pot with fuel. The study finds that age affects the likelihood of utilizing clean and efficient fuels positively.

4.4.3. Level of education of the participants

In this study, four educational levels were considered. R to 3rd grade, 4th to 6th grade, 7th to 12th grade, and tertiary education. The majority of respondents (46%) had a grade R-3 education, followed by participants with a grade 4-6 education (36%), participants with a grade 7-12 education (17%), and finally participants with a postsecondary degree (1%). Educated people may have better occupations and earn greater wages than illiterate people. Educated persons may also be aware of the health risks linked with the usage of traditional/solid fuels. Consequently, it was vital to examine if there was a correlation between education level and energy source preference (Katusi, 2020).

Most respondents in this survey had a poor level of education, as 86 % did not complete primary school and 17 % had secondary education.

4.4.4. Employment Status of participants

This study included four employment status categories: employed, unemployed, self-employed, and part-time. Respondents were asked to select their present occupation from the available alternatives. **Table 4.1** depicts the present employment position of respondents. The bulk of respondents (86%, n=60) are unemployed, while 6 % (n=4) are self-employed, followed by 4 % (n=3) who are employed and 4 % (n=3) who work part-time.

According to Uhunamure (2017), employed and self-employed households rely on contemporary energy sources to some level, whilst jobless households are most likely to rely on traditional fuels. Additionally, unemployed households rely on pensions, government subsidies, and income from urban-working family members. This holds true for this survey as well, as the majority of respondents rely on social assistance for income.

4.4.5. Source of Income of participants

The definition of household income is "all income, whether financial or products and services, received by persons in a household on an annual or frequent basis, excluding bonus increases and other such irregular and often one-time income" (United Nations, 2011). A household's energy choices are influenced by characteristics like occupation that affect household income (Maseleka, 2020). According to the research, income is the beginning point for energy decisions. Figure 4.1 depicts the monthly household income in the area of study. It reveals that the majority of participants (n=62, 89%) receive government-provided social assistance, while just n=8 (11%) receives a salary.

High unemployment and illiteracy prevalent among the village's residents. This condition has made social assistance the primary source of income for members. According to the South African Social Security Agency (SASSA, 2020), the two most important grants that provide people with a source of income are the "child grant" (which amounts to R480.00 per kid per month) and the "old age pension" (which ranges from R1980.00 to R2000.00 per month).

Low-income households in South Africa, as defined by the Standard Bank South African Consumer Brief (2016), are those with an annual income of less than R89 000.00. In light of this and based on replies from

participants, Gonani Village homes can be classified as low-income households. Studies have shown that households with greater incomes prefer cleaner fuels than those with lower incomes that rely on firewood (Wassie *et al*. 2021).

According to Sole (2015), households choose to utilize firewood since power is inaccessible and electrical gadgets are costly. One participant in the survey reported that firewood is readily available and less expensive than electricity. When the participant was asked when she would cease using firewood, she said as soon as the government provided her with free electricity.

It was also indicated during the discussions that social subsidies are frequently insufficient to support households, thus it is necessary to find alternative sources of income. One of the participants mentioned that by burning firewood, she is able to manufacture and sell traditional village beer. For every eighty litres of traditional beer she sells, she earns an average of R1,000. According to Shackleton (2005), rural residents utilize firewood to produce both traditional beer and bricks.

4.4.6. Marital status of participants

Women collect firewood mostly for domestic use, whereas males collect wood for commercial purposes (Damm & Triebal, 2008). In the interviews, female participants noted that firewood collection is a primarily female (young to middle-aged) activity in the village. According to Damm and Triebel's (2008) research, married women view this pastime as a social activity because it affords them the opportunity to spend "girl time" with their friends. In addition, gathering firewood is culturally conditioned for married women. One respondent stated, "Collecting firewood makes them women," while several others highlighted that their moms and grandmothers also engaged in this activity. For some observers, the usage of firewood is even viewed as a rite of passage between generations.

Figure 4.5 reveals that 40% (n=28) of respondents lived in a cohabitation relationship, whereas 26% (n=18) were widows/widowers, 17% (n=12) were married, 16% (n=11) were single, and 1% (n=1) lived in a cohabitation relationship.

4.4.7. Family size of participants

Among the variables identified to influence a household's choice of energy source is the size of the

household; consequently, the size of the households of the participants must be determined. Mensah and Adu (2013) and Tchereni (2013) found that household size had a negative effect on the likelihood of households utilizing clean fuels as opposed to conventional fuels. Traditional fuels are more likely to be used by larger households than clean fuels, but smaller households are more likely to utilize cleaner fuel sources.

This example is attributed to the notion that larger houses may cook larger quantities of food to feed the entire family, hence necessitating the usage of inexpensive energy sources. It can be deduced that smaller households can afford to prepare lesser quantities of food with electricity.

Table 4.1 depicts the household sizes in Gonani Village, which ranged from one (1) to sixteen (16). (10). Five household size categories were utilized to distribute data, ranging from 1 to 2 (23 %), 3 to 4 (23 %), 5 to 6 (33 %), 7 to 8 (16 %), and 9 to 10 (6%), with the majority of households consisting of 5 to 6 individuals and fewer having 9 to 10 members. The average size of a household in the research area was five people. According to larger households, cooking with firewood helps them to make enough food to feed the entire family.

4.5. Study Descriptives of the observation phase

After the survey questionnaire phase the researcher with the assistance of the field assistants undertook observations of 25 of the 70 participants. The observations involved observing the participants in their homes (as they were cooking), observing their stacks of firewood, as well as when some of the participants went out to the forests to collect firewood (refer to **Appendix E** for the photographs from the observations). During the observation phase discussions were had with the participants.

Table 4.9.: Findings from the observation checklist (N=?)

Observation	Frequency (n)	Frequency (%)
Are there stacks of firewood:		
Yes	25	100

No	-	-
Does the participant collect firewood:		
Yes	25	100
No	-	-
Do they collect in groups:		
Yes	19	76
No	6	24
Do they have a Xithanga (traditional cooking hut):		
Yes	25	100
No	-	-
Does the home have electrical appliances:		
Yes	17	68
No	8	32

4.5.1. Socio-cultural preferences

From the observation it was seen that the use of firewood is strongly linked to socio-cultural practices. All the participants observed during the observation phase of the study (n=25) all had a stack of firewood in their home. When probed about the reasoning behind the firewood collection, the participants indicated that it is a social norm, it signifies a rite of passage that has been transferred from one generation to the next. This supports the findings of Ndamase (2012), who assumed that firewood collection may be motivated by prestige and social norms. According to Tabuti *et al*. (2003), firewood collection is an activity mainly performed by women (wives and daughters). They usually collect firewood three to four times a month, with most people collecting daily, once a week, or once every two to three weeks. They usually choose one day a week to go collect wood (Damm & Triebal, 2008). In Uganda, it was found that firewood collection for women was originally a group activity where several female friends went out together to collect firewood. The female participants of the study have indicated that they collect firewood as a group as it is considered to be their bonding time, where they catch up on gossip. According to Tabuti *et al*. (2003), most people travel short distances of less than 2 km and spend less than two hours collecting firewood. Traditionally, women build a firewood pile in their households behind the main dwelling. This eis a symbol of a hardworking housewife.

Women collect firewood mainly for domestic purposes, while men collect wood for sale (Damm & Triebal, 2008). In the interviews, female participants indicated that firewood collection is an activity mainly performed by women (young to middle-aged women) in the village. Married women consider this activity a social activity because it gives them the opportunity to spend " girl time" with their friends, which supports Damm and Triebel's (2008) study. One of the participants in the study indicated that he collects wood in order to carve wooden cooking utensils that he sells another male participant indicated that he collects wood to sell to rich families that may require firewood for events such as funerals and weddings. For married women, moreover, gathering firewood is culturally conditioned. One respondent noted that "collecting firewood makes them women," while many respondents also noted that "it is a practice that was done by their mothers and grandmothers. The use of firewood is considered part of the cultural/traditional value system and a valuable tradition that is passed from one generation to the next; for some observers, this activity is even a generational rite of passage.

During the interview with the Induna, he stated that collecting firewood is a norm and was done by his mother and grandmother. The Induna also indicated that food cooked by firewood is better than food cooked by electricity. This is supported by the observation that all the observed participants (n=25) have a xithanga (traditional cooking hut) in their home.

Interviews revealed that firewood is also used in times of need, as households are expected to donate a load of firewood to a household having a funeral. Households preparing for a funeral must cook at least three times a day for at least five days before the funeral. They have to cook for more than fifty people per meal, hence the need for firewood.

It was observed that 68% (n=17) of the participants have electrical appliances such as kettles, two plate stoves and irons, the participants indicated that

Table 4.10.: Physical characteristics of participants dwellings

Variable	Frequency (n)	Frequency (%)
Average number of roofs:		
1 – 2	17	68

3 – 4	4	16
4 – 5	3	12
>5	1	4
Roof materials:		
Tiles	13	52
Straw	12	48
Etc.	0	0
Wall materials:		
Bricks	25	100
Mud	0	0
Etc.	0	0
Fence materials:		
Wood	2	8
Metal	11	44
None	12	48
Is the house connected to the electricity grid:		
Yes	25	100
No	0	0

4.5.2. Type of dwelling

According to Rahut *et al*. (2014), factors such as home ownership and number of rooms may influence a household's fuel selection. During the observation phase it was observed that all of the observed participants are connected to the electricity grid. Furthermore, it was observed that all the participants have at least one stack of wood in their yard, which they have indicated that they use to cook and warm water for bathing. Based on the questionnaires and interviews, it was determined that there was no correlation between the type of home the participants owned and their fuel preference

Table 4.11.: Energy use by households (N=?)

Variable	Frequency (n)	Frequency (%)
Main energy source: Cooking		

Firewood	20	80
Paraffin	0	0
LPG	0	0
Biogas	1	4
Electricity	4	16
Other	0	0
Main energy source: Space heating		
Firewood	24	96
Paraffin	0	0
LPG	0	0
Biogas	0	0
Electricity	1	4
Other	0	0
Main energy source: Water heating		
Firewood	21	84
Paraffin	1	4
LPG	0	0
Biogas	1	4
Electricity	2	8
Other	0	0
Main energy source: Lighting		
Firewood	0	0
Paraffin	15	60
LPG	0	0
Biogas	0	0
Electricity	10	40
Other	0	0
Preferred energy source: Cooking		
Firewood	18	72
Paraffin	0	0

LPG	0	0
Biogas	0	0
Electricity	7	
Other	0	0
Preferred energy source: Space heating		
Firewood	20	80
Paraffin	0	0
LPG	0	0
Biogas	0	0
Electricity	5	20
Other	0	0
Preferred energy source: Water heating		
Firewood	0	0
Paraffin	0	0
LPG	0	0
Biogas	0	0
Electricity	25	100
Other	0	0
Preferred energy source: Lighting		
Firewood	0	0
Paraffin	0	0
LPG	0	0
Biogas	0	0
Electricity	25	100
Other	0	0

Majority of the participants (78%) use firewood for cooking, furthermore 72% (n=18) of the participants indicated that they prefer using firewood for cooking. The reasoning behind this according to the particpants is that food cooked over firewood tastes better than food cooked over the stove. Some of the particpants also indicated that the time spent cooking over firewood is shorter than time spent time cooking over the stove. The cost of electricty units and electrical applicances such as stoves also prevents the

participants from using electricity for cooking as they cannot afford the appliances.

For lighting purposes 100% (n=25) of the participants indicated that they prefer using electricity for ligting although 60% (n=15) of the participants are currrently using paraffin for lighting. The partcipants indicated that is safer to using electricity as compared to paraffin as they currently use oil lamps for lighting, which could break at anytime and could result in bodily harm or even fires. Some of the particpants indicated that they worry when they children have to light up the house as that their children will get hurt. The same is true for water heating as they use what they called a “chechisa (water heating urn), as this is an unsafe practice and some of the children cannot even use it. 81% of the particpants indicated that use firewood for heating, although 100% (n=25) of the particpants indicated that they would prefer using electricity for water heating. The problem with using electricity for water heating is that they cannot afford geysers and also the cost of using kettles or urns to heat up water will waste the electricity units.

When it comes to space heating the 96% (n=24) particpants indicated that they use firewood for space heating and 80% (n=20) of the particpants indicated that they would still prefer using firewood over electricity for speace heating as firewood covers a larger area in terms of heating and heating appliances such as heaters and aircons are expensive and would waste the electricty units. When probed on the use of gas heaters, the particpants indicated that gas heaters as well as gas is expensive.

From the observations it was clear that the participants view the use of electricity as a luxury. The cost of electricty units forces the particpants to use electricity in a sparingly manner. Furthermore, the cost of electrical appliances makes it hard on the particpants to use electricity as a main source of energy supply as they cannot afford the appliances.

4.5.3. Distance to fuel

According to Grainger (2006), people used to collect firewood close to their houses and in agricultural areas, but the need for firewood has forced communities to drive farther to find it. During the discussions held during the observation phase of the study, participants revealed to me how far they now had to travel to get a sufficient supply of firewood, revealing the ever-expanding scope of firewood collection. Participants reported having to travel to the village's outskirts to obtain firewood. When questioned why

they go to the outskirts of the hamlet, they explained that the firewood there is superior to the firewood next to their home since it lasts longer and cooks nicely. This contradicts Jumbe and Angelson's (2007) conclusion that the distance to the fuel source is one of the most critical drivers of fuel selection.

CHAPTER 5 SUMMARY, LIMITATIONS OF RESEARCH, CONCLUSION, AND RECOMMENDATIONS

5.1. Introduction

This chapter covers the study's findings as well as its limitations. Recommendations were offered when applicable, especially with respect to further research on fuel stacking behavior.

5.1.1. Considerations

It is evident that rural populations depend heavily on firewood, not only for domestic duties but also as a means of survival. The collecting of firewood poses a significant danger to environmental sustainability. We face the problem of assessing our alternatives and determining whether sustainable development can be realized in the future or whether it will be jeopardized by the current generation's actions.

By restricting firewood collection and permitting rural people to collect only dried and dead wood, the Ministry of Environment acknowledges that rural residents require fuel for subsistence. In spite of limits established by the Ministry of the Environment on the collecting of firewood in some protected forests, firewood continues to be gathered in certain locations.

5.2. Summary

Even though households have access to electricity, they continue to rely on firewood for domestic needs such as cooking and water heating because cooking with electricity is regarded as inefficient and time-consuming. In addition, electrical cooking and heating gadgets, such as stoves and kettles, are pricey. Participants in the study indicated that firewood is readily available and less expensive than electricity. This has underlined the fact that Gonani Village is an energy-poor community. This suggests that the providing of energy to households exacerbates the issue of poverty since households cannot afford the electricity that has been provided.

Due to cultural preferences, firewood is also utilized alongside electricity. The collection of firewood is a rite of passage that is passed down from generation to generation. Women traditionally construct a firewood store behind the primary dwelling in their houses. This represents a hardworking homemaker.

Presumably, reputation and societal standards can motivate the collecting of firewood. In addition, the majority of men believe that food cooked with firwood tastes better than food prepared with electricity and on a stove.

A significant element evaluated in this study is that the use of firewood poses difficulties for the community. Firewood is typically collected by women and girls, who walk to the village's outskirts to obtain it; this poses a threat to the safety of women and girls. In addition, continued use of firewood poses health hazards, including TB, respiratory infections, and eye infections. The use of firewood is also detrimental to the environment, as it contributes to deforestation, and the combustion of solid fuels produces toxic gases that contribute to indoor air pollution.

Based on the assessing the objective of identifying the role of family size in fuel choices it can be ascertained that family size does not influence fuel stacking behaviour.

This study demonstrates that both economic and non-economic factors (cultural) influence household energy choices, and that the reasons for fuel stacking include reliance on energy source, energy poverty, indigenous knowledge, and the inaccessibility of free basic electrical services.

5.3. Limitations of the Study

Following is a discussion of the study's shortcomings, which include sample processes, study design, limitations in data gathering, and limitations in data processing.

5.3.1. Sampling

In a convenience sample, a sample is taken from a nearby segment of the population. There are no selection criteria other than the person’s availability and willingness to participate. This can result in sample error, lack of demographic representation, and potential bias.

5.3.2. Study design

This is a descriptive study that employs both qualitative and quantitative methods of research.
For this study, both qualitative and quantitative descriptive research approaches were employed. Because

it accurately and systematically explains the circumstances and occurrences of the study sample, a descriptive study was chosen on purpose. This type of study design is neither repeatable or replicable due to the observational aspect of the investigation, which may be a restriction of the study. In addition, because there are no statistical testing, there may be some degree of bias in the study's findings.

5.3.3. Data collection

The participants were given questionnaires, however due to their illiteracy, the researcher and study assistants had to fill out their forms. The research was aided by two village residents who have attained degrees. Even though the researcher spoke the same language as the participants, he frequently had to ask his assistants to translate particular words and local terms.

The data observation phase comprised participant farm visits. These house visits caused participants some difficulty, since they felt rather uneasy during this phase. Participant observation is a helpful method, but it provides only a "glimpse into the lives of the participants" (Mouton: 2001).

5.3.4. Data Analysis

This study employed a mixed methods approach, which mixes and integrates qualitative and quantitative research techniques. Due to the collecting and analysis of qualitative and quantitative data, a mixed-methods strategy is perfect for gaining a deeper knowledge of phenomena and addressing research questions. This method is abstract because the researcher's understanding of the topic influences the selection of participants and classes and may result in a biased presentation of the findings.

5.4. Conclusion

The purpose of the study was to comprehend the behavior of fuel stackers in Gonani village, Limpopo. This was performed to analyze the factors that influence rural fuel stacking behavior by determining the type of fuels used by households and for what purposes and whether household size has an impact on fuel choices. The study's hypothesis was derived from its background, purpose, and aims. The hypothesis of the study is that a variety of socioeconomic (such as the role of income in fuel choices) and cultural factors (generational knowledge transfer or cultural preferences) influence a household's choice and utilization of different fuels. This investigation was founded on the notions of energy laddering and fuel stacking. This research intended to add to the existing body of knowledge and provide insight into the factors that drive

fuel stacking behavior in rural South Africa. Literature reveals that there is neither fuel substitution nor fuel switching in low and middle-income countries, including South Africa, and that households use a variety of fuels for domestic uses. There are references to fuel stacking behaviour in the literature, but there are few studies that explain the causes of fuel stacking behaviour. It is therefore important to comprehend the causes of fuel stacking behavior. This study investigates the socioeconomic and cultural factors that impact fuel stacking in rural South Africa. The following can be concluded based on the objectives that have been formulated for the research:

5.4.1. Determining the types of fuels that are being used in households:

The results of the study reveal that rural settlements have been electrified but that households continue to use both firewood and electricity. Firewood is utilized for domestic activities such as cooking, water heating, and space heating, whilst electricity is only used for lighting. Although household income has a substantial impact on fuel selection. This study demonstrates that low-income households fulfill their energy demands by gathering firewood, as they cannot afford electricity and electrical gadgets are costly.

5.4.2. Examining the role of income in types of fuel being used:

Studies have shown that households with greater incomes prefer cleaner fuels than those with lower incomes that rely on firewood. Although households in Gonani Village can be classified as low-income households, based on the data anaysis it can be concluded that income does not have a influence on fuel choices.

5.4.3. Role of culture in types of fuel being used:

The questionnaire that was used for data collection in the study also revealed a correlation between firewood collection behavior and sociocultural preferences. In Venda and Tsonga tribes, there is a cultural idea that elders prefer meals cooked with firewood over food cooked with electricity because the former tastes better. In addition, the usage of firewood is related with a cultural/traditional value system and a valuable practice that is passed down from one generation of women to the next; some observers even regard this action to be a rite of passage.

5.4.4. Role of family size in fuel choices:

From the study it can be concluded that the size of the household will not influence fuel consumption of

a household.

5.5. Recommendations

According to SEA (2014), rural areas have the highest prevalence of energy poverty. Equally as crucial as delivering power is making it affordable and ensuring that it is utilized once it is connected.

5.5.1. Access to free basic electricity

Eskom and the municipalities established Free Basic Energy (FBE) in 2003 to offer electricity to indigent communities and enhance their quality of life. Municipalities choose households in need and add them to Eskom's list of FBE users. Thus, recipients can collect their monthly FBE coupons from Eskom locations. The monthly maximum is between 50 and 60 kWh per household. The customer will be charged for any amount over this threshold.

The Free Basic Alternative Energy (FBAE) policy was implemented in 2007. Under this strategy, poor households without power have access to alternative fuels valued at R56.29 that are deemed adequate by the towns. The Inclining Block Tariff (IBT) was implemented in 2010 to assist low-income and low-income households in paying less for electricity and to encourage energy efficiency in low-income homes.

Energy poverty continues to affect South African households, particularly in rural regions, despite the implementation of these programs, as not all targeted beneficiaries have been reached. Moreover, it is regrettable that eligible households are unaware of these steps. In addition, tests have revealed that 50-kWh FBE tokens do not meet a month's worth of household energy consumption (Masekela, 2019).

It is suggested that government personnel be dispatched to rural regions to engage more closely with rural communities and aid them in preparing the documentation required to benefit from the energy policies enacted by Eskom and the communities. Officials must also communicate with communities in their local language to facilitate communication and comprehension of the imparted information.

5.5.2. Education on the health impacts of using “dirty fuels”

The study indicated that participants were unaware of the health and environmental effects of conventional fuel consumption. Despite the fact that some of the participants experience health issues, such as an acute

cough, they are confident that this is not the result of using firewood.

In addition, while they have observed a loss in forests in recent years, namely a decline in dry wood, they have not connected this decline to the harvesting of firewood. Some older participants claimed that they were unwilling to depart from their traditional norms.

The government should educate rural communities about the social, environmental, and bodily hazards of traditional use. Community gatherings could be a appropriate venue to increase community knowledge, and if these concepts are also taught in schools, children can also educate their families.

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APPENDICES

Appendix A - TURN-IT-IN Digital Receipt

turnitin

Digital Receipt

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File name:	Nkhensani_Sithole_12773905_MSc_Research_Dissertation_Re...
File size:	2.26M
Page count:	84
Word count:	16,242
Character count:	89,774
Submission date:	14-Feb-2023 11:47PM (UTC+0200)
Submission ID:	2014312175

ASSESSING FACTORS THAT INFLUENCE HOUSEHOLD FUEL-STACKING BEHAVIOUR WITHIN RURAL HOUSEHOLDS IN THE GONANI VILLAGE, LIMPOPO PROVINCE, SOUTH AFRICA

by

NKHENSANI SITHOLE

Submitted in accordance with the requirements for the degree

MASTER OF ENVIRONMENTAL SCIENCE

in the

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES
DEPARTMENT OF ENVIRONMENTAL SCIENCE

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR
DR K SEMENYA

2023

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Appendix B: Ethical Clearance Approval

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 08/11/2021

NHREC Registration # : REC-170616-051
REC Reference # : 2021/CAES_HREC/158
Name : Ms NTP Sithole
Student #: 12773905

Dear Ms Sithole

Decision: Ethics Approval from 04/11/2021 to 31/10/2024

Researcher(s): Ms NTP Sithole
12773905@mylife.unisa.ac.za; 066-334-7166

Supervisor (s): Dr K Semenya
semenk@unisa.ac.za; 011-471-2138

Working title of research:

Factors that influence fuel-stacking behaviour within rural households in the Gonani village

Qualification: MSc Envrionmental Management

Thank you for the application for research ethics clearance by the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for three years, **subject to further clarification and submission of yearly progress reports. Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

The researcher is cautioned to adhere to the Unisa protocols for research during Covid-19.

Due date for progress report: 31 October 2022

Please note the points below for further action:

1. How will the risk posed by Covid-19 be addressed? What measures will the researcher take to mitigate this risk?

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2. The researcher indicates that photographs will be taken – will these include photographs of people? If so, the researcher is cautioned to ensure that participants will not be identifiable from the photographs.
3. The researcher indicates that non-English speaking groups will also be approached – how will this be handled? Will the questionnaire be translated? If so, who will do it? Will the researcher make use of an interpreter?
4. The researcher is cautioned that all assistants/interpreters must sign confidentiality agreements. The draft confidentiality agreement must be submitted as part of the application.
5. The committee recommends that question 1.6 in the questionnaire be amended to include solar power and charcoal/coal.
6. Please amend the age options in the questionnaire – the options go from 25-40 to 45-60.
7. Please provide more detail on data analysis: Will descriptive statistics answer the research question or objectives? The researcher is advised to indicate how the data for each objective will be analysed – provide the model and the variables that will be applied.

*The **low risk application** was **reviewed** by the UNISA-CAES Health Research Ethics Committee on 04 November 2021 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

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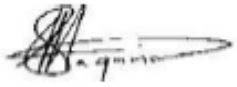
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2021/CAES_HREC/158** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi
Chair of UNISA-CAES Health REC
E-mail: antwima@unisa.ac.za
Tel: (011) 670-9391



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Executive Dean : CAES
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Appendix C: Observation checklist

Observation Checklist

Observation	Yes	No
Use of Firewood (are there stacks of firewood)		
Does the participant collect firewood		
If yes, do they go in groups?		
Do they have a Xithanga (a small kitchen outside of the main house) mainly used for cooking		
Does the home have electrical appliances?		

Appendix D: Household Questionnaire

QUESTIONNAIRE

Date: _____

SECTION 1: BIOGRAPHICAL INFORMATION AND DEMOGRAPHICS

1.1. Gender:

☐ Male ☐ Female ☐ Other

1.2. Age:

☐ 18-25 ☐ 25-40 ☐ 45-60 ☐ 60>

1.3. Are you the household head?

☐ Yes ☐ No

1.4. Highest Level of Education

Education Level	Please tick the correct answer
No schooling	
Foundation Phase: Grade R – Grade 3	
Intermediate Phase: Grade 4 – Grade 6	
Secondary Phase: Grade 7 – Grade 12	
Higher Certificate	
Tertiary: Diploma, bachelor's degree, Honours Degree, Master's Degree, PhD	

1.5. Employment Status

Permanently employed	Part-time employed	Self-employed	Unemployed

1.6. Source of income

Please indicate the source of income for the following family members:

Family member	Salaries/wages	Social Grants	No income

1.7. Marital status

Single	Married	Divorced	Cohabit	Widow/Widower

1.8. Family size

SECTION 2: PHYSICAL CAPITAL

2.1. How many rooms do you have in total?

2.2. Describe the basic nature of the building:

2.2.1. Roof materials:

2.2.2. Wall Materials:

2.2.3. Describe the basic nature of the fence:

2.2.4. Is the house connected to electricity grid?

SECTION 3: BACKGROUND INFORMATION ON ENERGY USE BY THE HOUSEHOLDS

3.1. Which one of the following energy sources is mainly used in the household for the listed uses?

	Firewood	Paraffin	LP Gas	Biogas	Electricity	Other, please

						specify below
Cooking						
Space heating						
Water heating						
Lighting						

3.2. Which energy source do you prefer for cooking and why?

Firewood	Paraffin	LP Gas	Biogas	Electricity	Other

3.3. Which energy source do you prefer for space heating and why?

Firewood	Paraffin	LP Gas	Biogas	Electricity	Other

3.4. Which energy source do you prefer for water heating and why?

Firewood	Paraffin	LP Gas	Biogas	Electricity	Other

3.5. Which energy source do you prefer for lighting and why?

Firewood	Paraffin	LP Gas	Biogas	Electricity	Other

3.6. How often do you use the energy source for the following in your household?

	Everyday	Once a week	Twice a week	Never	Other, please specify below
Cooking					
Space heating					
Water heating					
Lighting					

SECTION 3: OPEN-ENDED QUESTIONS

3.1. Do you prefer using electricity or traditional fuels for your basic energy needs? Why?

3.2. Do you think you will ever stop using traditional fuels? If Yes, please explain why? If No, please explain why.

3.3. Are you aware of any negative environmental impacts/affects associated with the use of traditional fuels?

3.4. Are you aware of any social environmental impacts/affects associated with the use of traditional fuels?

3.5. Are you aware of any health environmental impacts/affects associated with the use of traditional fuels?

Appendix E: Photographs from observations

Appendix F: Permission Letter

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Attention: Xikundu Tribal Authority

LETTER OF INTRODUCTION AND REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Sir/Madam

My name is Nkhensani Tiyani Precious Sithole and I am a registered Masters's student in the Department of Environmental Sciences at the University of South Africa (student number: 12773905). My supervisor is Dr K Semenya. The proposed topic of research is "Factors that influence fuel-stacking behaviour within rural households in the Gonani Village, Vhembe District Municipality, Limpopo, South Africa". The purpose of the study is to assess the factors that influence fuel stacking behaviour in rural areas, particularly, Xikundu Village.

I am hereby requesting your permission/consent to conduct a study into your village. I want to assure you that participation in the research will be completely voluntary and the details of all the respondents will be treated as confidential. The information gathered will only be used for academic purposes and I endeavour to be respectful and responsible in my interactions with village members.

Furthermore, the following Covid 19 prevention practices will be adhered to:

- Masks will be worn over mouth and nose.
- Hand sanitising will be done before, during and at the end of any observations or interviews.
- A distance of at least 1.5 metres will be kept

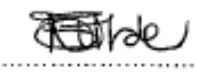
Upon completion of the study, I undertake to provide you with a bound copy of the dissertation on request. If you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are follows:

- Dr K Semenya (011) 471 2138 / semenk@unisa.ac.za
- Ms NTP. Sithole 072 577 4812 / snkhensani@gmail.com

GONANI ROYAL COUNCIL
MALAMULELE
25 October 2021
P. O. BOX 567
SASELAMANI - 0928
LIMPOPO PROVINCE

UNISA college of graduate studies

Yours sincerely



.....

Miss Nkhensani Sithole (Student)

.....

Dr K Semenya (Supervisor)

Appendix G: Participant Information Sheet

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PARTICIPANT INFORMATION SHEET

Ethics clearance reference number:
Research permission reference number:

Date:

Title: Factors that influence household fuel-stacking behaviour within rural households in the Gonani Village, Vhembe District Municipality, Limpopo.

Dear Prospective Participant

My name is Nkhensani Sithole and I am doing research with Dr Khomotso Semenya, a Senior Lecturer in the Department of Agriculture and Environmental Sciences towards a Master of Science at the University of South Africa. We are inviting you to participate in study entitled "factors that influence household fuel-stacking behaviour within rural households in the Gonani Village, Vhembe District Municipality, Limpopo".

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research in order to understand fuel stacking behaviour in Gonani Village, Limpop Province. The aim of the study is to add to limited evidence on what motivates fuel stacking behaviour and also to enhance household energy policy making in Vhembe District, Limpopo Province.

WHY AM I BEING INVITED TO PARTICIPATE?

You have been selected to participate in this study because you are a resident of Gonani Village and you are within the targeted age group for this research. You have also been selected because details have been obtained from the Induna. A total of 70 questionnaires will distributed amongst different households in the community.

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WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

This study involves questionnaires and observations which will include taking pictures. You will be requested to answer a household questionnaire, which has been structured in a way that will allow to you to answer all the questions that are necessary to achieve the aims and objectives of this research. The questionnaire has been divided into three sections. Section 1 involves demographic questions whilst Section 2 and 3 are open-ended questions which analyses income, household dynamics as well as fuel choices and how choices are influenced. The questionnaire will take approximately 30 minutes to complete.

During the observation phases, photographs may be taken by the researcher. Please be advised that your permission will be requested before any photographs are taken.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are not obligated to consent to participate. If you do decide to take part in the study will be provided this information sheet which you will be requested to sign as proof of written consent. You are free to withdraw at any time without giving a reason from this research. Your personal details will not be given out without your written permission, you are assured of anonymity. Withdrawing from participating in this study will however not be possible should your questionnaire be submitted for analyses.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

During the study you will learn more about how traditional fuels may impact your health. Furthermore, the research study will enhance household energy policy making in the Vhembe District, Limpopo Province.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no major consequences from participating in the study. You may however feel inconvenienced in terms of time as we will require you time to answer questionnaires. Furthermore, there may be a sense of discomfort from the observations.

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WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorder anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. Additionally, your answers will be given a code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Your answers may be reviewed by people responsible for making sure that research is done properly, including the data analyst and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

Kindly note that a report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked safe in Johannesburg for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

Your participation is voluntary and therefore there will be no payment.

Your full corporation will be appreciated should you wish to proceed with this research study. Please sign the form below, should you wish to proceed with the study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Health Research Ethics Committee of the College of Agriculture and Environmental Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

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HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Nkhensani Sithole on 0663447166 or snkhensani@gmail.com The findings are accessible for one year.

Should you have concerns about the way in which the research has been conducted, you may contact Dr Khomotso Semenya (011 471 2138 / semenk@unisa.ac.za) Contact the research ethics chairperson of the CAES Health Research Ethics Committee, Prof MA Antwi on 011-670-9391 or antwima@unisa.ac.za if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.
Thank you.

Nkhensani Sithole

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CONSENT TO PARTICIPATE IN THIS STUDY

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the <insert specific data collection method>.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname..... (please print)

Participant Signature.....Date.....

Researcher's Name & Surname.....(please print)

Researcher's signature.....Date.....

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