ASSESSMENT OF THE FACTORS THAT INFLUENCE FIREWOOD USE AMONG HOUSEHOLDS IN GA - MALAHLELA VILLAGE, LIMPOPO PROVINCE.

by

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DEDICATION

To my mother, I will forever remain indebted to you for all your sacrifices.
You are strength personified.

DECLARATION

I, Masekela Mahlodi Esther hereby certify that this dissertation, which I hereby submit for the degree of Master of Environmental Science at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution.

I declare that the dissertation does not contain any composed or written work exhibited by other persons whether written, pictures, graphs or data or any other information without acknowledging the source. I declare that where words from a written source have been used, those words have been paraphrased and referenced and where exact words from a source have been used, those words have been placed inside quotation marks and referenced.

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I declare that during my study I adhered to the Research Ethics Policy of the University of South Africa, I received ethics approval on the 3rd of December 2018 with ethical reference number: 2018/CAES/159 for the duration of my study prior to the commencement of data collection and have not acted outside the approval terms. I declare that the content of my dissertation has been submitted through an electronic plagiarism detection programme before the final submission for examination.

Signature:  Date: 28 November 2019

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ABSTRACT

Access to firewood and other affordable energy sources is essential to the livelihoods of rural households in developing countries. Studies have been conducted to understand the reasons behind an extensive reliance on firewood in rural areas, especially in developing countries, despite improved electrification rates and a number of government policies introduced to encourage rural households to switch from traditional to modern fuels. This study aimed at assessing and thus understand the factors influencing the use of firewood by households in Ga - Malahlela village in Limpopo Province. Limited research has been conducted on firewood use, subsequent to improved electrification in rural areas in South Africa, hence it was to shed light on this little-explored subject on which the study was carried out. The assessment was based on household demographics and household energy use patterns, with a structured questionnaire being utilised to arrive at a detailed understanding of the factors that drive firewood use. It was established that firewood was still used to a significant degree, to satisfy household energy needs such as cooking, water heating and space heating. This was mainly due to the socioeconomic status of households. Socio-economic factors such as income, education level, household size and preference were found to be the factors exerting the greatest influence on the use of firewood among households in the study area. Psychological variables and the geographical location of the study area were also shown to promote the use of firewood. The study further revealed that, as indicated in the reviewed literature, households in the study area fuel stack and do not ascend the energy ladder. The reviewed literature further indicated that not all factors have equivalent significance in determining the behaviour and pattern of household energy use. This indicates that energy sources such as firewood are not completely discarded but are instead used in conjunction with modern energy sources such as electricity. In conclusion, this study established that despite the availability of electricity, as a result of poverty and the lack of free basic services such as free basic electricity, reliance on firewood in rural areas will continue.

Keywords: Electricity; Energy sources; Energy ladder; Energy poverty; Firewood; Free Basic Electricity; Fuel stacking; Household energy use; Rural households; Socio-economic factors.

SETSOPOLWA

Go hwetša dikgong le methopo ye mengwe ya dibešwa tšeo di rekegago go bohlokwa go mekgwa ya malapa a dinagamagaeng go hwetša dilo tše bohlokwa tša bophelo dinageng tšeo di hlabologago. Dithutelo di phethagaditšwe go kwešiša mabaka ao a thekgago kholofelo go dikgong mafelong a dinagamagaeng a dinaga tšeo di hlabologago le ge go na le ditekanyo tše di kaonafaditšwego tša tlhagišo ya mohlagase le palo ya melaotshepetšo ya mmušo yeo e tsebišitšwego go tutuetša malapa a dinagamagaeng go fetoga go tloga go dibešwa tša sekgale go iša go tša sebjale. Thutelo ye e ikemišeditše go lekola ka gona go kwešiša mabaka ao a huetšago malapa a Motsaneng wa Ga-Malahlela ka Profenseng ya Limpopo go diriša ya dikgong. Dinyakišišo tše lekantšwego di phethagaditšwe ka ga tirišo ya dikgong ka morago ga tlhagišo ya mohlagase yeo e kaonafaditšwego mafelong a dinagamagaeng ka Afrika Borwa, gomme e be e swanetše go fa tshedimošo ka ga hlogotaba yeo e hlohlomišitšwego gannyane gore thutelo ye e phethagatšwe. Tekolo ye e theilwe go dipalopalo ka ga malapa setšhabeng le mekgwa ya malapa ya go dirišwa dibešwa, ka go diriša lenaneopotšišo leo le beakantšwego gore go fihlelelwe kwešišo ye e hlalošago ka botlalo mabaka ao a hlohleletšago tirišo ya dikgong. Go lemogilwe gore dikgong di sa dirišwa ka bontši bjo bo bonagalago go kgotsofatša dinyakwa tša malapa tša enetši tše bjalo ka go apea, go ruthetša meetse le go ruthetša lefelo. Se se be se swanela gagolo ka lebaka la boemo bja ka moo ekonomi e amago tšwelopele ya malapa. Mabaka a ka moo ekonomi e amago tšwelopele ya setšhaba a go swana le ditseno, boemo bja thuto, bogolo bja lelapa le tšeo di ratwago go hweditšwe go ba mabaka ao a hlohleletšago khuetšo ye kgolokgolo go tirišo ya dikgong gare ga malapa thutelong ye. Dielemente tšeo di ka fetolwago le lefelo tikologong ye e itšeng tša thutelo le tšona di bontšhitšwe go godiša tirišo ya dikgong. Thutelo ye gape e utollotše gore, bjalo k age go šupilwe dingwalong tšeo di lekotšwego, malapa a lefelong la thutelo a latela mekgwa ya dibešwa tša mehutahuta gomme ga a latele manamelo a enetši. Dingwalo tšeo di lekotšwego di laeditše go ya pele gore ga se mabaka ka moka ao a nago le bohlokwa bjo bo lekanago go šupeng boitshwaro le mokgwa tša tirišo ya enetši ka malapeng. Se se šupa gore methopo ya enetši ye bjalo ka dikgong ga se ya tlogelwa ka gohlegohle eupša e dirišwa mmogo le methopo ya sebjale ya enetši ye bjalo ka mohlagase. Go ruma, thutelo ye e utollotše gore le ge go na le mohlagase, ka lebaka la bohloki le tlhaelo ya ditirelo tša motheo tša mahala tše bjalo ka mohlagase wa motheo wa mahala, kholofelo go dikgong dinagamagaeng e tlo tšwela pele. vi

Mareo a bohlokwa: Mohlagase; methopo ya Enetši; Manamelo a Enetši; bohloki bja Enetši; Dikgong; Mohlagase wa Motheo wa Mahala; Mekgwa ya Dibešwa tša Mehutahuta; Tirišo ya malapa ya enetši; Malapa a dinagamagaeng; mabaka a Ka moo Ekonomi e amago Tšwelopele ya setšhaba

MAṄWELEDZO

U swikelela khuni na zwiṅwe zwiko zwa fulufulu zwine zwa swikelelea ndi zwa ndeme kha u tsireledza zwo teaho zwa vhutshilo kha miṱa ya vhupo ha mahayani kha mashango o no khou bvelelaho. Ngudo dzo farwa u itela u pfesesa zwiitisi zwa u ḓitika zwihulwane nga khuni kha vhupo ha mahayani kha mashango ane a khou ḓi bvelela zwi si na ndavha na u khwiniswa ha u dzheniswa ha muḓagasi na tshivhalo tsha mbekanyamaitele dza muvhuso dzo ḓivhadzwaho u ṱuṱuwedza miṱa ya vhupo ha mahayani u bva kha u shumisa zwivhaswa zwa kale u ya kha zwa ano maḓuvha. Ngudo iyi yo livhiswa kha u asesa na u pfesesa zwiṱaluli zwine zwa ṱuṱuwedza u shumiswa ha khuni nga miṱa ya Muvhunduni wa Ga-Malahlela Vunduni ḽa Limpopo. Ṱhoḓisiso dzi si nngana dzo itwa nga ha u shumiswa ha khuni hu tshi tevhela u dzheniswa ha muḓagasi vhuponi ha mahayani Afurika Tshipembe, ho vha u bvisela khagala nga ha zwiṱuku zwo wanululwaho kha thero heyi ye ngudo ya i bveledzisa. U linga ho vha ho ḓisendeka nga ngudamirafho ya miṱa na kushumisele kwa fulufulu miṱani, hu na mbudzisombekanywa dzo dzudzanywaho dzo shumiswaho u swikelela kha u pfesesa nga vhuḓalo zwiṱaluli zwine zwa ta u shumiswa ha khuni. Ho dzhielwa nṱha uri khuni dzi kha ḓi shumiswa nga maanḓa u ḓisa ṱhoḓea dza fulufulu miṱani u fana na u bika, u vhilisa maḓi na u dudedza vhudzulo. Hezwi zwo tea nga maanḓa kha vhuimo ha matshilisano a zwa ikonomi miṱani: zwiṱaluli zwa ikonomi ya matshilisano zwi ngaho sa mbuelo, vhuimo ha pfunzo, vhuhulu ha muṱa na zwo no takalelwa ho wanwa uri ndi zwiṱaluli zwine zwa shumisa ṱhuṱhuwedzo khulwane ya u shumiswa ha khuni vhukati ha miṱa ya vhupo ha ngudo. Variabuḽu dza saikhoḽodzhikhaḽa na vhupo ha ḓivhashango zwa vhupo ha ngudo zwo sumbedziswa u ṱuṱuwedza u shumiswa ha khuni. Ngudo yo isa phanḓa na u wanulusa uri, sa zwo sumbedziswaho kha maṅwalwa o sedzuluswaho, miṱa kha vhupo ha ngudo i kuvhanganya fulufulu ngeno hu sina u gonya ha tshanduko ya kushumisele kwa fulufulu. Maṅwalwa o sedzuluswaho o sumbedzisa a tshi i sa phanḓa uri a si zwiṱaluli zwoṯhe zwine zwa vha na ndeme i linganaho kha u ta vhuḓifari na kushumisele kwa fulufulu miṱani. Hezwi zwi sumbedza uri zwiko zwa fulufulu zwi ngaho sa khuni a zwo ngo laṱelwa kule tshoṯhe fhedzi zwi shumiswa zwo ṱanganyiswa na zwiko zwa fulufulu zwa ano maḓuvha zwi ngaho sa muḓagasi. Ri tshi pendela, ngudo iyi i ta uri na musi muḓagasi u hone, nga nṱhani ha vhushayi na ṱhahelelo ya tshumelo dza muḓagasi wa mahala wa mutheo u fana na muḓagasi wa mahala wa mutheo, u ḓitika nga khuni vhuponi ha mahayani hu ḓo ḓi bvela phanḓa.

Maipfi a ndeme: Muḓagasi; zwiko zwa Fululu; u gonya ha tshanduko ya kushumisele kwa Fulufulu; vhushai ha fulufulu; Khuni; Muḓagasi wa Mahala wa Mutheo; u kuvhanganya Fulufulu; u shumisa fulufulu Muṱani; miṱa ya vhupo ha Mahayani; Zwiṱaluli zwa ikonomi ya matshilisano

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LIST OF ABBREVIATIONS AND ACRONYMS

%	Percentage
°C	Degrees Celsius
Amp	Ampere
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DoE	Department of Energy
FAO	Food and Agriculture Organization of the United Nations
FBE	Free Basic Electricity
GHS	General Household Survey
IARC	International Agency for Research on Cancer
i.e.	That is
IEA	International Energy Agency
kWh	Kilowatt per hour
LPG	Liquified Petroleum Gas
Mt	Megaton
PJ	Petajoules
PLM	Polokwane Local Municipality
SEA	Sustainable Energy Africa
SSA	Sub-Saharan Africa
Vs	Versus
WHO	World Health Organisation
UNDP	United Nations Development Programme
ZAR	South African Currency (Rand)

CHAPTER 1

BACKGROUND

1.1. Introduction

This study describes how certain factors influence the use of firewood as an energy source within rural households. The government has worked tirelessly to ensure that rural areas in South Africa are electrified. The provision of free basic electricity was also introduced to relieve poor households from the burden of high energy costs. However, households consequently turn to the use of firewood as a supplement to electricity for household energy needs, regardless of the free basic electricity they receive. This raises questions as to "why households turn to firewood for specific domestic energy needs?" whilst having access to electricity and free basic electricity.

This study, therefore, unpacks the relationship/link between socio-economic factors and energy choice and/or energy use. The comprehension behind the study is that; studies (Kebede *et al*., 2002; World Bank, 2003; Duflo *et al*., 2008; Hiemstra-van der Horst & Hovorka, 2008; Hoffman *et al*., 2015) conducted in middle-income countries have put significant emphasis on the alternation or substitution of energy sources, as illustrated on the energy ladder by Masera et al. (2000). These studies hypothesised that energy alternation and substitution were driven particularly by economic factors. The fact that the energy technology and/or source households use is a function of the households' socio-economic status was the basis or foundation of this hypothesis (Cory *et al*., 2009).

Despite energy being a vital and basic need; the socio-economic status of households will determine the type of energy source the household uses, as a significant proportion of the South African population depends on expensive and subservient sources of energy (Balmer, 2007; AP Framework, 2018; Masekameni *et al*., 2018). Firewood use, particularly in rural Africa remains a key energy source as most people cannot afford other forms of energy for basic household energy needs (Boudreau *et al*., 2005; Shackleton *et al*., 2007). This constitutes the approximation of about one-third of the world's population of about 2.4 billion individuals in middle-income countries who depend on firewood for domestic energy needs (FAO, 2017). For example, firewood is usually used for cooking and heating because both cooking and heating require large amounts of energy. This ultimately makes firewood the most affordable

and reliable source of energy to use for such domestic energy needs (WHO, 2014). Other alternative energy options ranging from traditional sources (coal, paraffin, dung, etc) to modern sources (mechanical power, natural gas, electricity, etc) are also utilised for domestic energy needs (Louw *et al*., 2008).

The energy service (space and water heating, cooling, lighting, cooking, etc.), rather than the energy source, is a significant facet for rural households (Kimemia & Annegarn, 2012). However, the energy user would use readily available, affordable, and accessible energy sources, which is likely to be traditional sources of energy (Howells *et al*., 2010). A large proportion of rural households cannot access affordable and efficient energy resources (mechanical power, natural gas, electricity, etc), this remains a problem for households in rural dwellings in under-developed and middle-income countries (Boudreau *et al.*, 2005; Shackleton *et al*., 2007). Additionally, by the year 2030, the quantity of households utilising conventional energy sources is estimated to continuously ascend by 100 million (IEA, 2010a). This growth could be attributed to marginalised households, either topographically or financially (Shackleton *et al*., 2007). This is despite energy access forming part of the factors responsible for the sustainability of human life (Uhunamure *et al*., 2017). Moreover, the ability to access energy services has become a precondition for addressing global developmental challenges in poverty eradication, climate change, and inadequate healthcare schemes (Bensch, 2013; DoE, 2014; Reddy, 2015).

Several factors influence the manner and rate at which firewood and other traditional energy sources are used. These factors include energy demand, attitude, preference, forest cover, climate, household size, and socio-economic factors (Kituyi *et al*., 2001; Ding *et al*., 2016; Semenya & Machete, 2019). However, firewood resources are threatened, even though it is a renewable resource. Furthermore, factors such as; population growth, development activities, and over-utilisation of firewood resources pose a challenge to their sustainability which makes South Africa susceptible to energy poverty (Gaugris & Van Rooyen, 2010).

Ismail (2015) and Kohler et al. (2009) define energy poverty under the South African context as "*the inability to access modern services such as electricity for basic household energy needs, which are considered necessary for the development and well-being of humans*". Mohapi (2016) regards energy poverty in South Africa as a challenge because a significant extent of the country's populace is poverty-stricken or susceptible to becoming poor. However, when comparing South Africa's energy poverty to its neighbouring countries, South Africa remains

an example of a middle-income country struggling to develop or improve its economy and provide opportunities for its people to a future free from energy poverty (Ferriel, 2010; Ismail & Khembo, 2015).

Firewood, therefore, provides much-needed relief from energy poverty for rural households. This is despite its underlying devastating impacts on the environment and socio-economic status of the country is undeniable (Arnold & Persson, 2003). For example, the rate at which firewood consumption is estimated to rise will ultimately lead to the assertion of potentially devastating deforestations, which would eventually lead to global environmental degradation (Arnold & Persson, 2003). This background provides an informative scientific perspective of the community of Ga-Malahlela. Also, the projection of the future will help the municipality to comprehend the reasons behind the use of energy resources such as wood, even with improved electrification rates of its rural areas.

1.2. Problem statement

The electrification rate of households in the Polokwane Local Municipality currently sits at 98% (PLM, 2018). However, the use of firewood is still prevalent in the Municipality. Although literature shows that people use firewood because they do not have electricity, the situation in Ga-Mahlalela village is unique, because, despite electrification, households continue to use firewood. It was therefore unclear as to why these electrified communities continue to use firewood.

Moreover, most households in middle-income countries depend on various energy sources that are combusted on a day-to-day basis utilizing inefficient devices in poorly ventilated environments (Edwards *et al*., 2001; Masekameni *et al*., 2014). Inadequately ventilated areas frequently lead to incomplete combustion which produces a variety of irritant pollutants. These pollutants include but not limited to; polyaromatic hydrocarbons, carbon monoxide, formaldehyde benzene, butadiene and numerous different compounds posing several health and environmental impacts (Abbate *et al*., 1993; Ernstgård *et al*., 2002; Garte *et al*., 2008).

The environmental impacts include but not limited to; deforestation, related indoor pollution, and air pollution which consequently lead to health hazards. These health hazards include; fatigue, nausea, throat irritation, dizziness, eye irritation, mental confusion, and the induction of asthma attacks (Midzenski *et al*., 1992; Cometto-múiz & Cain, 1995; Bruce *et al*., 2002;

Ahaghotu *et al*., 2005; Wah *et al*., 2012). Additionally, over 1.5 million premature deaths a year are caused by acute respiratory infections from breathing smoke from open indoor cooking fires. Women and children endure the greatest health risks because they are generally exposed to the greatest levels of pollutants, which is a major issue of concern. After all, respiratory infections are the leading cause of death of young children worldwide. Thus, this study sought to investigate the variables/factors influencing the use of firewood in this community.

1.3. Rationale and significance of the study

Energy is a vital need for the livelihood of humans, it sustains all forms of life, from the food we eat daily to basic household energy needs and other forms of energy needed to run our lives and our ability to live (DEAT, 2012). As much as energy is a basic human need, it is associated with several factors that impact humanity, as research has shown that despite the electrification of poor households, households continue to use or alternate between different energy sources to meet their energy needs (DEAT, 2012; Masondo *et al.*, 2016; Semenya & Machete, 2019).

Numerous studies have established socio-economic factors influencing the choice of energy source a household utilises (Kebede *et al*., 2010; Onoja, 2012; Song *et al*., 2012; San *et al*., 2012; Johnson & Bryden, 2012; Rehnus *et al*., 2013; Ding *et al*., 2016; SEA, 2018; Semenya & Machete, 2019). It was established that the demand for energy is affected by socio-economic conditions, demographics, economic activities and conditions, equipment efficiency, and substitutable energy (Kebede *et al.*, 2010; Makonese *et al*., 2016). Similarly, this study sought to investigate the reasons behind firewood consumption in rural Limpopo. Several studies demonstrated that households in rural areas persist in utilising firewood as their primary source of fuel, due to different reasons (Dovie *et al.*, 2002; Shackleton *et al*., 2004; Madubansi & Shackleton, 2007; Giannecchini *et al*., 2007; Shackleton & Stickler, 2015; Nott & Thondhlana, 2017). The reasons behind firewood consumption in rural and poor households are mainly because of their inability to afford electricity which could sustain them for the whole month. Poor households generally have inefficient sources of household income, which results in them not being able to spend significant amounts of money on energy (SEA, 2018).

Although the government has successfully electrified rural households over the years, there is, however, still a backlog in the electrification of households. The backlog, which is frequently in rural areas and squatter camps is caused by distributor-grid restrictions. While the government experienced difficulties in electrifying a few households, few difficulties were

experienced where electrified households utilised other sources of energy other than electricity (SEA, 2018).

This study, therefore, presents the factors influencing the utilisation of firewood as an energy source. As there is a lack of literature on why firewood is still prominent, after the accoutrement of the electricity subsidy and the growth of electrification rates of South Africa's rural areas. Moreover, this study has a national significance in that its results may give insight into the main sources of energy used in the study area, as well as what influences their choice. These factors can assist the government and stakeholders to implement strategies or an energy system, which would enhance people's awareness of alternative and cleaner energy methods/options. This study also intended to help the Polokwane Local Municipality (PLM) and the relevant parties determine the factors influencing the utilisation of firewood as a domestic energy source by residents of their municipality. The study may also contribute to literature by providing an updated scenario of the factors that influence firewood use.

1.4. The Research aims and objectives

This study aimed to assess factors that influence the use of firewood in households in Ga-Malahlela village of the Limpopo Province. To accomplish this research aim, the following objectives were assessed:

i. To investigate why households, continue to use firewood even after electrification of Ga-Malahlela village,
ii. To determine the availability of firewood and what it is used for within households in Ga -Malahlela, and
iii. To determine the relationship between the socio-economic state of households in Ga-Malahlela and the choice of energy source used.

1.5. Chapter outline / Research outline

This dissertation is organised and presented in five chapters as follows:

Chapter 1 consists of the background and overview of household energy use, a problem statement, significance, and rationale of the research study, and the study's aim and objectives.

Chapter 2 outlines the reviewed literature, which encompasses factors that drive firewood use in the study area, it also presents the theoretical and empirical literature of the fuel choice and

use by households in the study area, as well as the empirical literature of the relationship between the socio-economic state of households in the study area and the choice of energy source used.

Chapter 3 describes the study area, the methodology of the research followed, which includes the research design, sampling method, method of data collection, and analysis as well as ethical considerations of the study.

Chapter 4 focuses on the presentation and analysis of the results and discussion of the study findings.

Chapter 5 outlines the summary, study limitations, key conclusions, recommendations, 0and future prospects for the study.

CHAPTER 2

LITERATURE REVIEW

This literature review encompasses studies that have been done concerning firewood and/or biomass as a household energy source in the context of rural households and developing countries. It also defines what energy poverty is and its relation to factors that influence firewood use, or the use of alternative energy options. The interactions between demographic factors and the energy shift patterns; that is, from one energy source to another. This literature review aided in the gathering of information on household firewood use, which was necessary for enhancing a better perspective of the factors that influence the use of firewood as an energy source in Ga-Malahlela village.

2.1. Introduction

Wood still forms part of the biggest biomass energy resource today Mohtasham (2015), for millenniums, fire has been vital for providing warmth in cold conditions, light in the dark and it has made it possible for humans to be able to prepare food. Since fire was first discovered, the primary source of fuel for it was wood energy, which is the energy source of interest in this study. In energy policy terms, firewood comprises of a variety of unprocessed biomass consisting of wood (Brack, 2017). According to Union of Concerned Scientists (2011); wood is a type of solid biomass, which includes agrarian crops and residues, herbaceous and organic waste, such as food waste or manure Brack (2017) that is utilised to fuel a small fire, which is at most times used for cooking, water and space heating (Union of Concerned Scientists, 2011). This makes wood one of the oldest sources of energy known to humankind, this biomass-derived energy continues to be the largest source of renewable energy globally, it accounted for about 8.9% of the world's total energy supply in the year 2014, most of which was consumed in rural areas (Brack 2017).

Households rely on different sorts of fuels for domestic activities, for example; cooking, water, and space heating in addition to other things. These fuels are extensively classified as traditional fuels which incorporate; firewood, charcoal, stocks, and present-day fuels, which incorporates; Liquid Petroleum Gas (LPG), Kerosene, and electricity. Njong & Johannes (2011) indicated that biomass for cooking is used by approximately 2.5 billion individuals in

middle-income countries and that this occurrence is widespread amongst Central American and Sub-Saharan African (SSA) households. Firewood is primarily and domestically utilised by poor households in remote rural areas. This makes wood a significant residential fuel in South Africa and throughout the African continent. The accurate amount of residential firewood utilised in South Africa is unknown, however, Shackleton and Shackleton (2004) estimated household firewood consumption to an average of 5.3 tonnes per year. Moreover, residential firewood consumption is however, estimated at 86 Petajoules (PJ), which is comparable to 7 Mt of wood every year. These evaluations imply that current firewood utilisation is unsustainable because it is consumed quicker than it is replenished (DoE, 2016).

Moreover, research has demonstrated that the utilisation of firewood, is prevalent in the following countries; Ecuador (63.2%), Brazil (52.9%) and Mexico (24.0%), while in Vietnam and Nepal, 60 % and 32 % utilise straw and leaves respectively (Heltberg, 2003; Jingchao & Kotani, 2010; IARC, 2010). Equivalently, both rural and urban SSA households including South African households, utilise firewood for household energy activities such as cooking and water heating (Howells *et al*., 2005; Bailis *et al*., 2007; Mekonnen & Kohlin, 2009).

2.2. Overview of the South African energy sector

South Africa, through Eskom (the national energy utility supplier), has realised household electrification rates of 85% as well as government supportive policies (DoE, 2015a). Despite such achievements, the Department of Energy (DoE) estimates that 40-49% of households are still energy poor (DoE, 2015b). According to *Statistics South Africa's General Household Survey (GHS),* majority of the 15% of energy-poor households in South Africa depend heavily on unclean energy resources such as traditional biomass for their cooking and heating needs (StatsSA, 2014). It is therefore evident that high electrification rates, especially in low-income households, do not necessarily increase household welfare or reduce energy poverty if households are unable to afford electricity services (SEA, 2014; Groh *et al*., 2016).

Access to sufficient energy services for, water and space heating, lighting, cooking, and communication was acknowledged by the DoE as a basic need. This was acknowledged because affordable, efficient, clean, and reliable energy services significantly reduce energy poverty. The DoE together with the National Electrification Programme (NEP); has therefore made energy poverty an issue of policy focus (Ismail & Khembo, 2015). The DoE and NEP implemented pro-poor policies, the principle focal point of these policies was to provide

indigents with access to free basic services and thereby subsequently diminishing destitution. The dissimilarities between energy-poverty policies and other policies are that; they explicitly focus on poverty mitigation by improving access to energy for indigents. This was done to alleviate the strain of having to secure day-to-day household energy sources for basic human endurance, in addition to improving the welfare of ordinary South Africans (DME, 2003). The government is authorized to furnish indigents with free basic services to diminish the negative effects of destitution on communities (DME, 2003). The South African government has commanded municipalities to relieve energy poverty by supplying indigent households with a restricted amount of free electricity (Free Basic Electricity [FBE]). This became an official government social welfare policy (Ruiters, 2011), that has been deemed to be enough to meet their basic energy requirements for endurance (DME, 2003).

SEA (2016), defines FBE as the amount of electricity believed to be enough to provide basic electricity services to an indigent household. The FBE policy ensures that poor households have free access to basic electricity. This policy allocates 50 Kilowatt-hour (kWh) of electricity to indigent households connected to the national grid monthly. A poor household in this regard is a household that earns below ZAR 3000.00 per month; these households should also be registered to receive a social grant (SEA, 2016). Households that are as of now connected to the energy grid meet all the requirements for a 50 kWh token every month, as this is regarded satisfactory to satisfy fundamental energy needs. ZAR40.00 is provided to off-grid households on a monthly basis, which is paid towards a ZAR 58.00 monthly administration charge which accounts for 80% of the subsidy, with the end goal that these households should make monthly payments of ZAR18.00 (DoE, 2013b). With reference to the Polokwane municipal area as indicated in Table 1 below, 100 kWh is offered to 8400 poor households within the Polokwane license area while, 21 243 households receive 50 kWh in the Eskom license area (PLM, 2018).

It was presumed that the realization of the FBE policy would address affordability issues related to the utilization of electricity and would urge poor households to shift towards using electricity for their domestic energy needs (DoE, 2013b); as the supplied electricity token was deemed enough to meet energy needs for survival (DME, 2003).

Table 1: Free Basic Electricity provision

Basic service	The Limited amount	Free basic electricity provided	Number of customers	The level and standard
Electricity				
Eskom Area	ZAR 82.00 per month	19 000 collected	21 243	50 kWh at RDP standard (20 amp connections)
Municipal License Area	ZAR 79.00 per customer	8 400 collected	8 400	100 kWh (20 amp connections)
Aganang Cluster	ZAR 82.00 per customer	3650 collected	3995	Above RDP standard

Adopted: (Polokwane Local Municipality, 2018).

A study by Mvondo (2010) conducted in Buffalo City of the Eastern Cape, found that the FBE policy socially impacted the population in the area, as the FBE policy showed beyond doubt to be extremely restricted in the productive utilisation of electricity. Another study conducted by Ferriel (2010) with about 30 households to determine if the 50 kWh FBE subsidy was ample, demonstrated that only 25% of the households felt that the 50 kWh was adequate, although these households had to use or mix electricity with other energy sources. This concluded that the 50 kWh token could not improve the lives of both rural and urban indigent households. Moreover, households should purchase an electricity voucher to be able to access the FBE token (Mvondo, 2010). This, therefore, burdens poor households and further increases poverty and energy poverty in the long run, which ultimately prompts households to utilise other energy alternatives such as firewood. The policy also limits the amount of current supply for indigent households to 20 Amps, this constrained 20 Amps confinement also burdens indigent households as it restricts the number of household errands that can be done (Ferriel, 2010).

Moreover, a General Household Survey (GHS) by StatsSA, showed that energy-poor households heavily rely upon dirty energy sources for their basic household energy requirements (StatsSA, 2014a). This makes it evident that improved electrification rates and the provision of FBE for indigent households, does not automatically increase the well-being of poor households or lessen energy poverty (SEA 2014; Groh *et al.*, 2016).

Moreover, the implementation of the FBE policy had some difficulties that hindered the success of the project roll-out (Ferriel, 2010). Firstly, there was an abnormal state of irregularity as far as the project roll-out across the country was concerned. This was because there were various agents in charge of its execution in various zones or areas and these agents did not adhere to similar rules or guidelines of this roll-out. Moreover, how the FBE policy was rolled-out caused contrasts between regions powered by municipalities and those powered by Eskom, of which this brought about various administrations being given. For example, a few areas are allocated 50 kWh when registered with their municipality as an indigent household, whereas households in the Ekurhuleni Metropolitan Municipality are given 100 kWh of FBE. Secondly, the absence of local government capacity caused major hindrance to the execution of the policy (Ferriel, 2010). Thirdly, the self-targeting approach also affected the implementation of the policy. Self-targeting according to the policy is defined as "*a system whereby a household approaches the service provider, indicating the intention to be considered for benefitting from the Free Basic Electricity program*." Illogically, a large number of households suggested that contacting the service provider implies that their current capacity will be constrained, and the installation of prepaid meters will consume a lot of money. Fourthly, indigent households are at most times unaware of the accessibility of FBE (Ferriel, 2010).

Nonetheless, energy policies in South Africa emphasize the significance of the accessibility to energy through the White Energy Paper (DoE, 2013a), which states the following, - "*energy security for low-income households can help reduce poverty, increase livelihoods and improve living standards*". This implies that the accessibility of energy is essential, as being able to access energy leads to the elimination of destitution through improved health services and education and may eradicate structural unemployment (DoE, 2009).

2.3. Energy access in South Africa and other developing countries

Energy access is defined and explained in various ways. The clearest definition of energy access according to Brew-Hammond (2010) is the '*ability to use energy*'. Energy in this context is referred to as Liquid Petroleum Gas (LPG), electricity, charcoal, firewood, etc. (Brew-Hammond, 2010). The *Energy Access Outlook 2017* estimated that around 1.1 billion individuals (14% of the global populace) have no access to electricity, with 84% and 95% being in SSA and developing Asia respectively (IEA, 2017b).

Arntzen and Kgathi (1984), indicated that access to energy sources has two distinct perspectives; first, physical access and second, financial access (that is the costs of the energy sources accessible). Regardless of whether alternative energy sources are physically accessible, they might be unreasonably costly for widespread utilisation. This obviously, depends on the income circumstance of individual households. Wood is typically gathered locally and access to wood diminishes if wood becomes scarce, given increment in physical and economical access to alternative energy sources (Arntzen & Kgathi, 1984). Poverty is the main influence behind household energy choices since it can either decrease or increase the household's survival (Cecelski, 2000). A prominent challenge, therefore, remains, as indigents survive through schemes that involve the acquisition and procuring of other sparse resources for energy (Cecelski, 2000).

Access to energy differs across middle-income countries. Poorer middle-income countries have limited access to energy, as compared to other middle-income countries. Statistical analysis by IEA (2017a) indicates that approximately 79% of individuals lack access to electricity in poorer middle-income countries. Moreover, 28% of individuals in middle-income countries as a whole have access to electricity. Access to present-day energy sources is evenly limited in middle-income countries and SSA, where 91% and 83%, respectively, lack access to present-day fuels (IEA, 2017a). This accounts to approximately 3 billion individuals in middle-income countries that are dependent on solid fuels for cooking (IEA, 2017a). Asian regions as compared to SSA have access to electricity but lack access to modern energy sources (IEA, 2017a).

The *Energy Access Outlook 2017* indicated that over 2.8 billion individuals (38% of the global populace) lack access to clean energy sources for cooking, this figure is again dominated by SSA and developing Asia (IEA, 2017b). However, the use of biomass for cooking is relatively higher in developing Asia (80%) as compared to SSA, this is because the population in SSA is much lower than that of developing Asia (IEA, 2017b). Additionally, SSA accounts for the world's most elevated local per capita firewood energy utilisation, with a mean utilisation of 0.69 cubic meters per year in 2011, in opposition to the worldwide mean of 0.27 cubic meters per year (Iiyama *et al*., 2014). About 93% of households in SSA rely on firewood energy for their day-to-day cooking needs, while firewood continues to be the favoured choice in rural areas (Girard, 2002; Arnold *et al*., 2003; Bailis, Ezzati, & Kammen, 2005; Mwampamba *et al*., 2013; Iiyama *et al*., 2014). Moreover, SSA except for South Africa, where coal is a significant fuel, has the biggest extent of its populace depending on conventional fuels such as charcoal and firewood (IEA, 2006: IEA, 2010b) (Table 2). Approximately 31% of the South African

populace dwells in the rural regions of the country. Despite the increase in the electrification of South African rural households, firewood is still prominently used for cooking. This is because of their inability to afford either the electricity costs or the appliances used for cooking, which correlates this to poverty (Prasad & Visagie, 2005). Research shows that the electrification of rural areas/households does not automatically replace firewood use to a significant degree (Prasad & Visagie, 2005).

Moreover, South Africans depend on different fuels to remedy the impacts associated with energy poverty (Aitken, 2007; DoE, 2012). The use of mixed-energy sources and carriers by poor households has been recognised, which is a result of different household tasks that need different energy sources (Cecelski, 2000; Winkler, 2006). Energy carriers, for example; paraffin, candles, biomass, and LPG are frequently utilised to satisfy household energy requirements, mainly in peri-urban neighbourhoods (DoE, 2012).

In Nigeria, electricity, LPG, and kerosene are the major alternative sources to household energy for cooking. Unfortunately, these choices are not physically accessible or financially reasonable to numerous households (Arntzen & Kgathi, 1984). The situation in India is different, as it continues to prioritise the electrification of households, which will see it reach universal electricity access by early 2020, increasing access to renewable energy for household energy needs. In other middle-income countries as indicated in Figure 1 below, the electrification rate will plunge to over by more than 80% in 2030, while in SSA the electrification rate will only increase by just over 50% (IEA, 2017b).

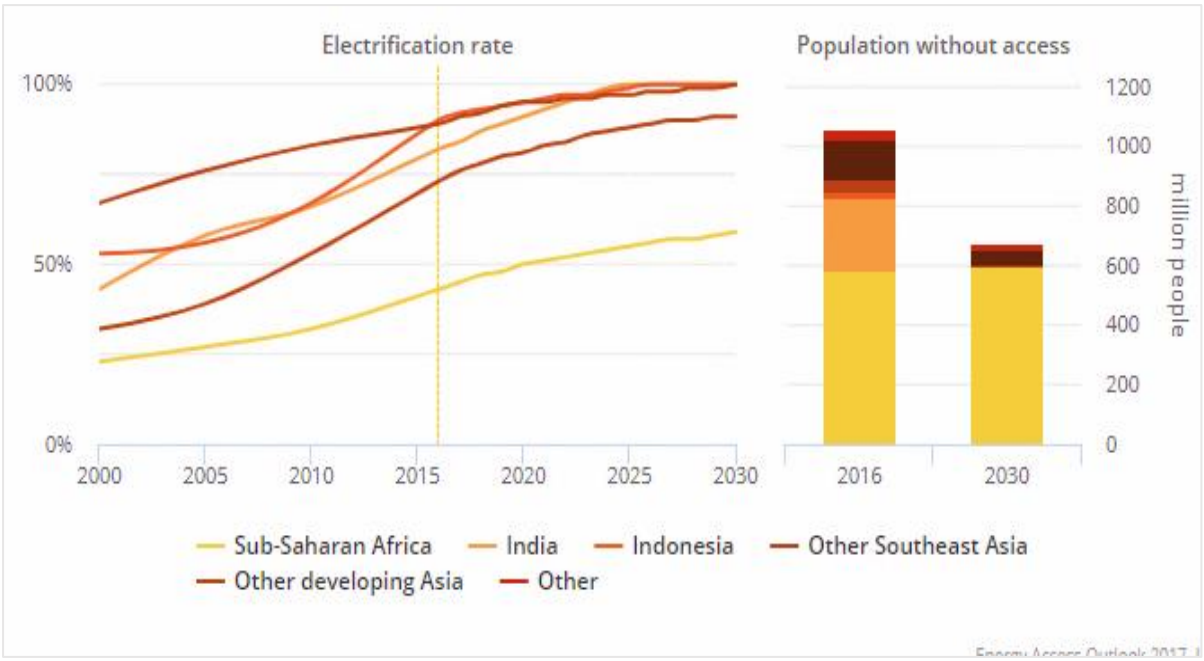


Figure 1: Electrification rates in selected middle-income countries

Adopted: (IEA, 2017b).

Energy poverty is accountable for the influence of energy choices by poor households since these households use tactics involving the securing of unrenewable energy resources (Cecelski, 2000). Energy poverty is perceived in many, if not every element of poverty (Srivastava *et al.*, 2012). It is at the top of the social problems encountered in the 21st century (Srivastava *et al.*, 2012). In middle-income countries, energy poverty is defined regarding the ability to access electricity, which is viewed as pivotal to all facets of sustainable development (Bazilian *et al.*, 2010; UNDP, 2010). Kohler et al. (2009) define energy poverty as the lack of access to recent energy services, it can either be heating or cooking fuels, or electricity which is fundamental for human development and the gratification of basic human needs, households need energy for imperative services, the lack of having the freedom of choice in acquiring safe, sufficient and eco-friendly services induces the manifestation of energy poverty (UNDP, 2000).

Energy poverty is thoroughly demonstrated about relative domestic expenditure; where poor households spend a significant proportion of 20 % of their household budget on energy, while wealthier households spend only 2% to 3% of their household budget on energy (SEA, 2006). Energy poverty has three inferences; initially, energy poverty indicates that low-income households have little or no access to safe, ample, and efficient energy sources and appliances to cater to their most basic energy needs. Secondly, it indicates that the impacts linked with

their energy consumption further burden them in the case of hazards such as fires or burns and illnesses. Lastly, it implies that there is a compromise of the income-generating activities of poor households (Ismail & Khembo, 2015).

Developing Asia and SSA are affected mostly by the inability to access modern energy services (IEA, 2015; IEA, 2016). According to estimates, approximately 620 million people in Africa are affected by energy poverty (IEA, 2015). On the other side, an estimated 730 million individuals rely heavily on conventional fuels for cooking (Cerutti *et al*., 2015), this figure is expected to rise to 922 million by the year 2030 as indicated in Table 2 below. In South Africa, poverty is a familiar sight as Mohapi (2016) confirmed that many South African citizens live in poverty, which further translates to energy poverty (Mohapi, 2016). This is despite South Africa being a relatively multifaceted country with an improvement in rural energy access (Shackleton & Shackleton, 2004).

Table 2: An estimate of the number of individuals relying on traditional biomass (millions) as the primary source of energy for cooking by 2030.

	2009 (Actual)			**2015**	**2030**	**Share of Populations on Biomass (%)**		
Region	Rural	Urban	Total	Total	Total	2009	2015	2030
Africa	481	176	657	745	922	67	65	61
Sub-Saharan Africa	477	1176	653	741	918	80	77	70
Developing Asia	1694	243	1937	1944	1769	55	51	42
China	377	47	423	393	280	32	28	19
India	765	90	855	863	780	75	69	54
Other Asia	553	106	659	688	709	63	60	52
Latin America	60	24	85	85	80	18	17	14

Developing countries*	2235	444	2679	2774	2770	54	51	44
Worldwide**	2235	444	2679	2774	2770	40	38	34
Africa in % of world	22%	40%	25%	27%	33%			

*includes Middle East countries
**includes OECD and transition countries

Adopted: (Cerutti *et al*., 2015).

Nevertheless, there have been several systematic investigations to evaluate energy poverty through the construction of energy poverty indicators. Some of these indicators have initially taken the form of unidimensional metrics, describing energy poverty as an energy poverty line or minimum energy required to live a basic daily life (Bazilian *et al*., 2010). While unidimensional indicators are straightforward and are easy to interpret, critics have argued that energy poverty is rather a multidimensional concept. In this respect, several multidimensional indicators have also emerged within literature, providing rich and decomposable information about energy poverty (Nussbaumer *et al*., 2012). This, therefore, makes access to energy a challenge among the poor (Fuma, 2016).

2.4. Household energy/fuel choice

The significance of understanding fuel choice practices was illustrated by Van der Kroon et al. (2013) as it relies upon various elements; this makes information on the drivers of a households' fuel choice noteworthy (Mekonnen & Kohlin, 2009). The household decision-making environment speaks to an intricate and intuitive web of explanations impacting personal conduct patterns (Van der Kroon *et al*., 2013). However, the depiction and further clarification of these examples of fuel use have unfortunately received substantially less consideration contrasted to research on the fuel transition process (Masera *et al*., 2000).

As reported by Farsi et al. (2005), rural households' energy choices are impacted by the inability to access progressively marketable fuels and markets for energy utilizing equipment and apparatus. Fuel choice is at most times decided by local accessibility and trade probability expenses relevant in collecting the fuel (generally firewood, animal dung, and various biofuels) as opposed to household spending limitations, costs, and expenses. Displaying choices in these

conditions is complex and available data concerning the time required for the gathering of these fuels or the opportunity expenses is usually minimal (Farsi *et al*., 2005).

The total energy utilization in rural regions comprises of fuels such as firewood, charcoal, and agrarian waste. Rural households gather fuels from different sources, i.e. dung from animals, forests, or the open land in the vicinity of their household, at times even from nearby retailers. The energy carriers are utilized for different intentions, for example; lighting, cooking, water, and space heating, and so on. Numerous families cook and water heat with wood while other households cook with LPG, and water heat with either firewood or electricity (Schipper, 2000). However, when comparing rural households to urban ones, urban households tend to have a more extensive choice and more noteworthy access to present-day commercial fuels and energy sources, utilizing end-user hardware and machines which give them a more prominent potential for fuel switching. The demand for household fuels and electricity has tremendously surged together with rapid urbanisation in middle-income countries (Farsi *et al*., 2005).

In India, according to Farsi et al. (2005) changing urban lifestyles has significant ramifications on the patterns of energy use in households. Moreover, household energy is expected to meet all household energy needs i.e. for cooking, lighting, water heating, and fuelling electrical appliances. However, energy is mostly used for cooking within households, hence an emphasis on cooking energy utilisation patterns assumes further significance (Farsi *et al*., 2005).

The provision of social services and the supply of infrastructure is not commonly practiced in South Africa’s rural regions, like other middle-income countries worldwide (Masekoameng *et al*., 2005). Social services and infrastructure provided in South Africa's rural areas are therefore minimal and are of low quality. Rural households, ultimately, depend on conventional fuel sources, for example, fuelwood and cow dung (Masekoameng *et al*., 2005). This explains the findings by StatsSA (2015), where a large number of inhabitants in the Limpopo province reside in rural areas, which makes the Limpopo province the highest consumer of firewood in the country in 2014 with 40% of the population relying on wood for cooking (StatsSA, 2015). A study was undertaken in Nigeria by Obayelu et al. (2017) also demonstrated that 65% of rural households utilise firewood for cooking, regardless of the accessibility of renewable and non-renewable fuel resources.

Household energy demand is classified into cooking, water and space heating and lighting, and other electrical demands for each specific household type (ERC, 2009). While in rural

household's energy demand is classified into heating and cooking, where most of the fuel used is collected rather than purchased. The probability of impoverished households relying on non-commercial firewood is more averse to shift to commercial fuels, except if their financial conditions improve, this is because these households are burdened with extremely high energy costs (Winkler, 2006). This upheld reliance on non-commercial fuels carries with it, various sustainability issues such as; well-being impacts, environmental degradation, diminished efficiency, and energy poverty (Winkler, 2006).

The commercialisation of firewood and the exhaustion of forests means further energy poverty and deteriorating livelihoods (ERC, 2009). Moreover, South African households spend 14% on average of their monthly household income for energy needs, which consequently contributes to the country's energy poverty battle. This statistic implies that about 7 million households will further rely on alternative detrimental and unsafe types of energy (biomass, coal, and paraffin) when they are unable to purchase electricity due to financial constraints.

During the last decade, household energy use patterns demonstrated an elevated level of utilization in electricity (Figure 2) to satisfy basic household energy requirements, more especially concerning cooking and lighting (SEA, 2014). Several authors stated that even though access to and the utilization of electricity has increased in rural households, it is mostly used for luxury items (phones, television, radio, etc.). Firewood, on the other hand, is used for domestic energy needs that use extensive amounts of energy such as; cooking, water, and space heating (SEA, 2016). Poor rural households prioritize cheap fuels for daily cooking and heating activities. This is because using electricity for cooking is perceived to be slow and inefficient. The electrical appliances required for cooking and heating are expensive. Additionally, firewood is cheaper compared to electricity (Knöpfle, 2004) and biomass fuel demand is affected by the dissemination of the populace and households within the country. The utilization of fuelwood is, therefore intensified in the most indigent provinces of the country with sizable rural populations, such as the Eastern Cape, Limpopo Province, North West Province, and KwaZulu-Natal (StatsSA, 2012). Louw et al. (2008) like Knöpfle (2004) also attributed this to the high costs of electrical appliances as well as other factors such as seasonal energy needs and cultural beliefs (Louw *et al*., 2008).

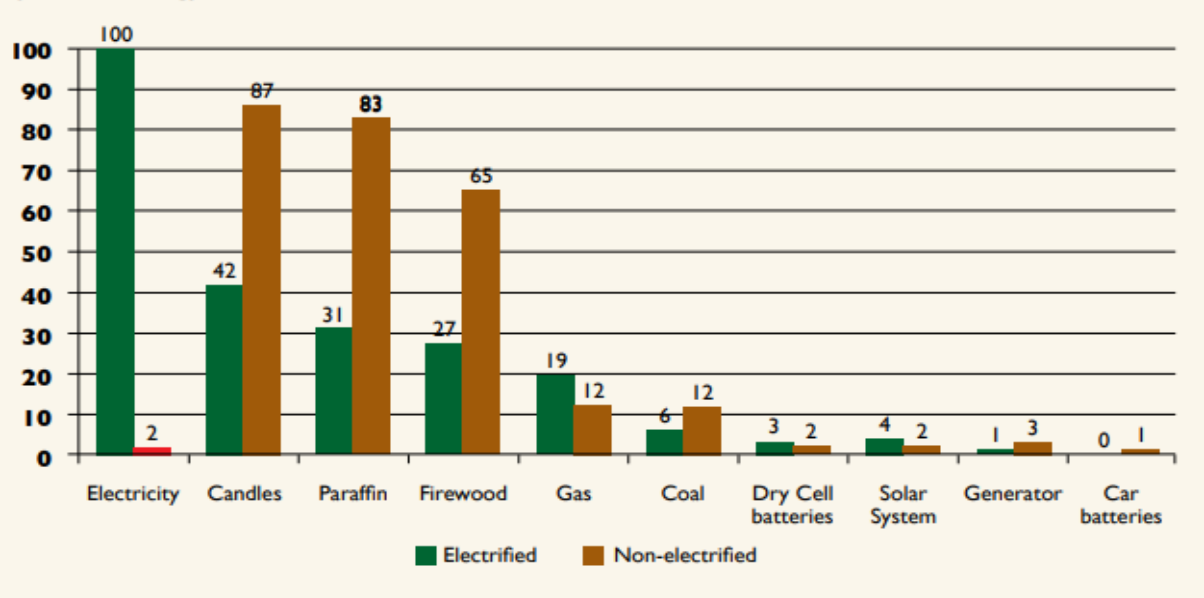


Figure 2: Use of energy sources among South African households, by electrification status (percent using*).*

Adopted: (DoE, 2012).

Research conducted in Chile, South America by Reyes et al. (2018) exhibited that distinctive socio-economic factors impacting and driving the utilization of firewood exist. Chile has a lower population density and lower poverty levels but has a competitive firewood market and a firm land tenure routine (Burschel *et al.*, 2003; Reyes, 2013). The usage of firewood continued to rise concurrently as the population of Chile and income increased. A study conducted by Vasicek & Gaugris (2014) in the Maputaland-Pondoland-Albany biodiversity hotspot in South Africa revealed that firewood is still a common source of fuel which is primarily utilized for cooking, water, and space heating, this is despite the diverse energy alternatives at its disposal (Vasicek & Gaugris, 2014).

Another study led in Dikgale, a rural settlement in Limpopo Province, showed that a large portion of the Dikgale population (62.5%) utilises electricity for cooking. This rate is higher than the utilisation rate in Limpopo Province (50%), however, it is lower than the 73.9% national use of electricity for cooking. Firewood was still widely utilised in Dikgale with 25.6% of the study participants stating that both electricity and firewood are used for cooking, while 9.6% indicated that they utilized wood only. With regard to water heating, electricity (70.5%) is the common method used for heating, which was greater than the national average (58.8%) in 2011. The study concluded that wood (20%) was the second most preferred source of energy

for heating, while 8.3% of the populace indicated that both wood and electricity are used for water heating (SEA, 2016).

The commercialisation of firewood and the exhaustion of forests indicates that South Africa's energy system and economic development will remain impacted (ERC, 2009). Moreover, the average spent (14%) of a monthly household income in South African households for energy needs consequently contributes to the country's energy poverty battle. This statistic implies that about 7 million households will stick to alternative unsafe types of energy such as; biomass, coal, and paraffin. Moreover, they will continue to do so when they cannot purchase electricity as a result of budgetary constraints. During the last decade household, energy use patterns demonstrated an elevated uptake in electricity to satisfy basic household energy needs more especially with reference to cooking and lighting (SEA, 2014).

The literature reviewed indicates that energy is crucial for the economy of South Africa, it also shows that there is an agreement amongst researchers that the manner in which households use energy is inadequately comprehended and further research is required to define significant approaches and intercession systems (Leach, 1992; Masera *et al*., 2000; ESMAP, 2003; Heltberg, 2004; Elias & Victor, 2005; Farsi *et al*., 2007; Pachauri, 2007).

2.5. Household energy use patterns

According to literature, several studies have attempted to explore the factors influencing fuel choice using separate household data. Among these studies, there were two types of analysis methods that were used particularly for developing countries, there were those that utilized simple descriptive statistics and those that used econometric methods to analyse fuel choice (Farsi *et al*., 2005). These studies assessed the conventional perspective on fuel switching in the household sphere of middle-income countries which indicated that the energy ladder is slowly but progressively ascended by households and that a straightforward linear movement exists from comparatively inefficient fuels and energy end-use appliances to progressively effective fuels, with rising levels of income and urbanization (Sathaye & Tyler, 1991; Leach, 1992; Smith *et al*., 1994, Reddy & Reddy, 1994). Nonetheless, current literature regarding household energy use in middle-income countries demonstrates that the energy ladder hypothesis is excessively short-sighted as there are numerous different factors apart from income that influence fuel choice (Davis, 1998; Barnett, 2000; Masera *et al*., 2000). Moreover,

household fuel choice and fuel stacking models have been utilized to determine household fuel choice.

2.5.1. The Energy ladder

The concept of household energy choice has frequently been explained within the context of the 'energy ladder hypothesis'. Research endeavouring to clarify household fuel choice has been conducted in developing countries and it was discovered that a household's fuel decision relies upon various factors. One factor that is vital for switching to different fuels especially in middle-income countries is the improved accessibility of alternative fuels, apart from standard biofuels. Such alternative fuels are commonly accessible in the capital cities of developing countries, yet accessibility to similar fuels is considerably more constrained in rural regions of these countries (IEA, 2006).

Energy use studies have further revealed a rather steady pattern of affirmation throughout the past two decades, which reveals that South African households, particularly poor households, gravitate towards numerous energy sources to guarantee that their day-to-day energy requirements are met (DoE, 2012). A moderately steady example of evidence has emerged from these energy use studies, which indicate that South African households, particularly those demonstrating elevated degrees of material deficiency, depend on several different energy sources (i.e. to guarantee that their daily energy requirements are sufficiently met) (DoE, 2012). The characterisation of households has been shown by this phenomenon, regardless of their electrification status. This is inconsistent with the triumphing energy transformation concepts and the energy ladder model, which have characteristically inferred a direct, linear transition from conventional to present-day fuels and appliances after households have been electrified (DoE, 2012).

The possibility of the energy ladder began to rise concurrently to the firewood exigency during the 1970s-1980s as Toole (2015) suggested. The energy ladder was structured like a tiered association between households' ascent in financial state and the type of fuel they utilise for domestic energy requirements (Toole, 2015). As indicated by the consumer economic theory; an increase in income prompts the consumer to buy more "sophisticated" goods than less "basic" goods (Toole, 2015). This theory was then linked with energy, which demonstrated what households are going through, though they were users, who attempt to maximise their distribution of energy according to their financial state (Kroon, 2013; Toole, 2015). This,

therefore, concluded that the energy ladder delineates a process whereby when a household's income increases, the household diverts from using traditional fuels such as biomass.

However, households initially adopt transition fuels such as kerosene and coal, then move to use modern fuels such as gas and electricity (Heltberg, 2005; Chambwera & Folmer, 2007; Lay *et al*., 2013). This is outlined and explained in the Figure 3 below. However, the multiple fuel model was suggested as a replacement to the energy ladder, which has consequently failed to precisely forecast developments (Masera *et al.*, 2000). From this perspective, the energy ladder hypothesis functions as an adapted prolongation of customary income effect of the consumer economic theory, which clarifies how users alternate essential goods and luxury goods for basic goods, with an increase in income.

The energy ladder model was however criticised by Masera et al. (2000) on the basis that it cannot appropriately delineate the dynamics of household fuel use. Instead, multiple fuel use is prevalent in both urban and rural regions of middle-income countries. The multiple fuel use model predicts that individuals utilise various fuels for energy, depending on their cost-efficiency (Masera *et al.,* 2000). Literature on household energy choice and conduct has generally connected the Energy ladder model in middle-income countries since the 1980s (Hosier & Dowd, 1987; Hosier, 2004; Nansaior, 2011; van der Kroon *et al.,* 2013). However, the multifaceted nature of the fuel switching process subsequently proposes that there is a variety of determinants that could influence fuel use. This drove few researchers and authors to dive into more complex demonstrating approaches.

The hidden idea of the energy ladder model is that households manage a scope of energy supply alternatives, which could be requested from the slightest to the most mechanically modern and clean (Leach, 1992; Hosier, 2004). The transition is commonly utilised to conceptualise the way toward ascending the energy ladder by various households. This could be characterised as a direct move (typically upwards) and as a major aspect of financial advancement (Hosier, 2004).

A subjacent supposition is that households encounter a variety of fuel choices that can be organised by technological advancements, and this is reflected in household preference (Hosier & Dowd, 1987; Chambwera & Folmer, 2007; Link *et al*., 2012). As an outcome, an improved household income influences a household to gravitate towards sophisticated fuels and simultaneously abandon less sophisticated alternative fuels (Kowsari & Zerriffi, 2011; Rahut *et al*., 2014). This concept, according to Muller & Yan (2016) is the characteristic of modern

technologies, which are by implication connected with certain highlights of user inclinations that partition the fuels into essential goods and high-end goods. Although this theory is yet to be substantiated, one realization of this concept is its potential to fit common observations of the strong income dependency of household fuel use.

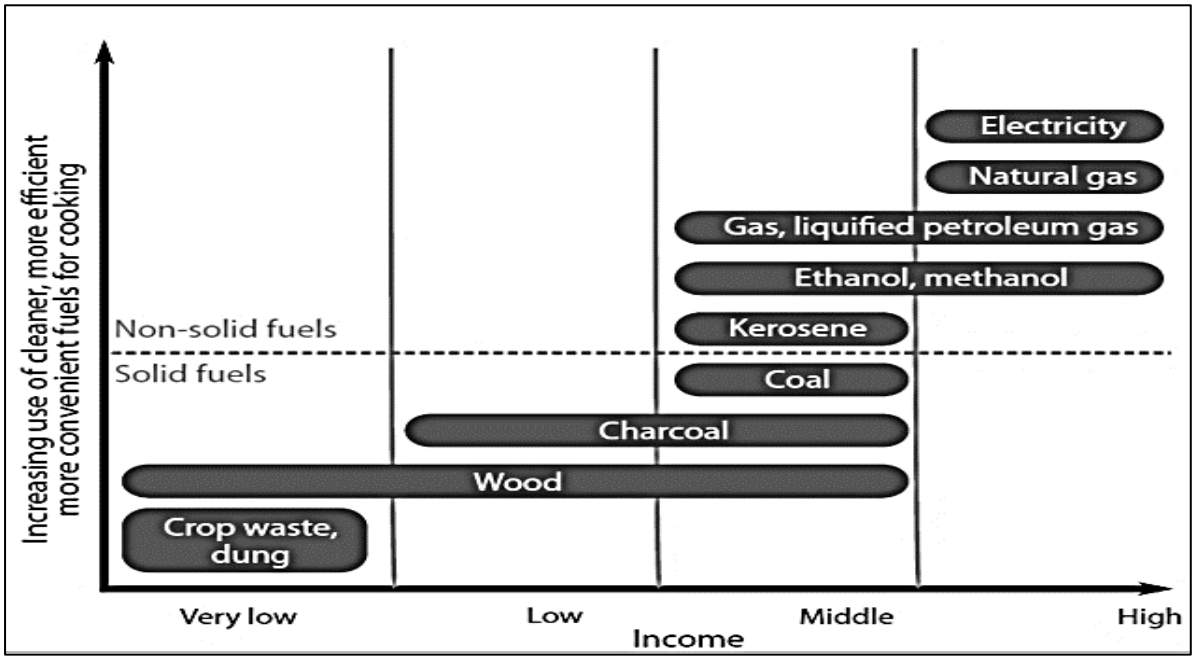


Figure 3: The Energy ladder

Adopted: (Paunio, 2018).

Additionally, the type of energy a household uses has a significant influence on the country's energy system and economic sustainability (Joyeux & Ripple, 2007; Lay *et al.*, 2013). This means that if a household depends primarily on conventional fuels for primary household energy needs such as; cooking, lighting or space and water heating, the economic activities of the country are at risk of being obstructed (Lay *et al*., 2013; Liu *et al*., 2013; Van der Kroon *et al*., 2013). In South Africa, research on trends of household energy use after electrification in traditionally wood-burning areas of the country revealed that, even with the transition to electricity usage, alternative polluting sources of energy were still being used, particularly for heating and cooking (Louw *et al*., 2008), which may negatively influence the country's energy system and economic development.

2.5.2. The Energy transition model

The energy transition model contends that income within a household is not the deciding determinant in the switching of fuels, however, there are additional factors that should be considered (Figure 4). The discrepancy in the single fuel alternation pattern intended by the primitive energy ladder model became evident, as the multiple fuel use concept is the standard for most households. This, therefore, concludes that the transition concept is not determined by the developing desire for present-day energy sources, owing to socio-economic amendments. Furthermore, the transition theory contends that by utilizing the energy ladder theory, comprehension of user decision making will be confined (Heltberg, 2004).

The hypothesis supports looking at why households may want to make choices except those anticipated by the energy ladder model. Determinants such as increased security supply, reducing risk strategy, the occupation of the head of the household, accessibility/availability, family size, and high expense of electrical appliances, become possibly the most important factors. The latter factors may influence the eagerness of households to change from traditional biofuels to alternative options. The transition concept states that different energy sources are utilised in complicated ways, each for a precise purpose. The level of utilization of present-day fuels ought to be seen as supplementing conventional fuels, instead of abandoning traditional fuels collectively (Hiemstra-van der Horst & Hovorka, 2008). The energy transition paradigm suggests that households do not mandatorily shift from one fuel to the subsequent one, they, however, opt for a mixture of primitive fuels, transition fuels, and modern fuels for diverse purposes. Conventional fuels are, therefore, not discarded but are utilised to supplement advanced fuels.

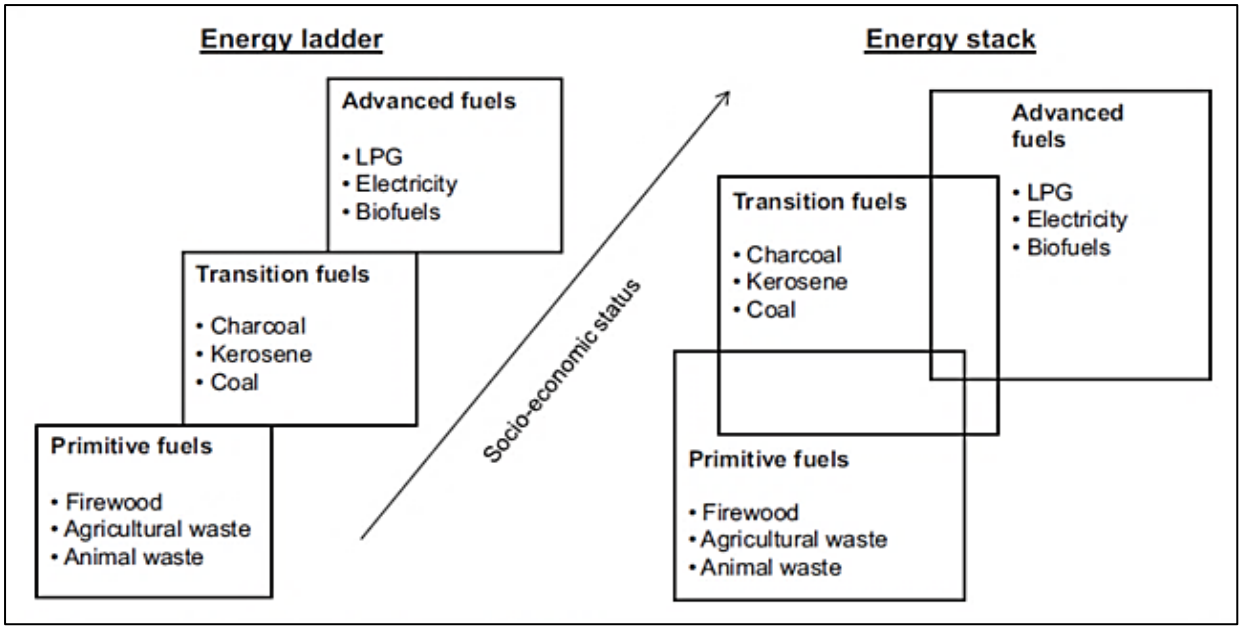


Figure 4: The processes of energy transition

Adopted: (Kroon *et al*., 2013).

2.5.3. The 'Fuel stacking' theory

The utilisation of various fuels is alluded to as 'fuel stacking' and it is a significant trait for energy use in rural households. Fuel stacking increases adaptability and endurance to the fuel supply, as households can change between energy sources depending on the fuels' accessibility and value (Louie 2018). Multiple fuel use/fuel stacking better depict fuel choice conduct of households in middle-income countries (Mekonnen & Kohlin, 2009).

According to Masera et al. (2000), the energy ladder once again failed to describe households' fuel use dynamics in terms of energy stacking. Households in both rural and urban regions of middle-income countries instead fuel stack. Fuel stacking relates to multiple fuel use trends where households elect and mix fuels from both lower and upper dimensions of the energy ladder. According to van der Kroon et al. (2013) and (2014), present-day fuels are not suitable alternatives for conventional fuels, they may only serve as partial substitutes to traditional fuels. This results in the use of multiple fuels, another basis' for multiple fuel use may arise from changes of commercial fuel costs (Leach, 1992), periodic deficiencies of current fuels (Hosier & Kipondya, 1993; Kowsari & Zerriffi, 2011), the increased value of appliances linked with utilising specifically modern fuels (Davis, 1998) and inclinations prompting households not to completely choose present-day fuels (Masera *et al*., 2000). The degree of complexity of the

fuel switching process, therefore, recommends that an assortment of factors exist, other than income that may influence fuel use. This drove a few authors to dig into progressively advanced modeling approaches.

Moreover, a study conducted by Masera and Navia (1997) explained that several households in middle-income countries do not use single-fuel exchange and linear transition illustrated by the energy ladder as indicated in Figure 3 above. Instead, these households use and exchange various fuels, which could include all levels indicated in the energy ladder. The use of multiple fuels increases energy security and gathering of several fuels, where they are most needed (Grimsby, 2013). The reasons behind the use of multiple fuels are mainly due to the need for securing enough energy, where supply could be irregular and inefficient (Masera *et al.*, 2000).

The situation in rural South African areas is that households usually substitute electricity into their domestic energy mix. From that perspective, a study conducted by Madubansi and Shackleton (2006) indicated that electricity was used primarily for lighting. This was despite the electricity subsidy of 50 kWh per month provided by the government, which was supposed to relieve rural households of their energy burden and ultimately reduce energy poverty (Davis, 1998; Thom, 2000).

According to Energypedia (2019), as indicated in Figure 3 above, two kinds of ways exist that clarify households' energy use and their financial advancement. That is; the energy ladder and the idea of fuel stacking. The energy ladder proposes that households entirely interchange the fuels they utilise with an increase in income, the fuel stacking idea however, opposes and recommends elective conduct of fuel substitution. Although the two ideas take after two unique methodologies, yet both develop a pyramidal relation for fuel types. Additionally, the prevalence of the energy ladder theory which clarified the energy conduct of households until the beginning of the 21st century is increasingly becoming obsolete and will eventually be replaced by the energy stacking concept.

2.6. Factors that influence household firewood use

Energy is vital for the welfare of households worldwide (Heltberg, 2003) because it is the main driver of economic, social, and political advancement in South Africa and the rest of the world (Nyankone & Waithera, 2016). Rehfuess et al. (2006) demonstrated that human activity, in either rural or urban households is dependent on energy for cooking, water, and space heating

among other things. Energy is divided into two categories; non-renewable and renewable energy (NRDC, 2018). Non-renewable energy resources sometimes referred to as 'Dirty energy' are described as energy resources that are only available in restricted quantities and take longer to deplete (NRDC, 2018). Renewable energy resources sometimes referred to as 'Clean energy' are described as energy resources that are non-depletable or can be replenished naturally (Armstrong & Hamrin, 1999). The irregularity in the supply of present-day energy sources (*Clean energy*) such as electricity which is to a great extent utilised for the greater part of the financial activities in the economy, has prompted the utilisation of alternative energy sources (*Dirty energy*) (NRDC, 2018). Table 3 below guided the structure of the empirical literature of this chapter, as a few categories in the table include some of the exogenous factors that drive firewood use in this study.

2.6.1. Exogenous factors that influence household fuel choice

Table 3: Exogenous factors that influence household fuel choice

Categories	**Factors**	**Measuring aspect**
	Exogenous factors	
Physical environment	Geographic location and climatic conditions	Exogenous factors influence household decisions about their energy system by affecting available choices and incentives to choose one energy technology or fuel over another
Policies	Energy policy, subsidies and market and trade policies	
Energy supply element	Affordability, availability, accessibility, and reliability of energy supplies	
Energy device characteristics	Conversion efficiency, cost, and payment method, and complexity of operation	

Adopted: (Kowsari & Zerriffi, 2011).

2.6.1.1. Physical environment

Human survival and improvement are exceptionally dependent on natural habitats. Numerous geographic factors such as climate, terrain, vegetation, energy, and mineral resources endowment drive household energy use (Ding *et al*., 2016).

The unique and diverse South African savannas are common in rural areas, with many individuals benefiting both directly and indirectly from these natural resources (Woolen *et al*., 2016; Findlay & Twine, 2018). The provision of wood used for firewood is one of the most frequented ecosystem services (Woolen *et al*., 2016). Firewood according to Wessels et al. (2016) is the most utilised energy source in SSA. However, the physical environment of the study area is currently overgrazed, exploited, and degraded (PLM, 2018).

The exploitation of this cluster's vegetation could be attributed to the constant collection or gathering of firewood that is free of charge May-Tobin (2011), specifically in rural regions (Charmes 2006). The social restrictions for firewood gathering are customarily carried out by local authorities, to oversee the practical use of firewood (Findlay & Twine, 2018). However, settlement expansion; a decrease in natural resources, and population growth exert pressure on the social-ecological framework (Coetzer *et al*., 2010; Ofoegbu *et al*., 2018). Moreover, changes in land use within communities, for example, a blend of different human activities (Giannecchini *et al*., 2007; Aspinall & Staiano, 2017) and climate change, add to a progressively unsustainable utilisation of this energy source. The over-clearing of trees for cooking fuel is damaging or possibly fragmenting the topography and vegetation in rural areas (Fisher *et al*., 2012; Woolen *et al*., 2016).

2.6.1.2. Availability of alternative energy sources

The accessibility and availability of alternative fuels contribute to clarifying household fuel use (Muller & Yan, 2016). Literature indicates that the accessibility of conventional fuels has been assessed by; distance to firewood, a household’s impression of the availability to firewood and geographical location (Hosier & Dowd, 1987; Kaul & Liu, 1992; An *et al*., 2002; Heltberg, 2005; Peng *et al*., 2010). Although the accessibility of present-day fuels is evaluated by energy sources such as LPG and electricity (Heltberg, 2004; Gupta & Köhlin, 2006; Lay *et al*., 2013).

The accessibility and degree of utilisation of various kinds of machines and the end-use of energy sources impact the efficiency of the fuel that is utilised. According to Konemund (2002), this by implication influences the type and quantity of the required household fuel.

Another external factor that influences the supply side is the potential accessibility and cost of energy sources. It is also perceived that the shortage of traditional fuels may influence fuel use. Literature indicates that the further away a household is from firewood sources the more it will shift towards firewood alternatives (Muller & Yan, 2016). For example, a study conducted in Zimbabwe by Hosier & Dowd (1987) established that households that have nearby access to firewood incline more towards wood. Another study by Lay et al. (2013) conducted in Kenya observed that households with improved electricity disregard or abort the use of firewood and kerosene. Jan et al. (2012) indicated that the accessibility of dissimilar energy sources is usual in rural areas. The study based its findings on household income, as it indicated that individuals move from one source to another with increasing income.

On a theoretical level, an investigation of complex and diverse comprehension of the energy ladder, which is made by income and lifestyle, clearly influences the energy transition in the developing world. Systematically with the conceptual deliberation, the determining factors of fuel use that are taken into consideration in the empirical literature are categorised into income, prices, household preferences, production characteristics, and energy supply factors. A household's choice of fuel/energy source is therefore not only decided by economic factors. There are various socio-demographic circumstances, which contribute to a household's choice of energy, these determinants incorporate, but not restricted to the sex and the education level of the household leader/head (Farsi *et al.,* 2005). The fuel choice of several developing countries is decided by cultural beliefs and taste preferences (Arthur *et al*., 2012).

2.6.2. Endogenous factors that determine household fuel choice

Many factors influence energy use within the household sector, these factors are summarised into three categories namely; social transformation, economic development, and physical geography. However, for the intent of this study, only the social transformation and economic development will be considered. According to several methodologies and studies, existing literature has analysed the link between household energy and numerous determinants and demonstrated their correlations and change pattern (Kennes *et al*., 1984; Dunkerley *et al*., 1990; Mahapatra & Mitchell, 1999; Bhatt & Sachan, 2004; Johnson & Bryden, 2012; Onoja, 2012; San *et al*., 2012; Song *et al*., 2012; Rehnus *et al*., 2013; Ding *et al*., 2016). These interactions depend on the biophysical condition, ownership factors, socio-economic factors, and the access and availability of energy sources.

The impacts of the social-economic determinants that influence fuel alternation have been frequently attained. These dissimilarities between authors translate into vulnerabilities when planning sufficient energy policies (Muller & Yan, 2016). Households' fuel choice grouping criteria of endogenous elements in Kowsari & Zerriffi (2011) outlined in Table 4 below directed the structure of the theoretical structure for the empirical literature.

Table 4: Endogenous factors that influence household fuel choice

Categories	Factors	Measuring aspect
Endogenous factors		
Economic characteristics	Income, expenditure, and landholding	Endogenous characteristics reflect the capabilities of households, behavioral attitudes, preferences, and experiences of households
Non-economic characteristics	Household size, sex, age, household composition, education, labor, and information	
Behavioral and cultural characteristics	Preference (e.g. food taste), practices, lifestyle, social status, and ethnicity	

Adopted: (Kowsari & Zerriffi, 2011).

Irrespective of intense research, information about the drivers of household fuel use stays constrained. For instance, the actual impact of fuel costs on fuel substitution is still discussed in literature (Muller, 2016). Past studies with regards to energy utilisation have demonstrated that socio-demographic and socio-economic factors can be highly linked with household energy use (Gatersleben *et al*., 2002; Lenzen *et al*., 2006; Abrahamse, 2007; Abrahamse & Steg, 2009). The Energy ladder depicts the correlation between fuel choice and socio-economic factors, particularly income within a household, hence it is considered as an essential paradigm for household fuel choice in middle-income countries (Hosier & Dowd, 1987; Leach, 1992; Alam *et al*., 1998; Davis, 1998). Through this hypothesis, the way households switch from utilizing dirty fuels to efficient cleaner fuels is clarified. Research in various countries was done to investigate biofuel preferences of households concerning socio-economic factors.

Income, for example, impacts the procurement choices, while age increases the need for heating or cooling, this will, therefore, increase energy consumption (Abrahamse & Steg, 2009). As these variables add to an individual's behaviour, a comprehension of the demographic structure of households may raise a significant measurement to any attitude-knowledge-behavior conduct analysis conducted (Steg, 2008). This may improve any measures taken to facilitate conduct change in participants.

A study led by Rao and Reddy (2007) demonstrated that in both rural and urban region's month-to-month household expenditure, household size, and education assume a critical role in deciding the fuel choices. The outcome of this study illustrated that a non-linear relation regarding month-to-month household expenditure and household size exists. The study additionally demonstrated that in both rural and urban regions, other fuels are less preferred. The results further demonstrated that sex impacts fuel choice. Households headed by women generally opt for present-day fuels in both urban and rural areas. Education also assumes a significant role in determining the fuel of choice. As indicated by the study, an increase in the educational status of household members increases the preference for present-day fuels.

2.6.2.1. Social factors

Household energy choices are affected by various social factors. Demographic traits have well-defined impacts on energy consumption; population growth is linked by comparative increments in energy utilisation and emissions (Cole & Neumayer, 2004). Energy consumption is impacted by differences in the age structure of the populace (Liddle & Lung, 2010). This is supported by the following example; the older generation consumes more energy than the younger generation (York 2007). The family size within a household is a critical illustrative variable. A bigger family in size usually consumes more energy as compared to a smaller one, the energy consumption per capita is, however, less than that of a smaller family (Kaza, 2010; Niu *et al*., 2016). Below are various factors that are categorised into social factors.

2.6.2.2. Age

A few studies found that age is positively connected with a preference for conventional fuels. Baiyegunhi & Hassan (2014) observed that the older the household head gets instigates rural Nigerian households to eliminate natural gas and introduce firewood. Edwards & Langpap (2005) demonstrated a positive and noteworthy relationship between the age of head of the

household and firewood consumption in Guatemalan households. Démurger & Fournier (2011) demonstrated that the average age within a household has a positive and significant impact on firewood consumption in rural households of northern China.

Another study by Gebreegziabher et al. (2012) conducted in Ethiopia reported that older household heads often utilise charcoal, as compared to kerosene and electricity. While a study conducted in Bhutan demonstrated that households with older heads opt for firewood as opposed to electricity (Rahut *et al.,* 2014). Such preferences for conventional fuels support the perception that older people will, in general, propagate traditional habits, as compared to younger people regarding fuel choice. However, several authors find that age is rather positively connected to the preference for modern fuels (Muller & Yan, 2016).

In India, Gupta & Köhlin (2006) and Farsi et al. (2007) proved that older household heads opt for light natural gas to firewood. A study conducted by Rao & Reddy (2007) optionally used the average age of the household members and discovered identical results to that of Farsi et al. (2007) and Gupta & (Köhlin 2006). A study by Guta (2012) discovered that older household heads are bound to lean towards modern fuels as compared to traditional fuels in Ethiopian rural households. In Turkey, Özcan et al. (2013) discovered that older household heads are bound to move away from wood towards natural gas, liquid fuel, and electricity. These outcomes may propose a life cycle impact, where younger people facing liquidity imperatives would fall back on less expensive fuels, while elderly individuals would almost certainly manage the cost of cleaner fuels more effectively. Moreover, An et al. (2002), Israel (2002), and Abebaw (2007) argue that age does not influence fuel use.

2.6.2.3. Sex

Demographic patterns propose that a greater number of women than men live in destitution, as single parents, or pensioners, this, therefore, restricts energy utilisation in accordance with household budget plans (Clancy & Roehr, 2003). Correlations of single male and female households also show uniqueness in the kind of appliances owned, such as washing machines. Females tend to own more appliances associated with the household, while males own a more noteworthy number of appliances, for example, personal computers and Television sets (Clancy & Roehr, 2003).

In many households, cooking is a women's responsibility and it is thought that the determination of fuel choice is their duty. Rahut et al. (2016) affirm that female household

members assume a functioning role in energy choice. WHO (2016) contends that males manage the household budget in numerous societies and have more leverage over energy selection, this suggests that regardless of whether women needed to change to cleaner fuels, they would most likely be unable to do so; due to a men's worries about expenses. However, Puzzolo et al. (2014), suggested that women who earn a salary will, in general, utilise clean fuels.

Patriarchal societies generally expect women and/or females to take responsibility for most household tasks, for example, cooking and washing. Sex can greatly impact fuel choice. In a household where a male is a sole provider and the primary decision-maker, the male household head may disregard the significance of the expenses and benefit of clean cooking fuels (Schlag & Zuzarte, 2008). Other factors regarding sex that may affect a household according to Treiber (2015) are; culture and tradition. Culture and tradition may influence women to ignore modern and safe energy technologies. Treiber (2015) found that women favoured using charcoal and firewood because they consumed less time given constant and controllable heat. Taste was also a contributing factor that influenced their choice of energy.

Additionally, a study by Van der Kroon et al. (2013) illustrated that women and children are often responsible for the collection of wood in many southeast Asian countries. Balmer (2007) maintained that sexual orientation roles alluded to the various tasks' individuals performed; in households, it implies a division of work where various commitments are allocated to men and women.

2.6.2.4. Level of education

The relationship between education level and energy utilisation appears uncertain within literature. For example, Poortinga et al. (2004), contended that a higher level of education might be linked with lower household energy use, while Gatersleben et al. (2002) suggested that education is not associated with energy utilisation. However, a few studies have shown the link between the level of education of an individual and the type of energy choice. For example, a study by Gatama (2014) established that those who had university education used kerosene and none used charcoal and firewood, while those who had completed primary education, the majority (7.2%) used firewood and 5.5% used kerosene. For those respondents whom their household heads had lower and upper primary education, the majority (5.0%) used kerosene. Those with certificate level of education, the majority (2.8%) used charcoal, while those with diploma majority (4.4%) used LPG. This indicated that the level of education of the household head influenced the type of energy used by the household. Another study by Heltberg (2003)

in Guatemala found that the education level of the household head had great negative impacts on firewood utilisation, while concurrently encouraging the demand for LPG (clean fuel).

Mekonnen & Kohlin (2009) completed a study to investigate the drivers of household fuel choice in major Ethiopian cities. The study found that a higher level of education when considering cooking fuels, induced households to utilise electricity and kerosene more as compared to wood and charcoal. Moreover, older household heads in Ethiopia's major urban areas were bound to utilise wood and lamp oil than electricity and charcoal, while the need for wood peaked with age. This finding was ascribed to the role of habits with respect to older individuals, who reflected resistance from fuel switching.

Link et al. (2012) affirmed that education level affected the transition of fuels in two different ways. Firstly, schooling confines the working population for fuel procurement, for example, the collection of wood, conceivably prompting an inclination towards fuels that require no procurement efforts, for example, paraffin and gas. Secondly, education can trigger transformation by giving comprehension about the threats that bioenergy poses to the wellbeing of communities and the environment (Bruce *et al.,* 2000; Holdren *et al*., 2000; Rehfuess *et al.,* 2006). Schlag & Zuzarte (2008) thus, concluded that household fuel preference will be significantly impacted by informal education.

The need for education and subsequent empowerment at household level was highlighted by Prasad (2008). This will enlighten them on the advantages of cleaner energy and the inadequacies of biomass fuels, as indicated by the concept of psychological variance, individuals seek for uniformity between their knowledge and behavioural attitudes (Kowsari & Zerriffi, 2011). This was also highlighted by Whitfield (2006) who mentioned that a household's choice of energy adoption can be significantly influenced by education and social learning. The educational level will affect households' disposition to adopt modern fuels (Musango 2014).

Adding to demographics and income, the educational level of the head of the house, could serve as an intermediary for the degree of human capital at the household level. The education level also influences a household's energy decision by improved non-farm income and ultimately the attainability of proficient energy sources, as well as the increased potential cost of the duration needed for firewood gathering (Leach, 1975). Observational proof affirms that education is a solid key factor of changing from conventional solid fuels to more proficient modern fuels (Heltberg, 2005; Pachauri & Jiang 2008).

Nonetheless, according to Leahy & Lyons (2009), the level of education of a household's breadwinner is linked to the type of household appliances a household possess. Households with a higher level of education are more likely to own modern household appliances such as washing machines and vacuum cleaners and vice versa for those with a lower level of education. This pattern is possibly brought about by the positive correlation of income with education; as those with a higher level of education are frequently employed with better wages and thus have a more noteworthy purchasing capacity (Leahy & Lyons, 2009).

2.6.2.5. Marital status

Marital status is defined as a situation whereby an individual is either single, divorced, or married (FAO, 1997). The status of household members mirrors an additional requirement for energy utilisation. Married households often cook more than divorced or single households, which influences them to choose less expensive and readily accessible energy sources such as firewood, when contrasted against single and divorced households, whose demand for energy is generally low (FAO, 1997).

2.6.2.6. Household size

According to FAO (2009), large scale determinants impact household energy utilisation patterns in a consolidated manner and indirectly. The direct factors of household energy utilisation are encountered unequivocally at the household level. According to Leach & Gowen (1987), several household energy utilisation surveys have been conducted and showed that energy use and the choice of fuel depend on most of the following interrelated variables; household size, household income, rain, and temperature. Household size was observed to be a significant determinant of household energy use than income. A higher-income was attributed to a larger household size (more household members contributing to household income), hence increasing the total household energy utilisation rate (Leach & Gowen, 1987).

Several studies have been conducted to determine how household size impacts the type or choice of energy source a household utilises. Dewees (1989); Heltberg et al. (2000) and Nepal et al. (2011) concluded that the size of a family and the age of the household head plays a significant role in the choice of energy a household utilises. Moreover, a relationship that shows that the family size is directly proportional to the amount of energy needed for the household was established, where such households could provide more labour for the collection of

firewood and other activities in rural areas. Experimental research conducted by Pandey & Chaubal (2011) indicated an inversely proportional relationship between family size and the use of clean fuel.

Another study by Kowsari & Zerriffi (2011) indicated that the household size measures the amount of energy a household consumes. Household size inversely influences a household to practice energy switching and energy stacking behaviours. The size of a household will impact fuel transition since larger households would, in general, practice energy stacking more than smaller ones. This is verbalised by Ado (2016) who indicated that household size significantly affects the use of energy fuel types (Ateba *et al*., 2018).

A study by Mekonnen & Kohlin (2009) conducted in Ethiopia, used a multinomial logit analysis with secondary data from a household survey to discover the determinants of household fuel choice. This study discovered that households with bigger family sizes were more likely to utilise charcoal and wood, as compared to kerosene. However, they found that households with a smaller family size consumed more kerosene. This study also demonstrated that electricity consumption was not dependent on family size.

A study was conducted in urban Ouagadougou, Burkina Faso by Ouedraogo (2005) in his investigation of household fuel preferences for cooking. The study demonstrated the presence of established relations between the utilisation rates of firewood, charcoal, and Liquid Petroleum Gas (LPG) and family size. The findings demonstrated that the largest users of firewood were larger families, while the richest households had the smallest families and were the main users of charcoal. This portrayed the way underprivileged families would have a large family size and would preferably utilise firewood over charcoal while rich families would preferably utilize charcoal over firewood. The study additionally established that households with highly educated heads had lower firewood adoption potential than households with a highly educated head. Further to this, household fuel preferences for cooking in urban Ouagadougou in Burkina Faso found that as the quality of life improved, the utilisation of firewood declined, while the utilisation of charcoal and LPG increased.

2.6.2.7. Socio-cultural habits and preferences

According to Van der Kroon et al. (2013), household energy options are linked to cultural resistance to change, owing to a household's socio-cultural habits and preferences. Nissing & von Blottnitz (2010) indicated cultural acceptance as one of the major enablers of the adoption of renewables or better energy options. One could, therefore, suggest that household energy

choice or preference may lead to energy stacking, rather than total fuel switching to safer energy sources such as electricity. Households may, therefore, continue to use low-efficiency and polluting fuels, according to local traditional practices, despite the availability of modern energy sources (Nissing & von Blottnitz, 2010).

Alternatively, another explanation for cultural acceptability is given by Masera et al. (2000), arguing that households tend to identify energy technologies with socio-economic status. This infers that energy users would, in general, ascend the energy ladder, not just as they want to use less contaminating energy sources, but to show a higher financial status (Arntzen & Kgathi, 1984).

Lifestyle factors, for example, cooking routines, food taste, and cultural convictions are observed to be firmly connected to fuel use behaviour. In Nigeria, according to Baiyegunhi & Hassan (2014), longer cooking time obstructs change from firewood to natural gas and electricity. A similar observation was made by Pundo & Fraser (2006) in Kenyan households, where households would prefer using firewood over charcoal or kerosene when food requires longer cooking times. A conceivable explanation might be that firewood substitutes have increased comparative expenses per unit of time (Baiyegunhi & Hassan, 2014). It is also noteworthy that extensive cooking is considered to be disadvantageous to some household individuals, hence utilising some fuel types might potentially minimize cooking time. The taste of the prepared meals might also be the reason behind fuel choice. For example, frequent cooking increases the probability of utilizing firewood in Ouagadougou (Ouedraogo, 2006).

2.6.2.8. Household income

The basic variable in all literature regarding household energy is the income level. It does not only measure the economic state of countries or regions, but it is also an indication of a household's financial capabilities (Ding *et al*., 2016). In middle-income countries such as China (Zhao *et al*., 2012; Niu *et al*., 2016) and India (Pachauri & Jiang, 2008). Household income is the determinative factor influencing the amount and pattern of energy use (Ding *et al*., 2016).

The impacts of salary on energy utilisation have been studied in practically all observational econometric studies. Literature indicates that income is a measure of household earnings. Various authors also utilize household expenditure as an intermediary for income because expenditure data is regularly increasingly dependable and progressively reflective of long-term income (Chen *et al*., 2006; Démurger & Fournier, 2011).

To some degree, two restricting thoughts associate the impact of income on household energy use. From one perspective, it was proposed that a household's energy intensity (the proportion of utilisation to a gauge of the demand for services) will debilitate towards increased household revenue and levels of income (Lenzen *et al*., 2006). Affluent households often purchase goods that are less energy-intensive (Lenzen *et al*., 2006). Households with lower earnings and consumption, in correlation, normally dwell in housing with little or no insulation and frequently use old appliances with a lower energy efficiency rating (Clancy & Roehr, 2003).

Absolute energy utilisation may subsequently be higher within these households. From other perspectives, a higher level of income has been associated with increased ownership of appliances and a higher level of energy utilisation (O'Neill & Chen, 2002; Abrahamse, 2007; Roberts, 2008; Abrahamse & Steg, 2009). This, therefore, concludes that more energy can be consumed by households with a higher income as they can afford to, and vice versa for households with a lower income who are consequently constrained to conserve energy.

A study by Uhunamure et al. (2017) confirmed that an individual's or a household's income is vital when determining the type of energy used. Edwards & Langpap (2005) conducted a study in Guatemala and demonstrated that wood is a normally useful fuel for destitute households, it is however subordinate for wealthier households. Heltberg (2004; 2005) observed that with an increase in income, households incorporate modern fuels into their household energy choices, as a fractional rather than ideal alternates for conventional ones. Every one of these studies corroborates against the energy ladder concept.

Another study conducted in Maun, Botswana, illustrated that the energy ladder is not exclusively ensued by most households. The energy ladder suggests that income is the determining factor of which fuel households may switch to. In this regard, households completely stop using one fuel source as they ascend the ladder. This is however often not essentially the situation, as the multiple fuel use approach theorises; as many households use firewood for different reasons other than income (Hiemstra-van der Horst & Hovorka, 2008). That is, despite the level of income and/or education level, households tend to utilize firewood regularly (Kebede *et al*., 2002).

2.6.2.9. Employment status

Most employed individuals and/or households frequently utilise electricity in their households, though some also utilize firewood. This is where educational status comes into light.

Employment and income are often attributed to educational status, thus households/individuals who are educated would likely use cleaner energy options such as electricity. The high rate at which firewood is used is linked to poor financial situations and easy access to wood (Roubik *et al*., 2018).

2.6.2.10. Economy

The economy measurement includes increased household wages, income variability, and the cost competitiveness of energy sources and/or technologies. Hosier (2004) initially described the energy ladder as an upward movement from customary to present-day fuels, with an increase in income. Secondly, Van der Kroon et al. (2013) redefined the traditional energy ladder model by attributing energy stacking to sporadic household income flows. This is supported by Reddy & Reddy (1994), who reported that a constant household income positively impacts the transition from dirty to cleaner and more efficient energy options (Reddy & Reddy, 1994).

The determination of the extent of a sporadic income source may be difficult because of informal goods sales as well as agricultural activities (van der Kroon *et al*., 2013). According to van der Kroon et al. (2013), rural households undermine the linear relationship between income and energy choice. Moreover, the boundary between rural and urban was found to clarify energy utilisation disparities in the residential sector. High financial costs proved to be an important economic determinant of household energy consumption behaviour, for which the cost competitiveness of certain energy types over others is critical (van der Kroon *et al.*, 2013).

Heltberg (2003) demonstrated that there is a significant difference across countries regarding the arrangement of households' energy expenditures. Biomass and kerosene are often expensive in under-developed countries, whilst in developed countries, money is mostly spent on electricity. Income-rich households tend to spend more money on hydrocarbons among all the cooking fuels, yet such households may allocate money to spend relatively more on wood and other hydrocarbons (Hetberg, 2003).

Moreover, electricity tends to weigh much heavier on urban household budgets, while rural households allocate far less on electricity. In rural areas, of all the energy sources; firewood particularly has the maximum budget share among its users. The costs of energy also influence

a households' choice of energy as well as how much energy is utilised by both households (rural and urban). This concluded that energy costs have a negative effect on the amount of energy utilised. This, therefore, means that the cost of energy is inversely proportional to the quantity of energy utilised (Hetberg, 2003).

CHAPTER 3

METHODOLOGY

This chapter discusses the methodology used in this study. A methodology is defined as the actions to be explored to investigate a research problem and the justification for the application and utilisation of the precise methods used to identify, select, process, and analyse data applied to understand the problem, as to allow the reader to fundamentally assess this study's overall validity and reliability (Kallet, 2004). Various issues discussed in this chapter include the introduction and description of the study area, the detailing of the study's location, its climatic conditions, soil, and vegetation. This chapter also covers sampling methods used, target population, sample size, study design, data collection methods, data analysis and validity, limitations, and ethical considerations that were used to achieve the objectives of the study.

3.1. Description of the study area

The study area was set in Ga-Malahlela Village, which is set under the Ga-Mamabolo area in the Polokwane Local Municipality of the Capricorn District Municipality, Limpopo Province, in South Africa. The study area is located 41.2 km east of Polokwane, with a total area of 0.38km^2. It is located at coordinates 23.8438° S and 29.8222° E. According to *Census 2011*, Ga - Mahlalela village comprised of a total of 80 households with a population of 344 (PLM, 2018). Figure 5 below shows the topographical map of the study area.

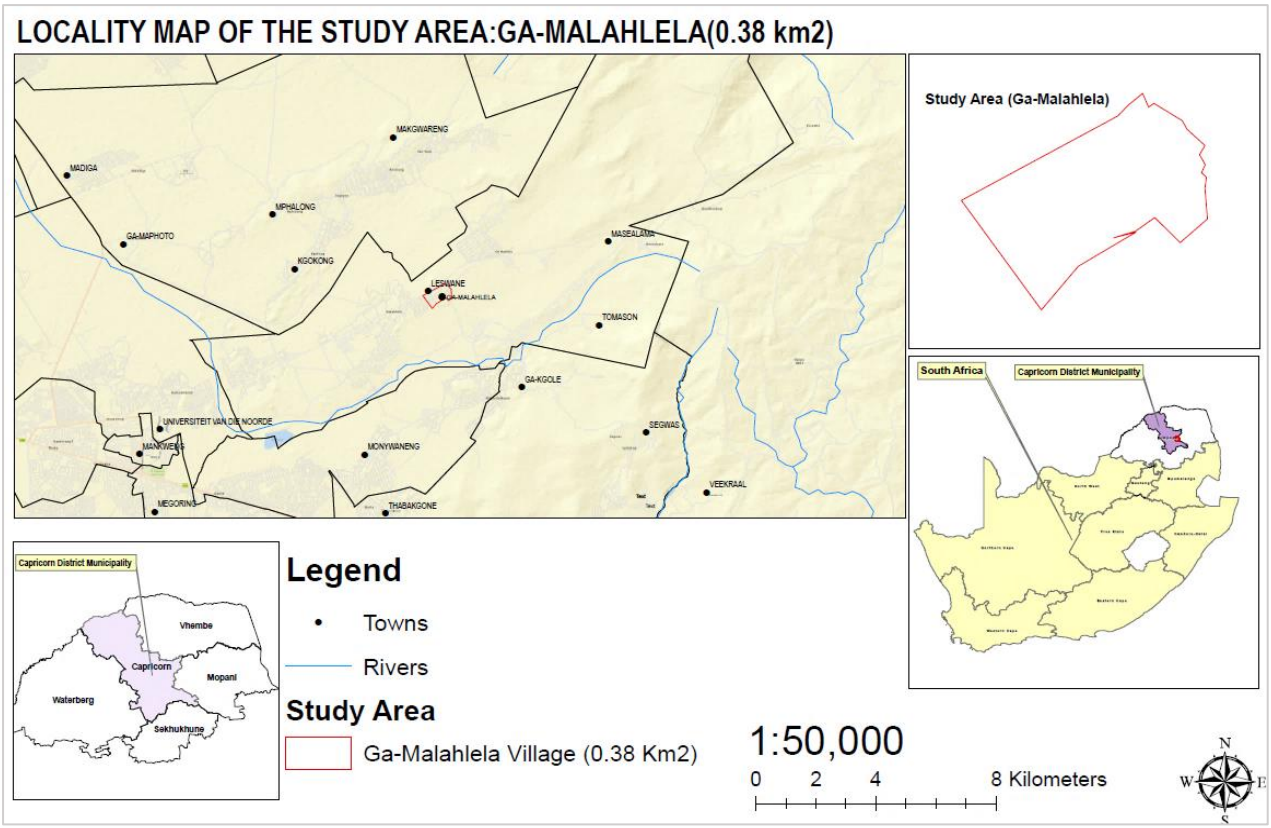


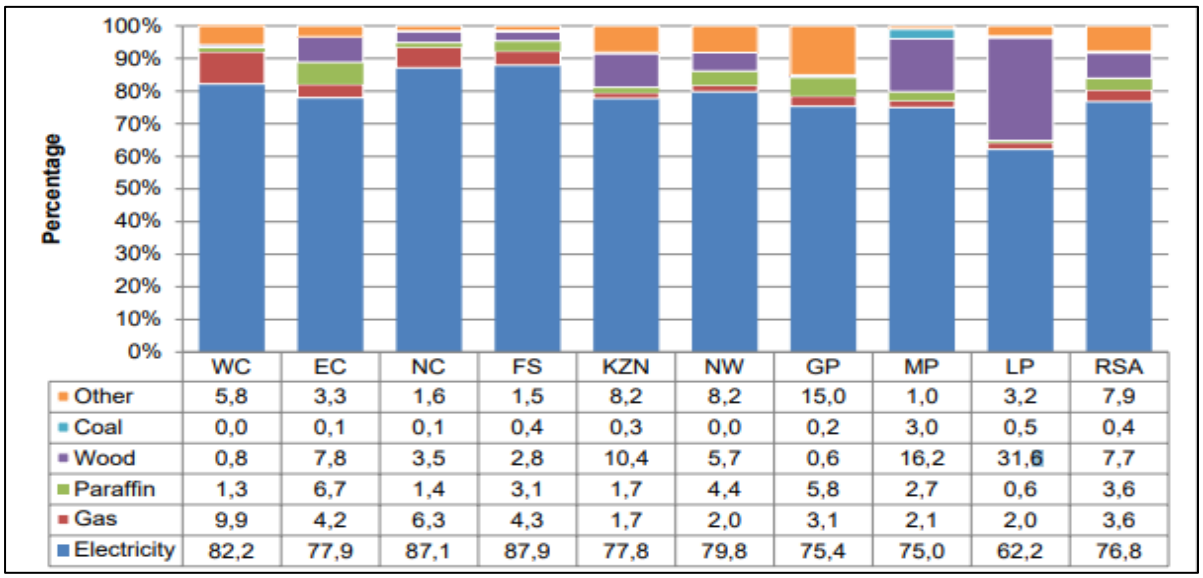
Figure 5: Locality map of Ga – Malahlela and its location in the Capricorn District Municipality, in the Limpopo Province and South Africa

Adopted: (Gulubela, 2018).

3.1.1. Energy

Access to adequate and affordable energy sources is fundamental to combat household energy poverty (StatsSA, 2018). The *General Household Survey* by StatsSA (2018) measured the primary sources of energy utilised by households, to gratify basic human needs such as water heating, cooking, lighting, and space heating. The primary source of energy in the study area is in the form of electricity distributed by Eskom. The supply of electricity in the country was 84.7% in 2018, while 92.7% of households in the Limpopo Province were connected to the electricity grid in 2018 (StatsSA, 2018). The Limpopo Province had the highest percentage of households connected to the electricity grid in the country (StatsSA, 2018). The province's electrification rate currently sits at 94.36%, with a backlog of 13 488 households which still need to be addressed (PLM, 2018). The rate at which the municipality is growing makes it difficult to keep every household electrified. The backlog could be attributed to the incorporation of 76.93% of the former Aganang municipality into the Polokwane Local Municipality in 2016 (PLM, 2018). Firewood is mainly used for cooking, water heating, and

space heating, however, is it mostly used for cooking especially in the Limpopo Province (31,6%) as indicated in Figure 6 below (StatsSA, 2018).



	WC	EC	NC	FS	KZN	NW	GP	MP	LP	RSA
Other	5,8	3,3	1,6	1,5	8,2	8,2	15,0	1,0	3,2	7,9
Coal	0,0	0,1	0,1	0,4	0,3	0,0	0,2	3,0	0,5	0,4
Wood	0,8	7,8	3,5	2,8	10,4	5,7	0,6	16,2	31,6	7,7
Paraffin	1,3	6,7	1,4	3,1	1,7	4,4	5,8	2,7	0,6	3,6
Gas	9,9	4,2	6,3	4,3	1,7	2,0	3,1	2,1	2,0	3,6
Electricity	82,2	77,9	87,1	87,9	77,8	79,8	75,4	75,0	62,2	76,8

Figure 6: Percentage distribution of main sources of energy used for cooking by province, 2018.

Adopted: (StatsSA, 2018).

3.1.2. Climate

The study area is characterised by warmer climate and summer rainfall. The occurrence of fog is rare. Temperature peaks usually occur during summer seasons between December and January. The average daily high temperature is 28.1 degrees Celsius (ºC), which is recorded in January and the minimum average temperature is 4.4ºC, which was recorded in July. The highest recorded temperature is 36.8ºC. The average yearly rainfall for the area is 478 millimetres. Precipitation levels peak between October and March, with the highest levels recorded during December and January. There is a domination of easterly and north-easterly large-scale surface airflow over the study area all year round. During October and November, the wind speed increases to 13.8 metres per second. The frequency of southerly winds peaks during June and July (PLM, 2018).

3.1.3. Soil and vegetation

The study area is located on the Pietersburg plateau and is characterised by soil types that contain iron developed on granite. The texture of these soil types is either gravel or sandy and often contains a hard iron-containing bottom layer of hard-pan. The characteristics of the

escarpment include round granite mounds formed by intrusions of younger granites (PLM, 2018). The municipal area, where the study area is located has six vegetation types. The veld types consist of the following: North-Eastern mountain sour veld, sourish mixed bushveld, a relatively small area of Lowveld, Pietersburg plateau false grass veld, sourish mixed bushveld, sour bushveld, and mixed bushveld (PLM, 2018).

3.2. Sample size

The sample size was determined according to a formula by Yarmane (1967) for simple approximation with a confidence level of 95% and an error margin of 5%. Census (2011) reported that Ga-Mahlalela village has a total of 80 households with a population of 344 (PLM, 2018). This household population was used to calculate the sample size using the formula below:

$$n = \frac{N}{1 + Ne^2}$$

Where;

N is the population size,

n is the sample size, and

e is the error margin'.

Therefore;

$$n = \frac{80}{1 + 80\ (0.05)^2}$$

$$= \frac{80}{1 + 0.20}$$

= 67 households

A number equal to or greater than a statistical value of 30 is appropriate for a statistical requirement size (Freund & Williams, 1983); Nyariki (2009), which is the case with the sample size of 67 households for this study. The minimum statistical requirement size of 30 needs to consider the possibility of non-response (40-45% chance) due to factors such as limited financial sources, nature of the research, and the time frame (Freund & Williams, 1983). However, according to Carley-Baxter et al. (2009), there should be an average response rate of 81.8% for statistical surveys, considering the possibility of non-response. This study, therefore, extenuated for the non-response possibility with a factor of 25%, like that of a study conducted in Dikgale by SEA (2016), which will, therefore, result in a sample size ranging from 50 to 84, which still falls within the appropriate statistical value of 30.

3.3. Sampling

The study area has a household population of 80 (PLM, 2018), of the 80 households, 67 respondents from different households were sampled as determined by the formula ($n = N / 1 + Ne^2$) of Yarmane (1967) for basic approximation. The sample was sampled using convenience sampling. Convenience sampling selects participants that are conveniently available to participate in the study. The participants, in this case, were one member per household above the age of 18 in Ga-Malahlela village. This sampling technique was selected because of the derived small sample size of 67 households. Convenience sampling is advantageous because data collection can be facilitated in a brief period and it is cheapest to implement as compared to other sampling techniques (Saunders *et al*., 2012). Moreover, the researcher was able to arrange access to the community through existing contacts.

Qualitative and quantitative research methods were utilised in this research, namely observation, and a self-administered household questionnaire. Access to the Ga-Malahlela community was done through contact and communication with the ward councillor in the study area, who led and introduced the researcher to the Ga-Mamabolo Traditional Authority. The researcher also informed the Polokwane Local Municipality of the intent to conduct research in the selected study area.

A self-administered questionnaire attached as *appendix A* generated both qualitative and quantitative data. For this purpose, a total of 67 household questionnaires, with closed and open-ended questions were utilized to collect data in 67 households. Several factors (socio-economic factors, household traits, and demographics and the reasons behind household energy

types and use) were assessed in this questionnaire, to evaluate how each of these factors influences the utilisation of firewood as an energy source in Ga - Malahlela village.

The use of open-ended questions allowed participants to give their perspectives and elaborate further on questions asked. Open-ended questions are usually placed towards the end of a questionnaire by many researchers, as the open-ended questions might colour the thoughts of respondents and influence their answers, this makes the analysis of data easier (The University of Leeds, 1996). Closed questions were also presented with a series of choices, which allowed the respondent to choose an answer that is most specific to them in each instance.

3.4. Target population

The target population consisted of community members from a rural dwelling called Ga–Malahlela of the Polokwane Local Municipality in the Limpopo province. The target group for sampling was 67 household members from different households above the age of 18 in Ga - Malahlela.

3.5. Study design

This study used a descriptive survey research design which was expected to generate statistical data and acquire data about an opinion of an individual or a group, pertaining facets of different characteristics, attitudes, and preceding experiences by asking questions and tabulating the answers that are of vital importance to households when choosing the type of domestic energy to use**.** The survey method was selected because many respondents/participants could be reached at relatively minimal costs. Secondly, the survey method allows for the measurement of various variables with a single instrument, which was a questionnaire for this study. According to Koh & Owen (2000), the survey method allows for the gathering of data through questionnaires, personal interviews, and phone surveys, in the same way, the researcher planned to and collected data. This chosen study design generated both qualitative and quantitative data that defined the state of factors influencing firewood use in the study area.

3.5.1. The Quantitative Approach

The quantitative approach accentuates counting, describing, and utilising basic statistics, for example, means and standard deviations. Numbers and figures were therefore utilised to analyse data gathered from the questionnaire. The questionnaire was administered to 67 households that were selected for this study. The questionnaire was divided into three sections;

demographics (age, sex, nationality, education levels, income level, occupation, size of the family household, etc.); energy sources (firewood, electricity, paraffin, cow dung, etc.); and energy use (cooking, heating, space warming, lighting).

3.5.2. The Qualitative Approach

Babbie & Mouton (2001) state that qualitative research is a research approach that takes its venture point as the insider viewpoint on a specific social action, where the objective of the research is characterised as depicting and comprehending, as opposed to clarifying and foreseeing human actions. Babbie & Mouton (2001) further clarify that researchers utilise a wide assortment of methods and techniques in experimental research, which change as per the tasks performed. Additionally, Babbie & Mouton (2001) attest that a qualitative researcher wishes to observe occasions and activities as they occur, with no intercession or impedance, which is inverse to a quantitative researcher, who tries to control conditions and settings to foresee and clarify behaviours. Furthermore, authors express that an objective of a qualitative research is characterised as portrayal and comprehension (Babbie & Mouton, 2001).

The qualitative approach is additionally alluded to as interpretative, constructivist, or anti-positivist. The researcher, therefore, characterises qualitative research as research that attempts to evoke meaning that individuals connect to a phenomenon, amid external military deployment of the member (Leedy & Ormrod, 2005). Qualitative research attempts to recognise issues experienced by the research subjects to the extent that the phenomenon is concerned. Moreover, qualitative research uses statements and classes from the research subjects' perspective. Therefore, because of the basis of the research problem in this study, a combination of both qualitative and quantitative research approaches was used. Qualitative data were organised and classified into different themes, dependent on each objective. The qualitative results were used to interpret the quantitative results. The qualitative data was valuable to give an in-depth clarification of certain issues that could not be gathered through the structured questionnaire.

3.5.3. The Mixed-research method Approach

To ensure that a study is definitive and comprehensive, the use of a combination of both qualitative and quantitative approaches must be used (Hopper & Hoque, 2006). The use of these approaches enforces the process of triangulation. Triangulation involves the collection of data through various data sources as it endows trustworthiness or confirms the regularity of the

facts while trying to take responsibility for basic bias (Mills, 2007; Mertler, 2009). Triangulation in its different structures has additionally been viewed as valuable in improving the reliability of a study (Lukka, 1988; Lillis, 2006). According to Collins et al. (2006), there are different justifications for conducting mixed-methods research which include participant melioration, instrument fidelity, treatment respectability, and significance enhancement. The fundamental reason for this approach is that the integration of methods grants a more comprehensive and synergistic usage of information than isolate quantitative and qualitative data collection and analysis (Wisdom & Creswell, 2013).

3.6. Data collection

The data collection techniques for this study involved gathering primary and secondary data. The primary data was collected through a self-administered household questionnaire and observations; and the secondary data was collected through relevant published and unpublished articles, Thesis', Dissertations, Journals, Websites, and Books.

3.6.1. Questionnaire

The primary method of data collection for this study was through a structured self-administered questionnaire (Appendix A). The questionnaire was administered to 67 households selected for the study. The questionnaire was divided into three sections; demographics (age, sex, education levels, income level, occupation, size of the family household, etc.); energy sources (firewood, electricity, paraffin, cow dung, etc.); and energy use (cooking, heating, space warming, lighting).

3.6.2. Observation

For clarification on the status quo on the type of energy, how and what is used for, and the practicality of what influences households' choice; photographs were taken with permission during the visits to different households. These images were used to quantify answers given in the questionnaire and to accumulate proof on what most of the households use for cooking and lighting and why they are inclined to that specific source of energy for that specific household energy need.

3.6.3. Literature

Secondary data was collected from published data sources such as official reports from government, books, institutions, and websites. This data was utilized to complement data obtained from the participants in a similar way that a study by Doro (2016) was executed.

3.7. Data analysis

Post data collection, the initial step made towards data analysis was ensuring that each one of the 67 household questionnaires was correctly filled out. After ensuring that all the questionnaires were correctly filled out, the data collected from the questionnaires were then analysed using descriptive and inferential/analytic statistics which use frequencies, distributions, and the percentages.

Microsoft Excel and the Statistical Package for Social Scientists (SPSS) named IBM (International Business Machines) SPSS statistics GRAD PACK 25.0 PREMIUM was used to code and log in the data, which involved both open and closed-ended questions, to lodge descriptive analysis to get reports on the status of data. This is because the study generated both quantitative and qualitative data. SPSS is a software which is mostly used for analysing survey data to provide detailed information. The software was selected since it is the most used package for analysing survey data that provides much detailed information as well as its advantages (Cohen *et al*., 2003), which include; the software is user-friendly, analyses multiple-response questions and can relate two data sets (Cohen *et al*., 2003). Data was also taken from relevant published articles. Images taken with permission were also used to conclude data obtained from the study area, particularly the environmental factors associated with firewood usage.

3.7.1. Statistical analysis

Statistical analysis was conducted with the help of a university statistician. The statistician assisted with selecting the most appropriate methods for data analysis and how to log and analyse data using the SPSS software. The statistician also assisted by twofold verifying whether the interpretations were precise. The questionnaires were screened to eliminate those that were incomplete. This methodology was promptly followed-up with the logging of data from the questionnaire on Microsoft Excel computer package. The Excel archive was then exported into the IBM SPSS Statistics Version 25, where it was coded in anticipation of data analysis. The data analysis included a few thorough statistical tests such as reliability tests,

descriptive statistics, and inferential statistics. An in-depth schematic representation of the research route selected for data analysis in this study is also outlined in chapter 4 below.

3.7.2. Descriptive statistics

Descriptive statistics arranges and summarises data, where graphs, tables, charts, and calculations are used to describe data in the form of percentiles, averages, and measures of variation (Weiss, 1999). This type of data proved to be advantageous because the researcher had the freedom to explore issues that were specific to the study. Frequency tables and the mean score ranking techniques are principal descriptive statistics employed in this study as indicated earlier.

3.7.3. Analytic/Inferential statistics

Analytic/inferential statistics was chosen because of the researcher's aim to determine a relationship between household demographics and the choice of energy. Analytical/inferential statistics is a type of regression analysis, which is an adaptable technique used to analyse data that might be suitable when a quantitative variable (the dependent factor) is to be assessed in a relationship to any other factors (the independent factor) (Cohen *et al*., 2003). The examined relationship may be non-linear, independent variables may be quantitative or qualitative, and one can analyse the impacts of a solitary variable or numerous factors with or without the impacts of different factors considered (Cohen *et al*., 2003).

3.7.4. Frequency distributions

To display the research findings frequency distributions such as percentages, graphical representations, line charts, pie charts, histograms, and bar charts were utilised. Frequency distributions are utilised to depict absolute and relative magnitudes, variations, magnitudes, and trends (Zikmund & Babin, 2013). These methods utilise both horizontal and vertical bars to investigate various components of a specified variable (Malhotra, 2011). The use of frequency distributions in this study facilitated the assessment of the socioeconomics (age, sex, nationality, education levels, income level, occupation, size of the family household, etc.).

Recurrence conveyances, for example, rates, diagrams, line graphs, pie outlines, histograms, and bar outlines were used to show explore discoveries. Recurrence dispersions are utilized to depict supreme and relative extents, contrasts, extents, and patterns (Zikmund and Babin, 2013). These strategies use both even and vertical bars to analyse various components of a

given variable (Malhotra, 2011). The utilization of recurrence disseminations in this examination.

3.8. Data validity and reliability

Lincoln & Guba (1985) made the most considerable contribution towards reliability and validity in qualitative research when they created four approaches considered appropriate for the qualitative paradigm, as indicated in Table 5 below, which are; credibility, confirmability, dependability, and transferability to ensure thorough objectivity. They unequivocally offered these as an option in contrast to a progressively customary quantitatively-oriented criterion, where validity in a quantitative paradigm, which according to Babbie (2008) refers to "*the extent to which an empirical measurement adequately reflects the real meaning of the concept under consideration*", which is guaranteed by internal validity, external validity, reliability, and objectivity. These approaches were therefore utilised in this study to ensure the legitimacy of the data collected for this study.

Table 5: The proposed criteria and the "analogous" quantitative and quantitative criteria.

Traditional criteria for judging quantitative research	**Alternative criteria for Judging qualitative research**
Internal validity	Credibility
External validity	Transferability
Reliability	Dependability
Objectivity	Confirmability

Adopted: (Lincoln & Guba, 1985)

3.8.1. Credibility/Internal validity

Credibility tries to demonstrate that the respondents' account is their own and that it does exist (Babbie & Mouton, 2001). The conceptual framework for this study was developed in a manner that seeks to achieve the purpose of this research and to accurately filter through data to spot similar trends in the answers the participants gave. These were then assessed to check for the

similarity between the information from the respondents and what is already known about that reality.

3.8.2. Confirmability / Objectivity

Confirmability is the time when discoveries are picked up because of the request, as opposed to the researcher's inclinations (Babbie & Mouton, 2001). All raw data concerning this study were presented to an allocated supervisor who guaranteed that the study is both legitimate and dependable by observing documentation and looking at the cognisance of information and findings made by the researcher to ensure confirmability.

3.8.3. Dependability/Reliability

Dependability evaluates the probability for research to be replicable so that if the research were to be rehashed with the equivalent or comparable respondents its findings would have the same ideas (Babbie & Mouton, 2001). The same self-administered questionnaire and data analysis were utilised for all selected households/respondents in this dissertation, this ensured dependability and/or reliability. Cronbach's Alpha approach was also used to ensure reliability.

3.8.4. Transferability/External validity

Transferability and/or External validity alludes to how much the consequences of research could be summed up or exchanged to different contexts or settings. Transferability and/or External validity could be assured through a thorough description of the research context and the assumptions that were fundamental to the study. Transferability and/or External validity for this study was assured by the ability to generalise findings from the sampled households in Ga-Malahlela village to a broad range of settings and many population groups.0

3.9. Ethical considerations

De Vos (2002) retains that ethics are a set of standards, which are generally acknowledged. These standards offer principles and social assumptions about proper conduct towards experimental subjects and respondents, entrepreneurs, sponsors, and different researchers, collaborators, and students. Babbie & Mouton (2001) established that the researcher has the option to search for reality, however not to the detriment of the rights of other individuals in society, in that regard; ethical considerations were appropriately followed in this study.

3.9.1. Gaining permission

The steps followed towards gaining permission from the Traditional Authority of Ga-Malahlela village was initially done through the help of the village councillor, who requested that a formal letter (Appendix C) seeking permission to conduct research and its purpose be written and delivered to the traditional authority offices. Subsequently, the researcher met with the traditional authorities who then read and signed the letter signifying that permission was granted to the researcher to conduct research in Ga-Malahlela, as Lupele (2002) emphasised the need to seek permission from the traditional authorities before any research could be conducted in their rural setup. The researcher also sought permission to conduct research from the Polokwane Local Municipality through a letter (Appendix D) where permission was also given with certain conditions as indicated in Appendix D.

Gaining permission from participants was conveyed before the researcher could give out questionnaires to the participants, as potential participants were briefly acquainted with the study and requested to demonstrate whether they would be keen on partaking in the study. Where permission was granted; a consent form was administered and fully explained to the participants, after this was done, the participants were asked to sign the consent to signify that they understood what was requested from them, thus giving the researcher permission to go ahead with the self-administered questionnaire.

3.9.2. Informed consent

Rose et al. (2009) emphasised the importance of informed consent before selecting a participant. An adult participant, capable of permitting to partake in a research study, can give consent. The subject must be 18 years old and equipped with the choice to participate in that particular study (Rose *et al*., 2009). In this regard; participants above the age of 18 were completely informed amid the point of contact concerning every aspect of the study. The informed consent form (Appendix B) was administered to the participants before the distribution of the questionnaire. The consent form made participants aware of the; nature and purpose of the study and the possible impacts of participating in this study.

3.9.3. Voluntary participation

The participants were informed that partaking in this study was voluntary and they could withdraw from the study at any point, should they wish to do so, with no negative consequences. Voluntary participation is a significant segment of honesty in research. The

participants were informed that this study is solely for research purposes and that no payment nor reward will be offered to them for participating in this study.

3.9.4. Anonymity and confidentiality

For this study, both the participants and the researcher signed the consent form, which had a clause stating that "*the participant had the right to insist that his/her name is not recorded anywhere and that no one, apart from the researcher could divulge members of the research team, will know about their involvement in this research"*. Moreover, the participants were made aware that data from the questionnaire will only be made available to the researcher for data analysis. However, their answers might be investigated by individuals liable for ensuring that the research is done appropriately, including the transcriber, external coder, and individuals from UNISA's Research Ethics Review Committee. Otherwise, records that recognize participants will be accessible only to individuals working on the study, except if the participant offers authorization to other people to see the records. Another event may emerge when information gathered from this study is required for other research purposes, for example, an exploration report, journal articles, and/or conference proceedings.

The information will be shared, although still maintaining confidentiality. This will also be assured by the signing of a confidentiality agreement by the persons involved. Confidentiality is when a researcher could recognize an individual's responses yet ensures not to do so openly (Babbie and Mouton, 2001). Confidentiality is crucial in research of this nature as participants shared individual information about them and their families' livelihoods. Breaking this confidentiality in any capacity has outcomes, as it may compromise the study and it could convey uncertainty to the ethics of the study and the researcher.

CHAPTER 4

RESULTS AND DISCUSSION

The current chapter begins by presenting the results obtained from the participants followed by a description of the characteristics of the research participants. This chapter aimed at finding the relationship between the socio-economic state of households in Ga-Malahlela and the choice of energy source used. Most of the results in the current chapter are presented either through a tabular arrangement or in a diagrammatic format. Data were analysed as per the research methodology, which was discussed broadly in Chapter 3 above. The results in this chapter focused mainly on the quantitative aspect of this study and briefly on the qualitative aspect. The results are presented the same way the literature review was structured, that is, the social factors were initially presented and discussed followed by the economic factors. This enabled the researcher to determine the possibility of a relationship between each factor and the energy source without the impact and/or influence of other factors. This also allowed the researcher to observe factors that most impacted households.

4.1. Energy access

Firewood in Ga-Malahlela is accessed in three ways; it is either purchased, collected from the nearest forest, or collected from the backyard. It was observed that most households in the study area purchase firewood, this indicates that firewood is easily accessible through wood vendors to this community. Moreover, all the sampled households indicated that they have access to electricity, or their households are connected to the electricity grid. However, for these households having access to or being connected to the electricity grid, did not encourage them to give up the use of firewood. Energy mixing is the ultimate solution to sufficient energy resources for these households. This ensures that their energy sources sustain them until they get their next salary or social grant. Households in this community, use this as a driver for energy staking relative to energy switching. DME (2008) indicated that 20 Amps are reticulated to rural households or low voltage lines. Households complained that the strength of the grid/ internal switch box was weak as they cannot simultaneously connect a refrigerator, television set, kettle, and stove, which compelled them to reduce the number of household appliances they have plugged in. This condition also encouraged or forced households to use firewood for cooking, so they could be able to use other household appliances whilst cooking.

4.1.1. Energy subsidy access

The sampled households in Ga-Malahlela, indicated that they do not receive the FBE token, most households did not know about the token while a few indicated that they knew about it but did not know how to go about accessing it. The token as indicated above is meant to improve the livelihoods of indigent households, and ultimately relieve them of energy poverty. However, because the Ga-Malahlela community does not receive this token though they qualify for it, this means that this condition will further enhance inequality, as poor households cannot afford to buy prepaid electricity vouchers, due to financial constraints within households as indicated by (Ferriel, 2010). Households expressed that a few FBE units would be very beneficial. This is despite Ferriel (2010) indicating that FBE subsidy has not alleviated the use of multiple fuels and energy poverty. Research shows that poor households use and deplete their FBE token before they are eligible for their next token. Consequently, these poor households then resort to their previous source of energy.

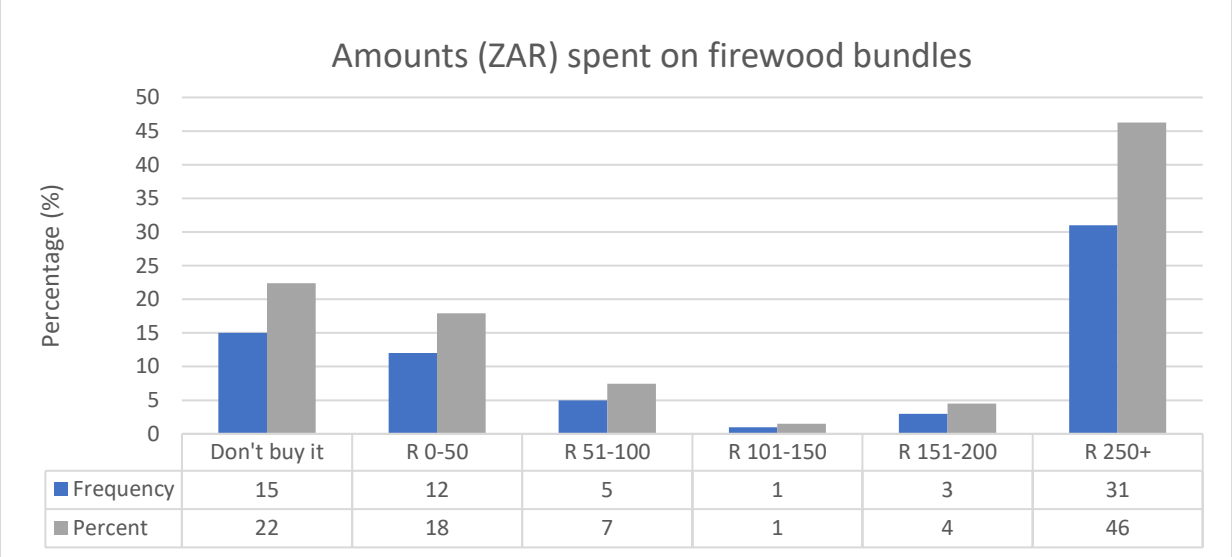
4.1.2. Availability and affordability of energy sources

Figure 7 indicates that Ga-Malahlela village can easily access energy resources. Households either purchase firewood bundles (Figure 8) that can sustain them for 6 months, this makes firewood readily accessible for them whenever they need it. Purchasing firewood bundles that could sustain households for longer periods is common among the Ga-Malahlela community, as 81% (n=54) indicated that they prefer buying in bulk.

Figure 7: How Often households buy or collect firewood

4.1.3. The cost of firewood in the study area

Figure 9 shows that 46% (n=31) of households spend more than ZAR 250.00 on firewood. A few households (n=5) indicated that they either buy or collect firewood once or more times per week as indicated in figure 7 above, such households spend as little as ZAR 20.00 for a bundle of wood that would sustain them for a week or two, then buy again when they run out. For households that collect firewood; stockpiling is common amongst these households, as they collect more than twice per week, even when they have enough to sustain them for a month. This may consequently lead to over-harvesting of firewood resources in the community, which may significantly reduce forest size, thereby making the availability and accessibility of firewood resources a future struggle.



	Don't buy it	R 0-50	R 51-100	R 101-150	R 151-200	R 250+
Frequency	15	12	5	1	3	31
Percent	22	18	7	1	4	46

Figure 8: How much (ZAR) households spend on firewood bundles

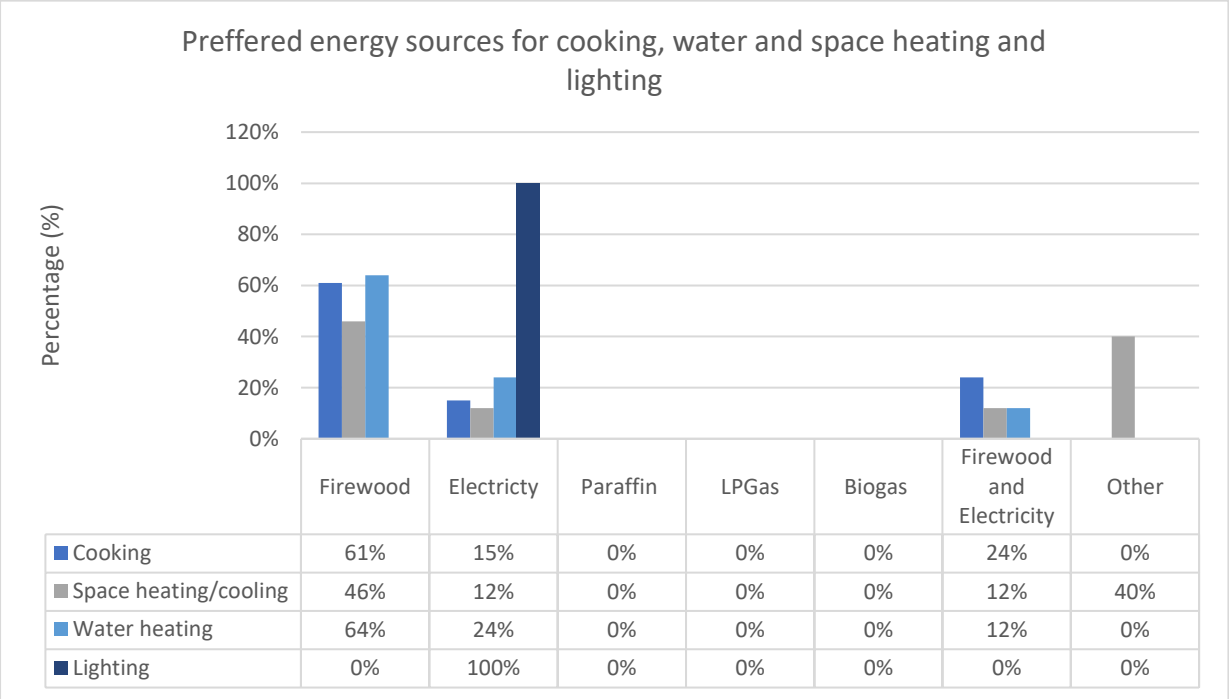
Figure 9: Firewood bundles

4.2. Energy choice and use by households

According to Joon et al. (2009), households choose a particular source of energy for various reasons. These reasons include; food taste, availability, and accessibility, the efficiency of the energy source and preference; given that consumers have beliefs or perceptions about an item that determines whether they will buy/use it or not.

4.2.1. Preferred household energy sources

Figure 10 shows the energy sources preferred by households for their domestic energy needs. The study revealed that electricity and firewood are the preferred sources of energy for household energy needs. Electricity is mainly preferred for lighting (100%), while firewood is mostly preferred for water heating (64%), cooking (61%), and space heating (46%).



	Firewood	Electricty	Paraffin	LPGas	Biogas	Firewood and Electricity	Other
Cooking	61%	15%	0%	0%	0%	24%	0%
Space heating/cooling	46%	12%	0%	0%	0%	12%	40%
Water heating	64%	24%	0%	0%	0%	12%	0%
Lighting	0%	100%	0%	0%	0%	0%	0%

Figure 10: Preferred energy sources for household energy needs (cooking, water, and space heating and lighting)

4.2.2. Energy sources used for cooking

Figure 11 depicts the actual energy sources used by households for cooking. Over half (57%) of the sampled households use firewood for cooking because according to participants, food cooked using firewood is preserved longer and tastes better as compared to food cooked using an electric stove. Firewood is said to be quicker in terms of cooking time, some indicated that

it is more reliable compared to electricity because of frequent power cuts in the village. Households, however, indicated that they tend to use electricity for cooking during rainy or cold weather conditions. The exclusive use of electricity for cooking was accounted for by 36% (n=24) of the households. Participants revealed that they use electricity for cooking because it is convenient, as one could cook three to four foods on the same stove simultaneously. This is opposed to cooking with firewood, which only allows cooking of one food item at a time, households regarded electricity as safer for cooking as compared to firewood because it does not emit smoke and the risk of fires is significantly reduced. 7% (n=5) indicated that they utilise both electricity and firewood for cooking, the basis for this was to save electricity and to stretch their monthly electricity token until they can purchase their next token. The study concluded that firewood was the overall actual energy source for cooking, this was because of its heat dispersing ability, which enhances the taste of food and its easy accessibility.

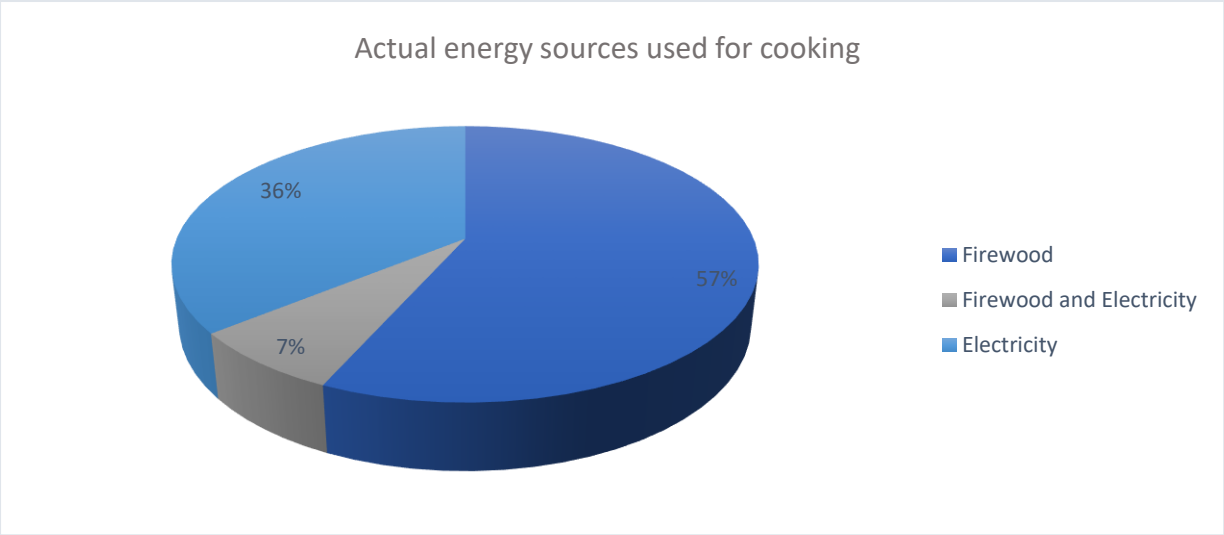


Figure 11: Actual energy sources used for cooking within households

4.2.3. Energy sources for used water heating

Figure 12 shows the energy sources households utilise for water heating. Firewood is utilised by 67% of the sampled households, followed by electricity (30%), then both firewood and electricity (3%). Households disclosed that they utilise firewood for water heating because water heated by firewood retains heat for a long time, as compared to water heated using an electric kettle. Households also indicated that they could heat large quantities of water in a big container "*tshatshakhuluma*" using firewood, as opposed to heating small quantities in an electric kettle which wastes electricity. Households that utilise an electric kettle for water heating indicated that they prefer it because it is quicker and convenient. Those utilising both

firewood and electricity indicated that they prefer an electric kettle for water heating since they have to get up very early for work and school because preparing firewood for water heating in the early hours of the morning is inconvenient for them and rather wastes time. The electric kettle is switched for firewood only during weekends where they can get up much later in the day.

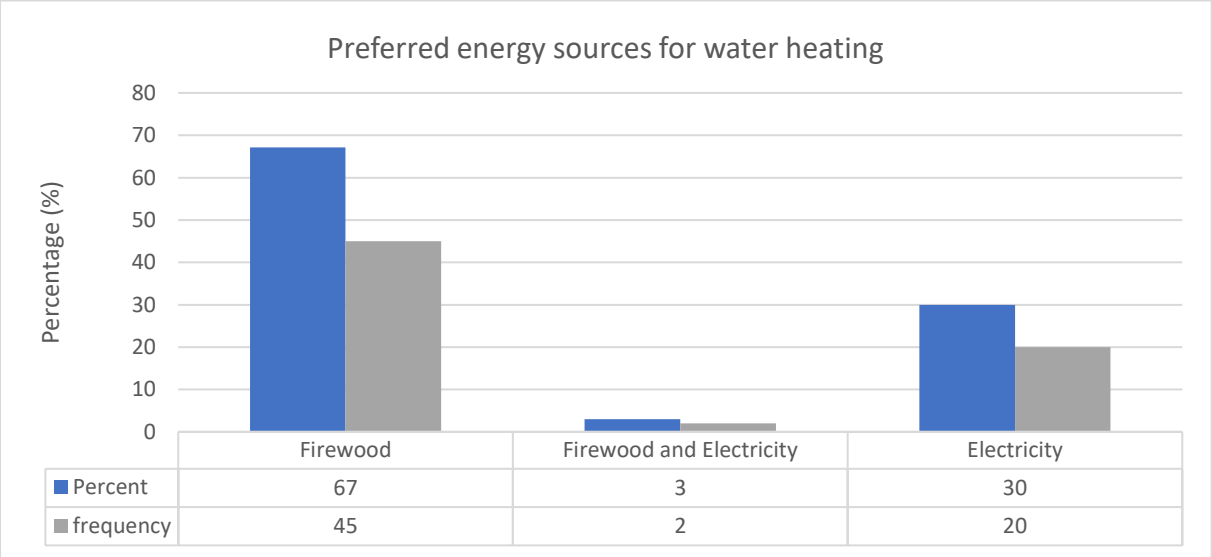


Figure 12: Preferred energy sources used for water heating within households

4.2.4. Energy sources used for space heating

Households indicated that they mostly space heat during the colder days of the year (i.e. during winter), Figure 13 indicates that the majority (48%) of the sampled households do not space heat at all. Participants revealed that they stay warm by either using blankets or warm clothes. Most households revealed that they prefer blankets and clothes because an electric heater uses large amounts of energy, which they cannot afford, or they simply do not own the relevant appliances for space heating such as a heater. Those that space heat mostly uses firewood (42%), because they can cook and space heat simultaneously, which saves electricity. While only 10% of the sampled households highlighted that they utilize electricity for space heating. However, some households disclosed that they use a two-plate stove for space heating and complained that it utilises large amounts of electricity. They also revealed that they had no choice, but to use a two-plate stove for space heating, as their village can get very cold during winter.

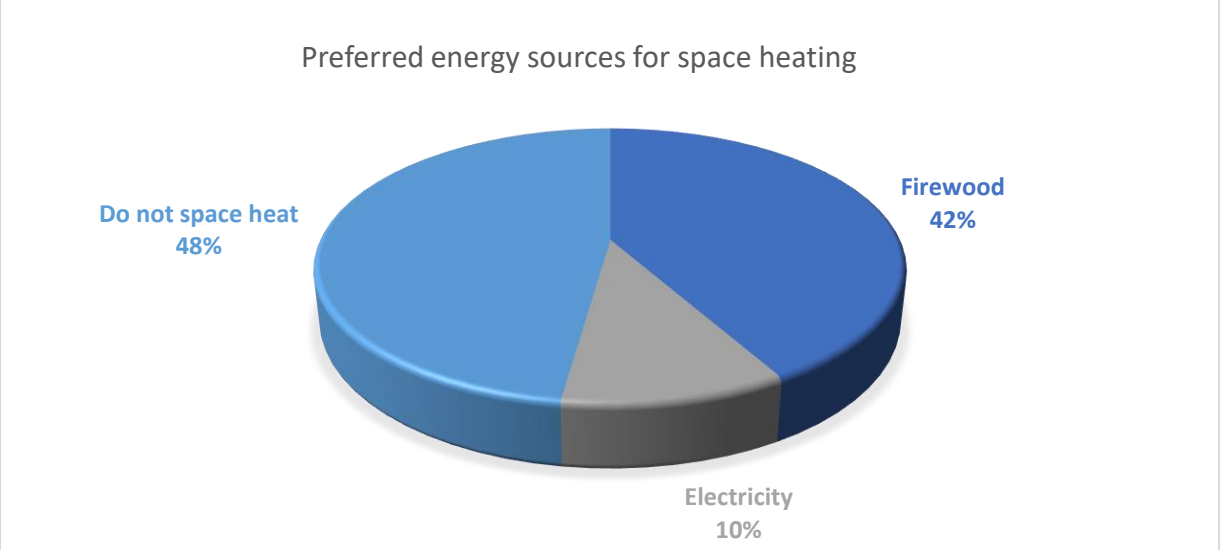


Figure 13: Preferred energy sources for space heating

4.2.5. Energy sources used for lighting

Table 6 indicates that 100% of the sampled households use electricity for lighting. The participants revealed that they prefer electricity for lighting because it does not consume large amounts of electricity and it is convenient as compared to candles and oil/paraffin lamps, which may pose a risk of fires and burns. Households, however, indicated that they often resort to oil/paraffin lamps during power cuts or in rare cases, when they run out of electricity units.

Table 6: Energy sources for lighting

Energy source	**Frequency**	**Percent (%)**
Firewood	0	0
Electricity	67	100
Paraffin	0	0
LPG	0	0
Biogas	0	0
Other	0	0
Total	**67**	**100**

4.3. Exogenous factors that influence firewood use

The exogenous factors researched included; the physical environment of the study area, how and where firewood is gathered, and/or collected. The questionnaire elicited data about the exogenous traits that influence firewood use amongst the participants.

4.3.1. Physical environment

Ga-Malahlela falls under the Mankweng/Sebayeng/Dikgale Cluster, where the harvesting of firewood for energy purposes is an on-going issue as indicated in Table 7. This is regardless of the improvements in rural energy access in the study area and several other rural areas in the province (PLM, 2018), the harvesting of firewood for energy use could be attributed to Figure 14, where 19% (n=13) of the participants revealed that they collect firewood from the nearest forest, where most participants (n=48) indicated that they travel over 2.5km to collect firewood. Collecting of firewood is mostly done by women (69%) than men (16%), which poses several risks to women as indicated by Eberhard & Van Horen, (1995); Barnes *et al.*, (2000); Clany *et al*., (2003); Modi *et al.* (2006); IEA (2010); IEA (2012); and Department of Women (2015). However, 67% (n=45) of the participants indicated that they purchase firewood despite earning below ZAR 3000.00. This indicates that energy in the form of firewood is an essential part of household dynamics in the study area. Moreover, 9% of the participants indicated that they either buy firewood or collect it from the nearest forest. The participants revealed that they purchase firewood when they have enough money and resort to collecting when they are financially strained for money to purchase firewood. The other 5% indicated that they use branches from around their household or they are firewood vendors, which means they use part of their stock for their household energy needs.

Table 7: Identified issues in the Mankweng/Sebayeng/Dikgale Cluster.

Mankweng/Sebayeng/Dikgale Cluster	
Sanitation	Lack of environmentally sustainable sanitation systems (pit latrines in use by most residents)
Water	Lack of potable water supply (at present the community is using a cattle drinking point for water)

Harvesting of firewood	Over-use of wood in the area for fuel, including removal of entire trees for fuel purposes
Harvesting of herbs	Harvesting of traditional herbs without control or regulation
Farming	Lack of skill and know-how in sustainable subsistence farming
Waste disposal	Lack of waste disposal and recycling facilities
Soil erosion	Soil erosion due to deforestation

Adopted: (PLM, 2018).

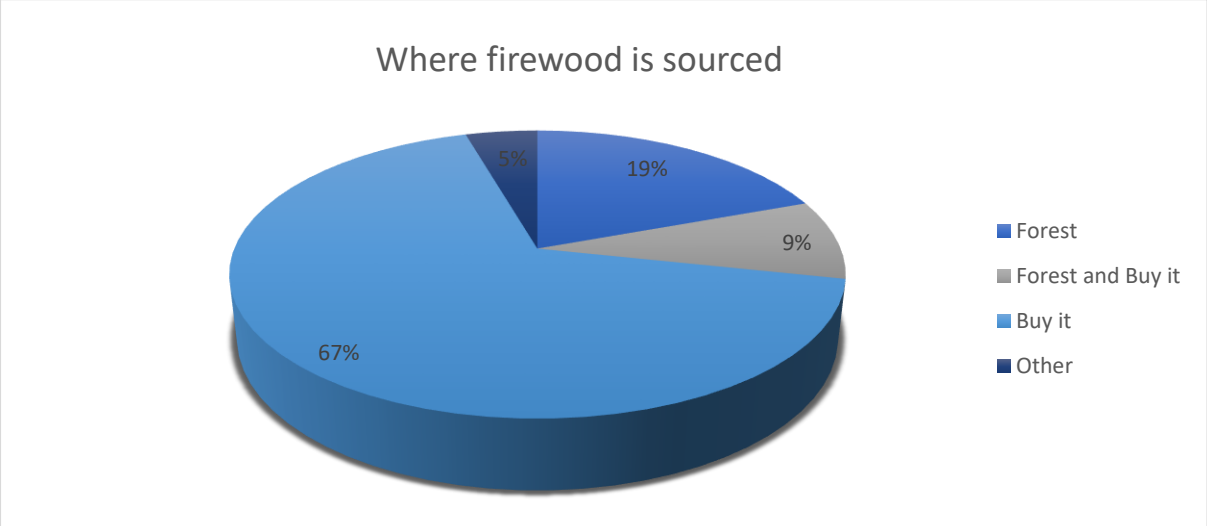


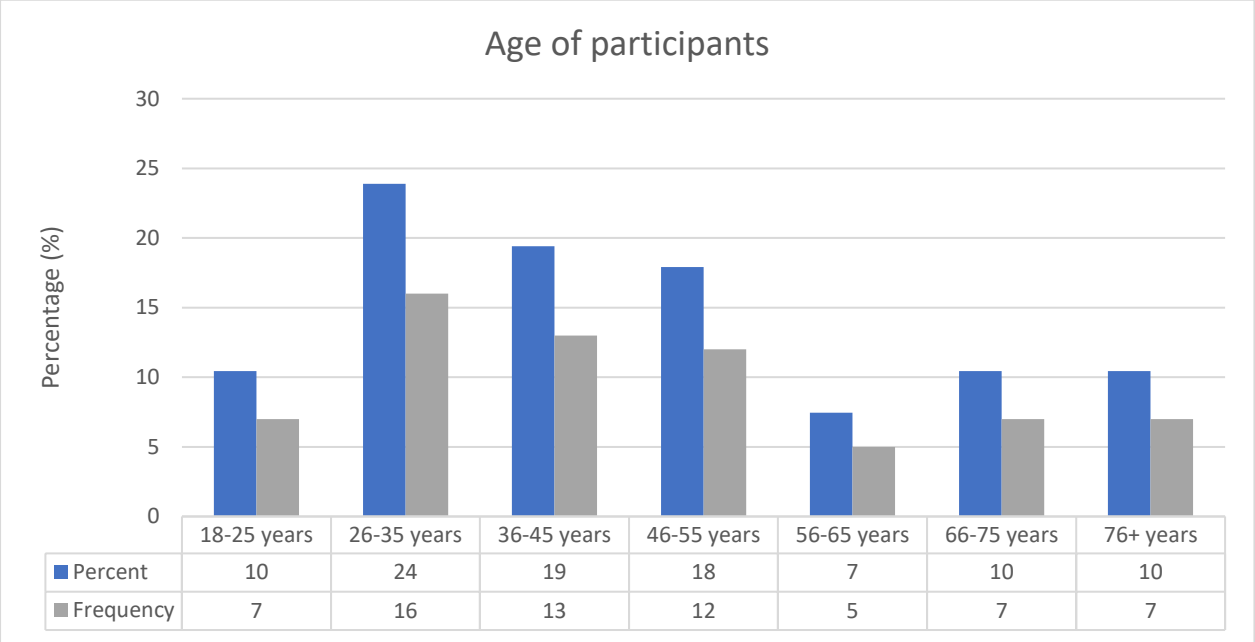
Figure 14: Where firewood is sourced from within the village

4.4. Endogenous factors that influence firewood use

The demographic information of the questionnaire highlighted data about the socio-economic characteristics of participants. The section addressed the following endogenous factors about the respondents: Age, Sex, Educational level, and Size of the family household, marital status, household income, and employment status. The categorical variables used in section 2.6.2 above have been utilized to depict and identify the social traits of the participants.

4.4.1. Age distribution of participants

Participants were requested to indicate their age, to establish whether age influenced firewood use. From the findings of the analysis as depicted in Figure 15, seven (7) age categories were utilized to determine the age of the participants. The participants were all above the age of 18, majority of them being between 25-35 years (24%), followed by 36-45 years (19%), then 46-55 years (18%), then three age categories of 18-25 years, 66-75 years and 76+ years with the same percentage of 10% each, which sums up to 30% and lastly the 56-65 years age category that made up (7%) of the total study population of 67.



	18-25 years	26-35 years	36-45 years	46-55 years	56-65 years	66-75 years	76+ years
Percent	10	24	19	18	7	10	10
Frequency	7	16	13	12	5	7	7

Figure 15: Age of participants

4.4.2. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs age using Chi-squared test

The possibility of an association between the energy sources used for cooking, water heating, space heating, and lighting and age was determined using the Chi-squared test. Table 8 reveals that there is no association between the energy sources used for cooking, water heating, space heating, and lighting, and age. This was concluded by the p-values for age which are more than the significance level (0.05) i.e. $p>0.05$, which indicates insignificant evidence to conclude that age is associated with the use of firewood or influences the use of firewood. Moreover, this study concluded that households would choose an energy source they prefer most regardless

of age. Age, therefore, has a negative effect on the probability of the use of clean and efficient fuels.

Table 8: Relationship between the choice of energy source used for cooking, water heating, space heating, and lighting and/versus (vs) the age of households using the Chi-squared test

Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Age					
Age	18-25 years	3	1	3	0.823
	26-35 years	8	0	8	
	36-45 years	7	1	5	
	46-55 years	9	1	2	
	56-65 years	4	0	1	
	66-75 years	4	1	2	
	76+ years	3	1	3	
Choice of energy source used for water heating Vs Age					
Age	18-25 years	3	0	4	0.226
	26-35 years	8	0	8	
	36-45 years	10	1	2	
	46-55 years	10	0	2	
	56-65 years	5	0	0	
	66-75 years	5	0	2	
	76+ years	4	1	2	
Choice of energy source used for space heating Vs Age					

Age	18-25 years	4	1	2	0.978
	26-35 years	6	1	9	
	36-45 years	4	2	7	
	46-55 years	5	1	6	
	56-65 years	2	1	2	
	66-75 years	4	0	3	
	76+ years	3	1	3	
Choice of energy source used for lighting Vs Age					
Age	18-25 years	0	7	0	0.191
	26-35 years	0	16	0	
	36-45 years	0	13	0	
	46-55 years	0	12	0	
	56-65 years	0	5	0	
	66-75 years	0	7	0	
	76+ years	1	6	0	

4.4.3. Sex of participants

The Sex of participants needed to be determined to understand their biographical inferences and how they influence firewood use, as literature revealed Sex to influence the adoption of fuel use within a household. Figure 16 depicts the Sex of respondents. The analysis indicated that the majority of respondents surveyed were female 79% (n=53) while males were 21% (n=14). As indicated before studies have illustrated that women are mostly responsible for household dynamics and the type of energy source the household uses. Literature has also indicated that a female's preferences are more likely to be given recognition if the household is headed by a female. However, findings in this study area indicate that not only are women responsible for household dynamics and the type of energy source a household uses, they are also responsible for the collection or purchasing of energy sources. The findings also revealed

that the providers "*breadwinners*" were also responsible for the type of energy source a household uses. The providers in most households were males as compared to females. Females were however given the responsibility for household dynamics and thus the choice of energy the household uses. The majority of females preferred firewood as their primary source of fuel as compared to males who preferred electricity. This indicates that females are mostly affected by energy poverty, as they are left with the responsibility of ensuring that the household does not run out of energy options for the entire month. This study further established that the provider and/or the person responsible for the household dynamics highly determines or influences the type of energy source a household uses.

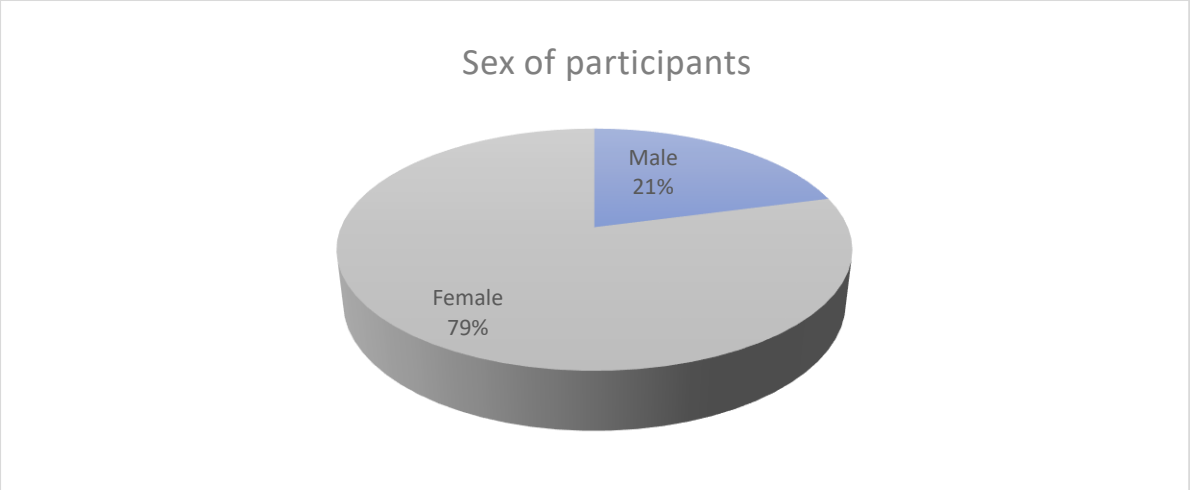


Figure 16: Sex of participants

4.4.4. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs Sex using Chi-squared test

Table 9 reveals the association between energy sources used for cooking, water heating, space heating and lighting, and the sex of the participants. A Chi-squared test was also administered to determine the possibility of an association between these variables. The significance level (0.05) was lower than the p-value for all tested variables ($p>0.05$), which concludes that there is no association/relationship between the energy sources used for cooking, water heating, space heating, and lighting and sex.

Table 9: Relationship between the choice of energy source used for cooking, water heating, space heating and lighting Vs Sex of households using the Chi-squared test

Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Sex					
Sex	Male	7	2	5	0.537
	Female	31	3	19	
Choice of energy source used for water heating Vs Sex					
Sex	Male	8	0	6	0.407
	Female	37	2	14	
Choice of energy source used for space heating Vs Sex					
Sex	Male	8	2	4	0.271
	Female	20	5	28	
Choice of energy source used for lighting Vs Sex					
Sex	Male	0	14	0	0.605
	Female	1	52	0	

4.4.5. Level of education of the participants

The researcher needed to know the education level of participants, as literature indicates that the overall relationship between education level and energy choice is somewhat inconclusive. This is despite education being viewed over time as one of the main drivers of economic development and innovation. Several studies (Osiolo, 2010; Eakins, 2013; Mensah & Adu, 2013; Nlom & Karimove, 2014) have however established a positive significant relationship with household firewood use and education level, it was, therefore, necessary to establish if a relationship between education level and the choice of energy exists. This study, therefore, utilised five educational level categories as per StatsSA (2016), which classified educational

levels into; no schooling, Grade 0-R (pre-schooling), Grade R-7 (primary schooling), Grade 8-12 (secondary schooling) and higher certificate to a doctorate (post-secondary/higher education). Figure 17 indicates that most participants had secondary schooling (60%), followed by primary schooling (22%), followed by those with higher education (9%) and no schooling (9%). According to Ouedraogo (2006); Farsi et al. (2007); Rahut et al. (2017a) and Rahut et al. (2017b), educational level influences a household's decision to adopt clean energy. The educational level of participants in Ga-Malahlela was generally low, with, 9% of the respondents having no formal education and the majority having secondary education (i.e. with most not completing it). It was therefore established that the higher the education level, the more the individual will gravitate or resort to using clean energy sources, such as electricity. On the other hand, individuals with a lower education level will gravitate or resort to using dirty energy sources, such as firewood. This, therefore, indicates that a higher education level is associated with the possibility of gravitating towards the use of cleaner energy options. Moreover, a higher level of education is expected to increase the income level and thus, increase the chance of choosing comparatively cleaner fuels. This concludes that individuals with a higher education level will lean towards upper hierarchal levels of the energy ladder.

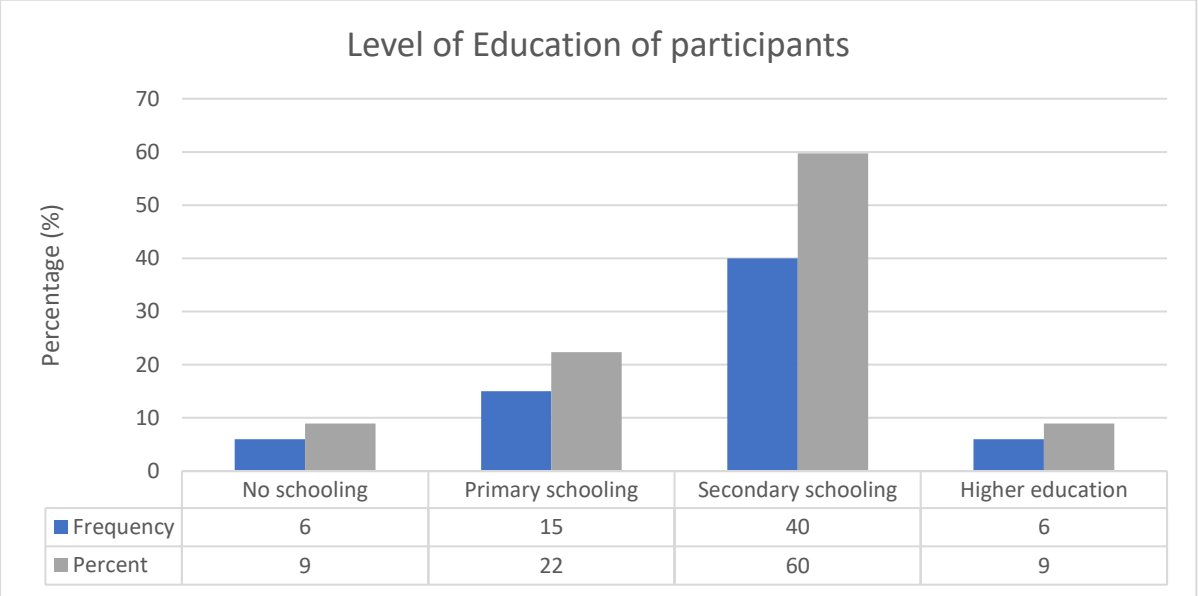


Figure 17: The highest level of education obtained

4.4.6. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs the level of education of households Chi-squared test

The possibility of an association between the energy sources used for cooking, water heating, space heating and lighting, and the education level of participants was determined using the Chi-squared test. Table 10 reveals that there is no association between the energy sources used for cooking, water heating, space heating and lighting, and the education level of participants, since $p>0.05$. This indicates insignificant evidence to conclude that there is an association between education level and the energy sources used for cooking, water heating, space heating, and lighting.

Table 10: Relationship between the choice of energy source used for cooking, water heating, space heating and lighting Vs the level of education of households using the Chi-squared test

Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Education level					
Highest level of education obtained	No schooling	4	1	1	0.655
	Primary schooling	10	1	4	
	Secondary schooling	22	2	16	
	Higher education	2	1	3	
Choice of energy source used for water heating Vs Education level					
Highest level of education obtained	No schooling	4	1	1	0.071
	Primary schooling	12	0	3	
	Secondary schooling	25	0	15	
	Higher education	4	1	1	
Choice of energy source used for space heating Vs Education level					

Highest level of education obtained	No schooling	5	0	1	0.453
	Primary schooling	7	1	7	
	Secondary schooling	14	5	21	
	Higher education	2	1	3	
Choice of energy source used for lighting Vs Education level					
Highest level of education obtained	No schooling	0	6	0	0.318
	Primary schooling	1	15	0	
	Secondary schooling	0	40	0	
	Higher education	0	6	0	

4.4.7. Marital status of participants

It was also imperative to determine the marital status of participants because according to Tchereni (2013) and Karakara & Osabuohien (2018), marital status "*a state of being married*" has a positive effect on gravitating towards the adoption of clean fuels. Figure 18 illustrates the marital status of respondents, it reveals that 48% (n=32) were single; while 28% (n=19) were married; 15% (n=10) were widow/widower and 7% (n=5) were co-habiting, while respondents who recorded divorced were only 1% (n=1). The findings reveal a similar pattern to that of Tchereni (2013) and Karakara & Osabuohien (2018). This implies that the community of Ga-Malahlela is dominated by single individuals who prefer firewood as their main energy source for water heating.

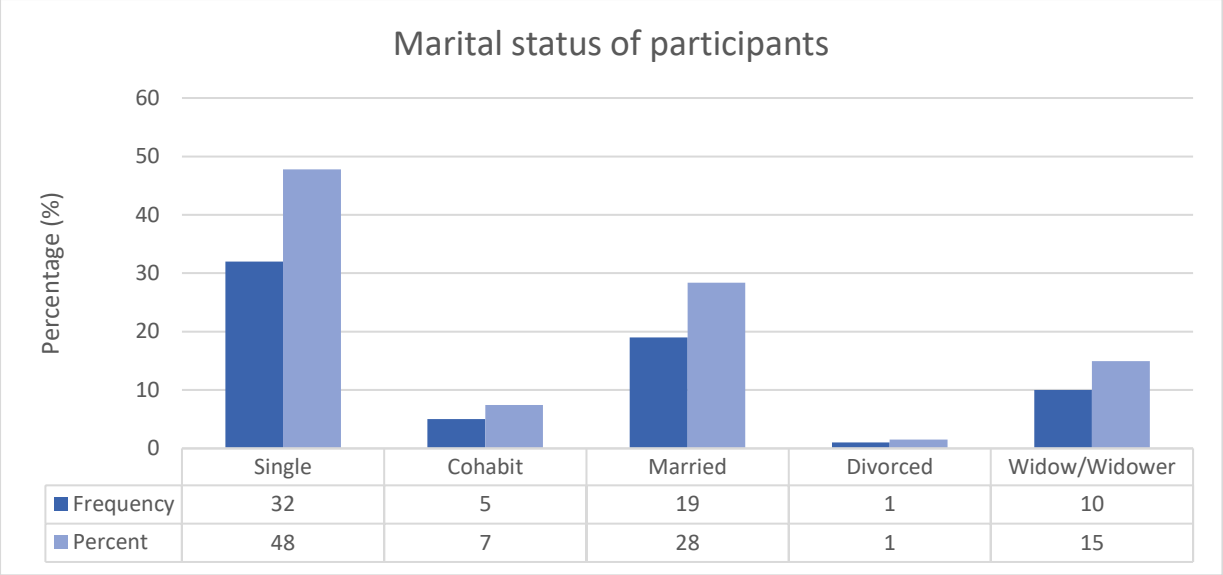


Figure 18: Marital status of participants

4.4.8. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs the marital status of households Chi-squared test

Table 11 indicates the Chi-squared test that was done between the energy sources used for cooking, water heating, space heating and lighting and the marital status of the participants to determine if any relationship exists between the variables. The test revealed that there is no statistically significant relationship between; marital status and the energy sources used for cooking, space heating, and lighting because $p>0.05$. However, a statistically significant relationship exists between energy sources used for water heating and marital status. This is because $p=0.000$, which is less than the significance level of 0.05, this concludes that single participants (30%) utilize firewood more, as compared to electricity for water heating.

Table 11: Relationship between the choice of energy source used for cooking, water heating, space heating and lighting Vs the marital status of households using the Chi-squared test

Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Marital status					
Marital status	Single	19	2	11	0.081
	Cohabit	3	0	2	
	Married	10	2	7	
	Divorced	0	1	0	
	Widow/Widower	6	0	4	
Choice of energy source used for water heating Vs Marital status					
Marital status	Single	20	0	12	0.000
	Cohabit	4	0	1	
	Married	14	1	4	
	Divorced	0	1	0	
	Widow/Widower	7	0	3	
Choice of energy source used for space heating Vs Marital status					
Marital status	Single	12	3	17	0.485
	Cohabit	1	2	2	
	Married	9	1	9	
	Divorced	1	0	0	
	Widow/Widower	5	1	4	
Choice of energy source used for lighting Vs Marital status					

Marital status	Single	0	32	0	0.216
	Cohabit	0	5	0	
	Married	0	19	0	
	Divorced	0	1	0	
	Widow/Widower	1	9	0	

4.4.9. Household size of participants

Household size is among the variables that were found to have an impact on the choice of energy source a household uses, thus the need to determine the household size of respondents. A Study by Karakara (2018) illustrated how larger households tend to gravitate towards the use of dirty fuels such as firewood for household energy needs such as cooking and water heating, while smaller households tend to use cleaner energy options. This illustration is attributed to the assumption that larger households may cook larger quantities of food to feed the entire family, thus the need to utilise energy sources that could be of minimal cost to them. Therefore, smaller households may cook smaller quantities of food using electricity because they can afford to. Table 12 depicts household sizes in the Ga-Malahlela community, the sizes of the households ranged from one (1) to sixteen (16). Five household size categories were used to distribute data, which ranged from 1-3 (24%), 4-6 (36%), 7-9 (22%), 10-12 (9%) and 13-16 (9%) with most households having between 4-6 individuals, while fewer households had 10-12 and 13-16 household members. The average household size in the study area was five. Larger households revealed that firewood for cooking allows them to prepare enough food to feed the entire family. On the other side, smaller households revealed that they utilise firewood for some of their household energy needs because they either prefer it or think it saves the electricity.

Table 12: Household size

Family size	**Frequency**	**Percent**
1 – 3	16	24
4 – 6	24	36
7 – 9	15	22

10 – 12	6	9
13 – 16	6	9
Total	**67**	**100**

4.4.10. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs household size of participants using the Chi-squared test

Table 13 reveals the association between energy sources used for cooking, water heating, space heating, and lighting and family size. A Chi-squared test was administered to determine the possibility of an association between these variables. The significance level (0.05) was lower than the p-values for all tested energy sources, which concludes that there is no association/relationship between the energy sources used for cooking, water heating, space heating, and lighting and the household/family size.

Table 13: Relationship between the choice of energy source used for cooking, water heating, space heating and lighting Vs household size of participants using the Chi-squared test

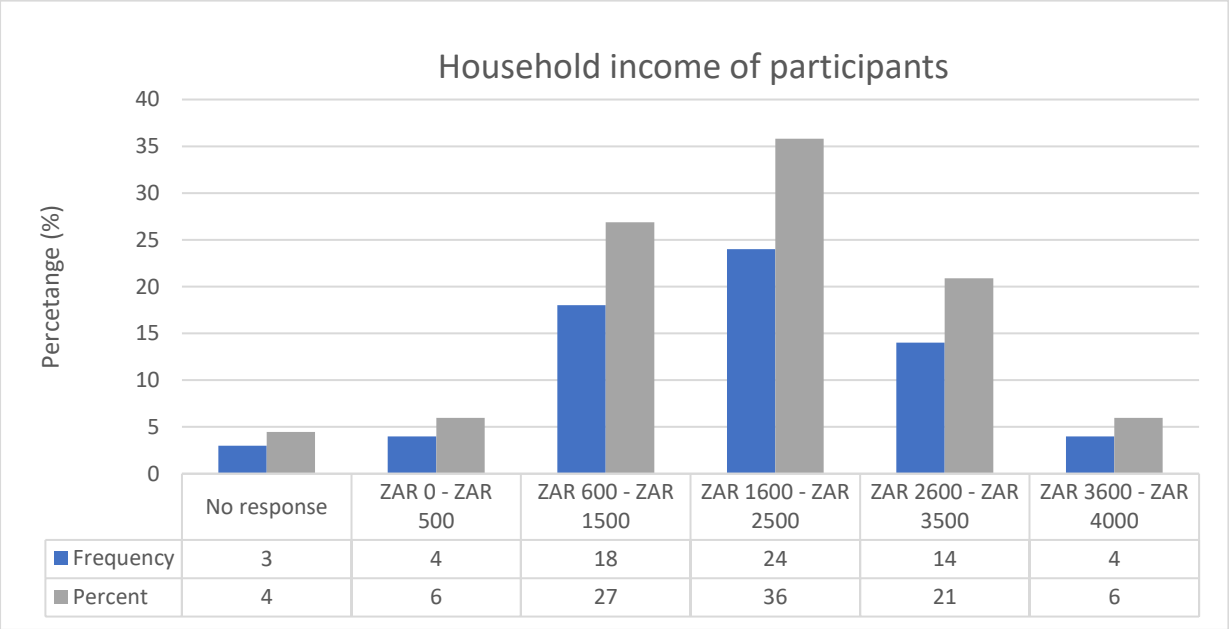
Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Household size					
Household size	1-3	7	3	6	0.164
	4-6	16	1	7	
	7-9	6	1	8	
	10-12	3	0	3	
	13-16	6	0	0	
Choice of energy source used for water heating Vs Household size					
Household size	1-3	12	1	3	0.882

	4-6	14	1	9	
	7-9	10	0	5	
	10-12	4	0	2	
	13-16	5	0	1	
Choice of energy source used for space heating Vs Household size					
Household size	1-3	8	1	7	0.907
	4-6	9	3	12	
	7-9	5	2	8	
	10-12	2	1	3	
	13-16	4	0	2	
Choice of energy source used for lighting Vs Household size					
Household size	1-3	1	15	0	0.874
	4-6	0	24	0	
	7-9	0	15	0	
	10-12	0	6	0	
	13-16	0	6	0	

4.4.11. Household income of participants

According to United Nations (2011), household income comprises all receipts, whether financial or merchandise and services that are obtained by individuals from a household at a yearly or frequent interval, but excludes bonus increases and other such sporadic and typically one-time receipts. Household income is affected by factors such as employment, which help determine a household's energy choices. Figure 19 depicts the monthly income of households in the study area. It shows that most participants earn less than ZAR 3000.00. This indicates that most households in Ga-Malahlela are indigent as per SEA (2016). This means that households in the study area should be registered to receive social grants and FBE. Uhunamure et al. (2017) indicated that low-income households spend most of their time harvesting firewood to meet their household energy needs. This was, however, a different case for the Ga-

Malahlela community as most households, even the low-income households purchased firewood. According to literature, the energy ladder indicates that households with a higher income will ascend the ladder and vice versa for low-income households. This means that household income has a positive correlation with energy choice. This was also the case for a study by Mensah & Adu (2013), who indicated that household income positively influences a household's choice for cleaner fuels and reduces the chance of utilising dirty fuels such as firewood. However, the results in this study indicate otherwise, as they do not conform to the energy ladder hypothesis, which indicates that income plays a vital role in the demand for cleaner energy sources as households in Ga-Malahlela utilise firewood, regardless of their income bracket.



	No response	ZAR 0 - ZAR 500	ZAR 600 - ZAR 1500	ZAR 1600 - ZAR 2500	ZAR 2600 - ZAR 3500	ZAR 3600 - ZAR 4000
Frequency	3	4	18	24	14	4
Percent	4	6	27	36	21	6

Figure 19: Household income of participants

4.4.12. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs monthly household income of participants using the Chi-squared test

Table 14 was used to determine the possibility of an association between the energy source used for cooking, water heating, space heating and lighting, and household income using the Chi-squared test. Table 14 reveals that there is no association between the energy sources used for cooking, water heating, space heating and lighting, and household income. This was

concluded by the p-values which are more than the significance level (0.05), which indicates insignificant evidence to conclude that variables are associated.

Table 14: Relationship between the choice of energy source used for cooking, water heating, space heating and lighting Vs monthly household income of participants using the Chi-squared test

Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Monthly Income					
Monthly income	No response	1	0	2	0.863
	ZAR 0 - ZAR 500	2	0	2	
	ZAR 600 - ZAR 1500	10	1	7	
	ZAR 1600 - ZAR 2500	14	2	8	
	ZAR 2600 – ZAR 3500	8	1	5	
	ZAR 3600 – ZAR 4000	3	1	0	
Choice of energy source used for water heating Vs Monthly Income					
Monthly income	No response	1	0	2	0.919
	ZAR 0 - ZAR 500	2	0	2	
	ZAR 600 - ZAR 1500	12	1	5	
	ZAR 1600 - ZAR 2500	16	1	7	
	ZAR 2600 – ZAR 3500	11	0	3	
	ZAR 3600 – ZAR 4000	3	0	1	
Choice of energy source used for space heating Vs Monthly Income					
Monthly income	No response	3	0	0	0.252
	ZAR 0 - ZAR 500	2	0	2	

	ZAR 600 - ZAR 1500	7	4	7	
	ZAR 1600 - ZAR 2500	10	2	12	
	ZAR 2600 – ZAR 3500	4	0	10	
	ZAR 3600 – ZAR 4000	2	1	1	
Choice of energy source used for lighting Vs Monthly Income					
Monthly income	No response	0	3	0	0.874
	ZAR 0 - ZAR 500	0	4	0	
	ZAR 600 - ZAR 1500	0	18	0	
	ZAR 1600 - ZAR 2500	1	23	0	
	ZAR 2600 – ZAR 3500	0	14	0	
	ZAR 3600 – ZAR 4000	0	4	0	

4.4.13. Employment status

Four employment status categories were used for this study; employed, unemployed, self-employed, and pensioner. Participants were asked to indicate their current occupation from the options given. Figure 20 presents the results of the current employment status of participants. The results indicate that most respondents are unemployed 46% (n=31) and 24% (n=16) are pensioners, followed by 21% (n=14) who are employed and 9% (n= 6) who are self-employed. The high unemployment rate is linked to the number of participants in the 26-35 years' age category. This indicates that households in Ga-Malahlela are mostly occupied by unemployed individuals of working age, most of whom are still living with their parents, usually pensioners, and are dependent on them for their livelihoods.

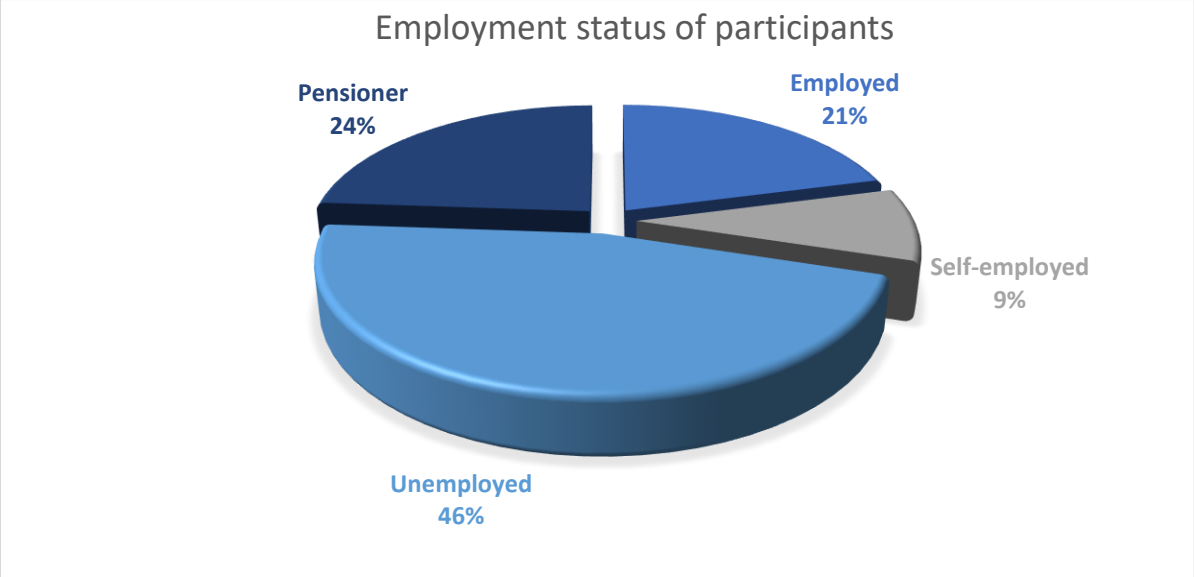


Figure 20: Employment status of participants

4.4.14. The Cross-tabulation between the choice of energy source used for cooking, water heating, space heating and lighting Vs the employment status of participants using the Chi-squared test

Table 15 indicates the test of a potential relationship between the energy sources used for cooking, water heating, space heating and lighting, and the employment status of the participants. A Chi-squared test was used to establish the possibility of this relationship. The test revealed that there is no statistically significant relationship between employment status and the energy sources preferred for cooking, water heating, space heating, and lighting since P- values are all above the significance level of 0.05. Moreover, this finding is attributed to the finding that households do not ascend the energy ladder as indicated earlier but utilize the type of energy they prefer.

Table 15: Relationship between the choice of energy source used for cooking, water heating, space heating and lighting Vs the employment status of participants using the Chi-squared test

Variables	Attributes	Energy sources preferred for cooking			P-value
		Firewood	Firewood and Electricity	Electricity	
Choice of energy source used for cooking Vs Employment status					
Employment status	Employed	8	1	5	0.792
	Self-employed	4	1	1	
	Unemployed	17	1	13	
	Pensioner	9	2	5	
Choice of energy source used for water heating Vs Employment status					
Employment status	Employed	11	0	3	0.877
	Self-employed	4	0	2	
	Unemployed	19	1	11	
	Pensioner	11	1	4	
Choice of energy source used for space heating Vs Employment status					
Employment status	Employed	7	3	4	0.330
	Self-employed	2	0	4	
	Unemployed	10	3	18	
	Pensioner	9	1	6	
Choice of energy source used for space lighting Vs Employment status					
Employment status	Employed	0	14	0	0.357
	Self-employed	0	6	0	
	Unemployed	0	31	0	

	Pensioner	1	15	0	

CHAPTER 5

SUMMARY, STUDY LIMITATIONS, CONCLUSION, RECOMMENDATIONS, AND FUTURE PROSPECTS

The purpose of this chapter is to synthesize the overall study, provide conclusions, make recommendations for mitigation strategies, and further research regarding factors that influence household firewood use in rural areas.

5.1. Summary

The study aimed to assess factors influencing firewood use in Ga-Malahlela. This was done to investigate why firewood use is still prominent even after the electrification of rural households in South Africa. Linked to the study's aim and background information the hypothesis was posed. The study hypothesised that; socio-economic factors influence the use of firewood for domestic energy needs. Following the guidelines of the energy ladder and energy stacking hypotheses, the study intended to expand literature and to illustrate the reasons behind rural household firewood use in rural South Africa. Literature indicated that firewood is still the preferred choice of energy for most rural households in several provinces across the country, the Limpopo Province included. This prompted the need to investigate the choice of energy households use, what it is used for, and the reasons behind these choices. The socio-economic state of households was also investigated to ascertain the kind of impact they have on a household's choice of energy, as these influenced and/or constrained the livelihoods of participants in the researched area.

The findings in this study established that firewood is mostly used for water heating, followed by cooking then space heating. The use of firewood for these household energy needs was influenced by only one socio-economic factor, marital status. The study also discovered how socio-economic conditions constrain respondents' choice of energy source, this finding revealed that the hypothesis for this study was correct. However, the difficult socio-economic circumstances in the researched area and their bearing on respondents' lives determine their choice of energy. These difficult circumstances are in turn contoured by a broader set of unresolved structural aspects in the form of economics, social policies, and politics. High unemployment levels, constrained electricity of 20 Amps, high electricity costs, and the inaccessibility of free basic services in the researched area are some of the issues pointing to

structural inequalities. The socio-economic conditions of respondents will continue to dictate the use of electricity alongside inefficiently combustible fuels such as wood and others.

5.2. Study limitations

This study's limitations are discussed concerning the sampling procedures, study design, data collection methods, and data analysis.

5.2.1. Sampling

The limitation regarding sampling procedures involved non-participation as the target population for the study was household members of Ga -Malahlela village above the age of 18, this resulted in the non-sampling of households that did not have household members above the age of 18. Moreover, the study used convenience sampling due to the small sample size of 67. This type of sampling technique is profoundly vulnerable to selection bias and impacts outside the ability of the control of the researcher which makes prone to errors.

5.2.2. Study design

This study used a descriptive study design and followed a survey method. Survey research is defined as a qualitative and quantitative technique used to acquire data for a study/research. The limitations with regards to using a descriptive study design for this study included; the dishonesty of participants when answering certain questions; the results gathered from this specific study are not repeatable and the study cannot be replicated, and the collection of both qualitative and quantitative data for this study was time-consuming.

5.2.3. Data collection

The limitations regarding data collection involved; a large portion of the Ga–Malahlela community are of the Bapedi tribe. The researcher initially experienced problems with English to Sepedi translations for the first 8 questionnaires as the participants could not answer certain questions because they could not understand the questions in English, to remedy this, the researcher tried to effectively translate those questions verbally as Sepedi is the researcher’s home language; lastly, data collection took longer than expected as the participants complained that the questionnaire is too long.

5.2.4. Data analysis

The process of mixed-methods data analysis could be an abstract procedure. The selection of subjects and classes is reliant on the researcher's dimension of comprehension of the topic, encounters, or absence of it in the field and insight into the more extensive issues of energy poverty. This could result in a skewed presentation of the information and findings. The use of data verification and the orderly examining of data should give a solid result to the study. The sample size affected the outcome of the analysis as there was only one statistically significant association (energy sources for water heating and marital status) which was probably due to the high number of single individuals in the study area.

5.3. Conclusion

The study was set out to understand the drivers of firewood use even after the electrification of Ga-Malahlela village. The study integrated literature and the results of the study, which described the conclusion of the investigation and the recommendations for future research. The research findings illustrate that the community of Ga-Malahlela can easily and readily access firewood by either purchasing or collecting it from the nearest forest. Electricity is also easily accessible within the community of Ga-Malahlela, as participants indicated that they have been connected to the national grid since the year 2015. Nonetheless, the study further established that households who were connected to the national electrical grid were seen to be more energy poor. This highlights the fact that access to basic services is only one part of the problem, the affordability of basic services is an issue that needs to be thoroughly tended to. The unaffordability of basic services within this community suggests that households will continue to energy mix for years to come. This is because of the constrained electricity of 20 Amps that is supplied to the village as well as the high costs of electricity tokens. However, most importantly, households will continue to use firewood because it is free of charge and is considered an important aspect of the upbringing in most household heads within the community. This important aspect is then passed down to the next generation and so on. Consequently, the issue concerning the over-harvesting of firewood in villages such as Ga-Malahlela is here to stay.

Moreover, reviewed literature and findings revealed that household energy use and choice are indeed influenced by several socio-economic factors. In this study marital status was found to have a great influence on firewood use. However, the use of firewood as an energy source is

not fully understood. as households are not only influenced by socio-economic factors alone, psychological variables and geographical location also greatly drive the use of firewood within this community. The continued and religious use of firewood in the study area will not only impact the environment, but the South African economy will also suffer a great loss. Moreover, from the reviewed literature, it was demonstrated that not all factors have equivalent significance in deciding energy use behaviour. The energy ladder was utilised to explain the concept of energy use and choice. Empirical evidence and/or findings revealed that households in Ga-Malahlela do not ascend the energy ladder, but rather fuel stack. This indicates that energy sources such as firewood are not completely discarded but are rather used together with clean modern energy sources such as electricity. This study, therefore, affirms that rural firewood reliance continues due to indigence, preference, and the inaccessibility to free basic services such as FBE.

5.4. Recommendations and future prospects

The recommendations are made based on the key findings of the research study. This study recommends the following management and mitigation strategies that could be used to combat or reduce the use of firewood within the study area;

The study area as indicated earlier has been experiencing issues with over-harvesting of firewood. The over-harvesting of firewood is known to cause serious environmental degradation such as deforestation, soil erosion, and the destruction of animal habitats. To combat this, further research is recommended; to establish the quantity of usable firewood and the number of people collecting firewood from the forest. This will help determine the link between demand and supply of firewood to explain the broader perspective of firewood use and its impact on topography. The Mamabolo Tribal Authority can also carry out the reforestation of the forests, surrounding the study area, Eskom (2019) indicated that biomass and/or firewood is a renewable source of energy in the sense that, just a brief timeframe is taken to supplant what is utilised as an energy source. Another solution to the reduction of local firewood demand would be to administer measures and technical knowledge to ensure that firewood is utilized more sustainably and economically.

5.4.2. Harvest regulation

This study established that there is continuous energy resource deterioration in the study area. This continuous deterioration of firewood resources indicates that there are no harvest

regulations and/or regulators in the village. It is recommended that the traditional authority and policymakers in the study area need to establish a rotational harvesting program, This is supported by Swallow & Bromley (1995) when they stressed that authorities who implement laws and define the ways resources such as firewood are used, this is also a crucial element in the functioning of common-property resource systems. The program should indicate when harvesters are supposed to harvest firewood resources, the quantity of the harvest should also be regulated as per household. This would ensure that each household gathers equal quantities of the firewood, while still sustaining and preserving the environment. The implementation of these laws could compel residents to abide by them, as they would be liable for the incurred consequences if not adhere to. This will ultimately facilitate its implementation, responsibility, and accountability with the harvesters. Technical assistance and sponsorship from the Polokwane Local Municipality and the *Department of Economic Development, Environment, and Tourism Limpopo* (LEDET) would encourage traditional leaders to effectively regulate the harvesting of firewood. Sponsorship from these organisations could be used to compensate patrolmen in and around the village forests. This could ultimately aid in the creation of highly needed jobs for unemployed residents in the study area.

5.4.3. Increase access to free basic electricity

While the electrification program has permitted low-income households' access to electricity, it has not reduced energy poverty to a considerable degree. Electricity use by destitute households continues to be excessively expensive and may only cover energy demands for fewer days of the month (Vermeulen, 2016). This shows that households keep utilizing a scope of polluting and unsafe fuels post-electricity conveyance. This lack of correspondence between user demand and supply needs to be considered the advantage of poor households.

SEA (2014) acknowledges combatting energy poverty in South Africa as a complex issue that requires complex solutions to meet the different needs of rural and/or indigent households. According to SEA (2014), energy poverty is particularly present in rural areas, and the solution to this is beyond access to basic services such as electrification. However, for the community of Ga-Malahlela, the provision of the monthly 50 kWh FBE subsidy would go a long way as indicated by the participants. The Polokwane Local Municipality thus needs to identify communities such as Ga-Malahlela that should receive FBE tokens and supply them with these tokens.

Moreover, studies have indicated that the 50 kWh FBE token does not meet all the household energy needs for the entire month. This is due to the high household energy requirements for appliances such as stoves and geysers. Households regrettably turn to firewood for cooking and water heating, until they can buy or receive their next token. The insufficiency of the 50 kWh token should be considered by the Polokwane Local Municipality when implementing and/or identifying households deserving free basic services. This will ensure that household energy needs are all met. Although not researched, this recommendation would significantly reduce the demand for firewood and household energy needs such as cooking and water heating, thereby curbing its seemingly inevitable over-harvesting. Moreover, more research needs to be conducted to determine if the amount of electricity used by a household. This would help determine the amount of FBE that should be distributed to deserving households.

Furthermore, much work should be done to empower all destitute households to be able to access FBE and the current grant-aided taxes. On a much greater scale, all forms of poverty should be eradicated as a result of employment opportunities. The provision of energy for improvement and profitable use will also create an empowering environment for entrepreneurs to further enhance poverty annihilation efforts. Although this country lacks a clear direction on developing an integrated household energy strategy for municipalities, the mandates to act on energy poverty are few. Going up against energy destitution addresses not only household poverty, but also the country's energy deficiencies, municipal sustainability, environmental sustainability, and climate change issues simultaneously.

5.4.4. Introduce cost-effective alternative fuel solutions

It should be acknowledged that poor households will continue utilizing various sources of energy and technologies, to meet their needs in the foreseeable future. Apart from firewood, electricity is another source of energy used by the community of Ga-Malahlela. The study, therefore, prompted a search into cost-effective alternative fuel solutions that could be utilised by households simultaneously with electricity to guarantee that households use up their electricity token for a month and do not revert to alternative "dirty" fuels (SEA, 2018). Alternative sources of energy, for example, biogas, solar energy, and LPG are unexplored in the study area. It is therefore important to determine why these energy sources are unexplored, as they are considered to be safer and more efficient as compared to firewood. It is understood that alternative fuels will have high financial implications. However, stakeholders need to embrace that these alternative sources of energy are a worthy and safer investment.

Additionally, the utilization of renewable energy will change people's lives, particularly women and children, who should walk long distances gathering firewood. Saved time and money could be diverted into profitable activities and education.

A study conducted by SEA (2018) found five alternative fuel/energy solutions: solar lights, solar cookers, energy-efficient light bulbs, hotboxes, and *Tshisa* hot water boxes. Providentially, there are various technological alternatives to provide for energy needs such as lighting, cooking, space, and water heating as indicated in Figure 21. However, there is, unfortunately, no universal solution and transparency around ideal energy mixing (SEA, 2018). An in-depth examination is needed to establish why the utilization of solar energy is not as widespread as could be expected in South Africa.

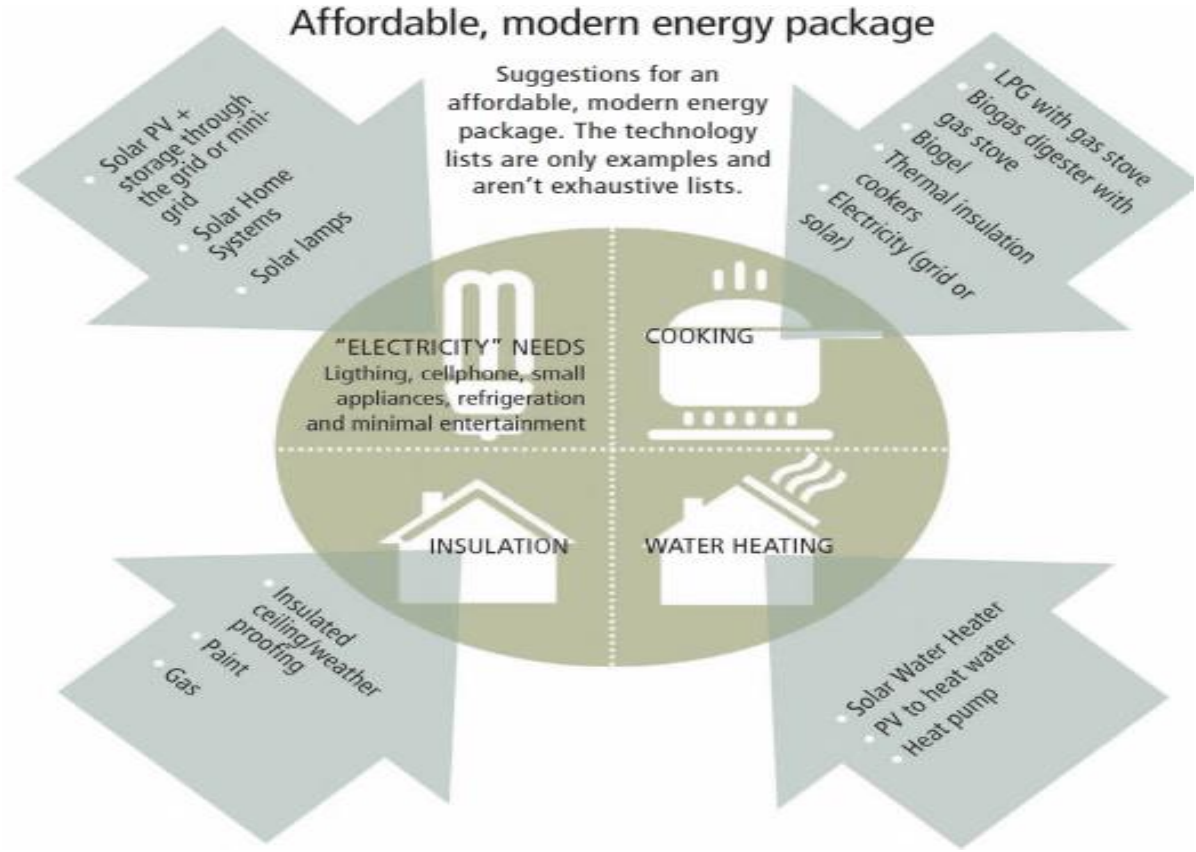


Figure 21: Energy options for households

Adopted: (SEA, 2018)

5.4.5. Increase affordability of electricity

The South African government as indicated earlier; has worked continuously to improve the rate of electrification and alleviate energy poverty in the country, especially in its rural regions. The roll-out of the electrification program did not have a major impact on the use and demand

of firewood (Madubansi & Shackleton, 2007), as firewood is still widely used in villages such as Ga-Malahlela, this was mostly due to the expensiveness of electricity. The continuous use of firewood is attributed to the high costs of modern energy sources such as electricity and solar panels. Therefore, despite having access to and availability of electricity in Ga-Malahlela, households will continue to energy mix because of their household economic circumstances.

Additionally, the assumption here is that households that can economically sustain themselves could afford the current electricity rates/prices. Inversely, those that cannot economically sustain themselves cannot afford the current electricity prices (Madubansi & Shackleton, 2006). As a result, these households would rely heavily on readily accessible energy alternatives, such as firewood. This study, therefore, recommends that indigent households are supplied with decreased electricity tokens. Moreover, policymakers should implement diversification of affordable energy alternatives, while measures to promote rural economic growth should not be disregarded (von Maltitz & Shackleton, 2004; Kirkland *et al.*, 2007).

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APPENDICES

Appendix A: Household Questionnaire

UNIVERSITY OF SOUTH AFRICA (UNISA)

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

DEPARTMENT OF ENVIRONMENTAL SCIENCES

Student Name: Masekela ME
Contact Details: +27 72 919 7562 or 55308120@mylife.unisa.ac.za

Household questionnaire

Date: ……. Questionnaire number: ……

Greetings.

I am a University of South Africa's student currently studying towards a Masters' degree in Environmental Sciences.

I am undertaking research entitled "*Assessment of the factors that influence firewood use among households in Ga-Malahlela village, Limpopo Province*".

I kindly request you to help me in answering the following questions in the spaces provided. Please note that this questionnaire is not a competence or knowledge test. Your truthful opinion is all that matters. There are no correct nor wrong answers. Your name will remain anonymous, and you are assured of confidentiality.

The questionnaire consists of Three (3) sections. Please complete all of them.

SECTION 1: BIOGRAPHICAL INFORMATION AND DEMOGRAPHICS

1.1. Are you the head of house?

Yes	No

1.2. Gender

Male	Female	Other

1.3. Age

18-25	26-35	36-45	46-55	56-65	66-75	76+

1.4. Race

Black/African	White/European	Asian/Indian	Coloured	Other

1.5. Highest level of education obtained

Education level	**Please tick the correct answer**
Grade 0	
Grade 1	
Grade 2	
Grade 3/ Std 1/ ABET 1	
Grade 4/ Std 2	
Grade 5/ Std 3/ ABET 2	
Grade 6/ Std 4	
Grade 7/ Std 5/ ABET 3	
Grade 8/ Std 6	

Grade 9/ Std 7/ ABET 4	
Grade 10/Std 8/ NTCI	
Grade 11/ Std 9/ NTCII	
Attended Grade 12, but did not complete Grade 12	
Grade 12 / Std 10/ NTCIII (without university exemption)	
Grade 12/ Std 10 (with university exemption)	
Certificate with < Std10/Gr.12	
Diploma with < Std 10/Gr. 12	
Certificate with Std 10/Gr.12	
Diploma with Std 10 /Gr.12	
Bachelor's degree	
BTech	
Post graduate diploma	
Honours degree	
Higher degree (Masters/Ph.D.)	
No schooling	

1.6. Employment status

Employed	Self-employed	Unemployed	Pensioner

1.7. Marital status

Single	Cohabit	Married	Divorced	Re-Married	Widow/Widower

1.8. Family size

……

……

……
……

1.9. What is your monthly income?

……
……
……
……

1.10. Do you receive the FBE token?

Yes	No

SECTION 2: BACKGROUND INFORMATION ON ENERGY USE BY THE HOUSEHOLDS

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

	Firewood	Electricity	Paraffin	LPGas	Biogas	Other, please specify below
Cooking						
Space heating/cooling						
Water heating						
Lighting						

……
……

……

……

2.2. 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/cooling					
Water heating					
Lighting					

……

……

……

……

2.3. If you use wood, where do you get it?

Forest	Buy it	Other, please specify below

……

……

……

……

2.4. Who is responsible for collecting or buying the wood?

Women	Children	Men	Everyone	Other, please specify below

……
……
……
……

2.5. How often do you buy or collect wood?

Once a week	Twice a week	More than twice a week	Other, please specify below

……
……
……
……

2.6. If you buy wood, how, much do you spend on it and how does it sustain you?

R 0-50	R 51-100	R 101-150	R 151-200	R 250+

……
……
……
……

2.7. If you collect wood yourself, how far, in kilometres, would you say you travel to collect firewood?

0.5 km	1 km	1.5 km	2 km	Other, please specify below

……
……
……
……....

2.8. Which of these energy sources are preferred for cooking and why?

Firewood	Electricity	Paraffin	LPGas	Biogas	Other, please specify below

……
……
……
……

2.9. Which of these energy sources are preferred for water heating and why?

Firewood	Electricity	Paraffin	LPGas	Biogas	Other, please specify below

……
……
……
……

2.10. Which of these energy sources are preferred for space heating, and why?

Firewood	Electricity	Paraffin	LPGas	Biogas	Other, please specify below

……
……
……
……

SECTION 3: OPEN-ENDED QUESTIONS

3.1. Why do you use firewood?

……
……
……
……....

3.2. Is your household connected to electricity?

……
……

……..……
……..

3.3. Has the supply of electricity helped you in any way? Please elaborate further.

……
……
……
……

3.4. Do you prefer using firewood or electricity for household energy needs such as cooking? Please elaborate further.

……
……..……
……..……
…….....

3.5. Do you think there are any negative issues involved in the use of firewood? If so, please elaborate further

……
……
……
……

3.6. Do you think firewood eases the burden of energy poverty in rural areas?

……
……
……
……

3.7. Are you aware of the environmental impacts/effects of firewood? If so, please elaborate further

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……..……

……..

……..

3.8. What do you understand by air pollution?

……

……

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……

3.9. Do you know of any health impacts caused by air pollution? If so, please elaborate further

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……

……

……

3.10. Has air pollution ever impacted you in any way? If so, please elaborate further

……

……

……

……...

3.11. Do you think you will ever stop using firewood? If Yes, please explain why? If No, please explain why

……

……

……

……

3.12. Do you feel that firewood is an efficient source of energy?

……

……

……
……...

If so, why?

……
……
……
……

Comments:

This marks the end of the questionnaire. Thank you very much for taking your time and dedication to complete this questionnaire.

Appendix B: Consent Form

UNISA university of south africa

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: 2018 / CAES / 159
Research permission reference number: REC – 170616 -051

April 2019

Title: Assessment of the factors that influence firewood use among households in Ga - Malahlela Village, Limpopo Province.

Dear Prospective Participant

My name is Masekela Mahlodi Esther and I am doing research with Miss Semenya Khomotso, a 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 a study entitled Assessment of the factors that influence firewood use among households in Ga – Malahlela Village, Limpopo Province.

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to find out the factors that influence the use of firewood as a source of energy, as not much research has been done on why firewood is still prominent after the provision of the electricity subsidy and the improvement of electrification rates of rural areas in South Africa. This study is expected to collect important information that could help the Capricorn District Municipality, Polokwane Local Municipality and the relevant parties to determine the factors that influence the use of firewood as a domestic energy source by residents of their municipality.

WHY AM I BEING INVITED TO PARTICIPATE?

You were chosen to participate in this study because you are a permanent resident of Ga- Malahlela village and you are within the targeted age group for this research. You are also invited to participate in this study because you own a household that is connected to electricity and still use firewood for other household energy sources. Your contact details were obtained from your traditional leader through the

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councilor in your village. A total of 67 questionnaires will be distributed amongst different households in your community.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves questionnaires and photographs. You will be requested to answer a household questionnaire. The questionnaire is structured in a way that allows you to answer all the questions deemed necessary to fulfil the aim and objectives of this research. It will take you approximately an hour to complete the questionnaire. The questionnaire is divided into three sections (Section A, B, and C). Section A involves bibliography questions and questions on demographics which will also take you approximately ten minutes to answer. Section A involves close-ended questions, this means that you are not expected to elaborate further. Section B involves questions about your household energy uses which will take you twenty minutes to answer. Section C involves open-ended questions which will allow you to elaborate further on their answer should you wish to. This section is mainly to establish your perspectives on the future use of firewood as an energy source, it will take you ten minutes to answer this section of the questionnaire.

The researcher may ask to take photographs with a cell phone of what and how firewood is used in your household. You will be notified and asked for permission by the researcher before any photographs can be taken.

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

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. 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. Your full cooperation will be appreciated should you wish to continue with this study.

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

Your participation in this study will most likely benefit you, as this study may act as an informative platform to your District and Local municipality and the government at large about the impacts the electrification program, and other socio-economic factors associated with firewood use in communities

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such as yours. You may also want to learn more about the impacts household firewood use has on your health and the environment you live in.

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

No.

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 recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. Data from the questionnaire will only be made available to the researcher for data analysis. However, your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, 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.

Should an occasion arise where the data gathered from this study is needed for other research purposes such as a research report, journal articles and/or conference proceedings. The data will be shared, although still maintaining confidentiality. This will also be assured by signing of a confidentiality agreement by the persons involved.

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 cupboard/filing cabinet, at the residence of the researcher 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. If necessary information will be destroyed by shredding of hard copies and by permanently deleting electronic copies from the hard drive of the computer using a relevant software program.

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

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You will not receive any form of payment for participating in this research as your participation is purely voluntary.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Research Ethics Review 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.

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 miss Masekela Mahlodi Esther on 072 919 7562 or E-mail at 55308120@mylife.unisa.ac.za findings are accessible for one year after the signing of this form.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact miss Masekela Mahlodi Esther on 072 919 7562 or E-mail at 55308120@mylife.unisa.ac.za

Should you have concerns about the way in which the research has been conducted, you may contact Miss Semenya Khomotso on 011 471 2138 or E-mail at semenk@unisa.ac.za or you can contact the research ethics chairperson of the CAES General Ethics Review Committee, Prof EL Kempen on 011-471-2241 or kempeel@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.

Masekela Mahlodi Esther

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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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Appendix C: Permission Letter from Mamabolo Traditional Authority

Unit 8 Benfleur
38 Burger street
Polokwane
0699
26 November 2018

Mamabolo Tribal Authority
P.O Box 725
Leshoane
0724

Request for permission to conduct research in the Ga-Malahlela Village

Dear Sir/Madam

My name is Masekela Mahlodi Esther and I am doing research with Miss Semenya Khomotso, a lecturer in the Department of Agriculture and Environmental Sciences towards a Master of Science in Environmental sciences at the University of South Africa for a study entitled Assessment of the factors that influence firewood use among households in Ga – Malahlela Village, Limpopo Province.

I am conducting this research to find out the factors that influence the use of firewood as a source of energy, as not much research has been done on why firewood is still prominent after the provision of the electricity subsidy and the improvement of electrification rates of rural areas in South Africa. This study is expected to collect important information that could help the Capricorn District Municipality, Polokwane Local Municipality, the Ga – Malahlela community and the relevant parties to determine the factors that influence the use of firewood as a domestic energy source by residents of their municipality and/or community.

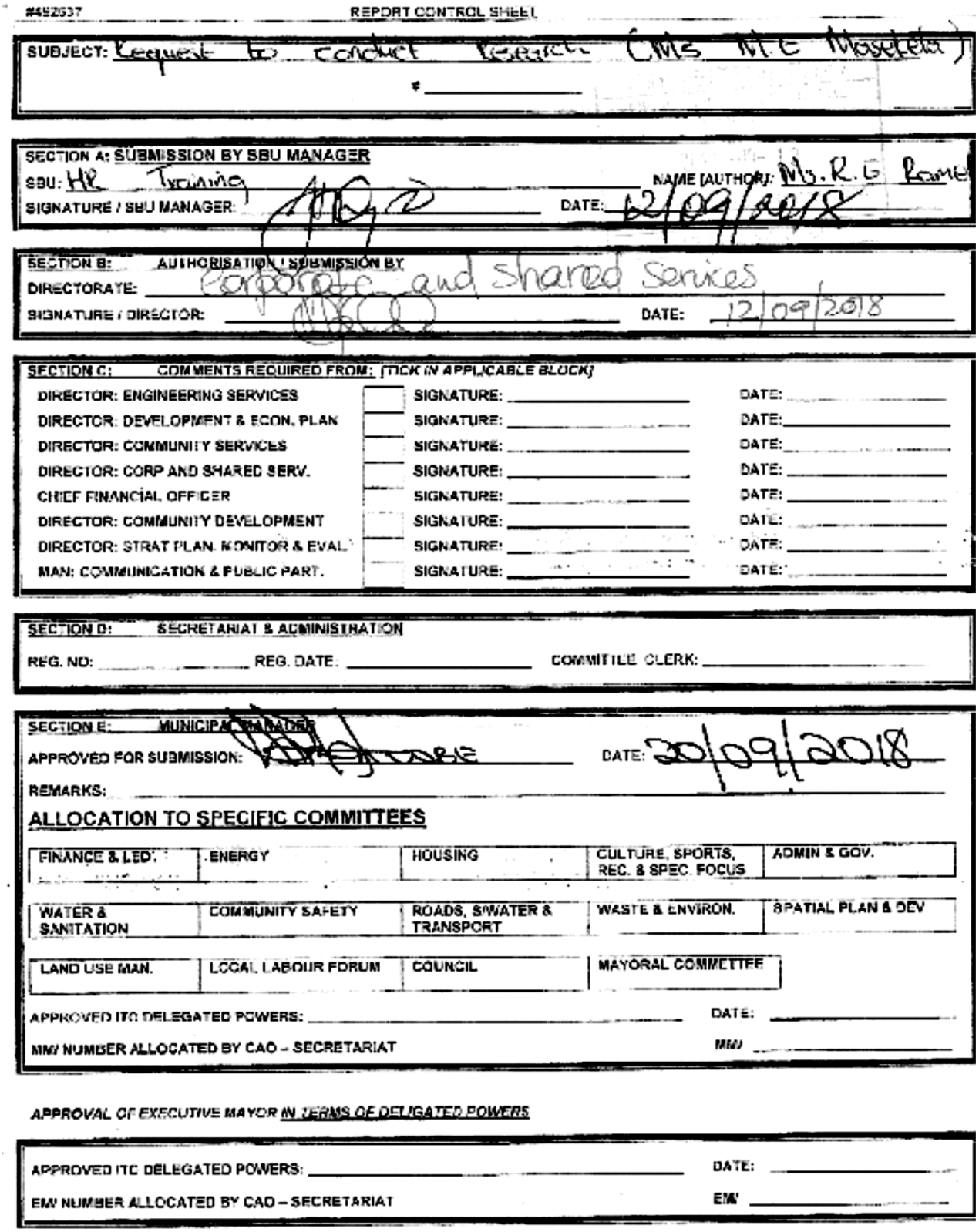
Should you want to make any further contact, please contact me on my E-mail mahlodimasekela@gmail.com or cell phone 072 919 7562.

In this regard, can you kindly allow me to conduct research in the Ga – Malahlela Village.

Yours Sincerely
Masekela ME

Student Signature	Print Name	Date
Village Representative Signature	Print Name	Date
Witness Signature	Print Name	Date

Appendix D: Permission Letter from Polokwane Local Municipality



#452937 REPORT CONTROL SHEET

SUBJECT: Request to conduct Research (Ms MC Mosetlha)

SECTION A: SUBMISSION BY SBU MANAGER

SBU: HR Training NAME (AUTHOR): Ms. R.G Ramela

SIGNATURE / SBU MANAGER: DATE: 12/09/2018

SECTION B: AUTHORISATION / SUBMISSION BY

DIRECTORATE: Corporate and Shared Services

SIGNATURE / DIRECTOR: DATE: 12/09/2018

SECTION C: COMMENTS REQUIRED FROM: [TICK IN APPLICABLE BLOCK]

DIRECTOR: ENGINEERING SERVICES		SIGNATURE:	DATE:
DIRECTOR: DEVELOPMENT & ECON. PLAN		SIGNATURE:	DATE:
DIRECTOR: COMMUNITY SERVICES		SIGNATURE:	DATE:
DIRECTOR: CORP AND SHARED SERV.		SIGNATURE:	DATE:
CHIEF FINANCIAL OFFICER		SIGNATURE:	DATE:
DIRECTOR: COMMUNITY DEVELOPMENT		SIGNATURE:	DATE:
DIRECTOR: STRAT PLAN, MONITOR & EVAL.		SIGNATURE:	DATE:
MAN: COMMUNICATION & PUBLIC PART.		SIGNATURE:	DATE:

SECTION D: SECRETARIAT & ADMINISTRATION

REG. NO: REG. DATE: COMMITTEE CLERK:

SECTION E: MUNICIPAL MANAGER

APPROVED FOR SUBMISSION: DATE: 30/09/2018

REMARKS:

ALLOCATION TO SPECIFIC COMMITTEES

FINANCE & LED	ENERGY	HOUSING	CULTURE, SPORTS, REC. & SPEC. FOCUS	ADMIN & GOV.
WATER & SANITATION	COMMUNITY SAFETY	ROADS, S/WATER & TRANSPORT	WASTE & ENVIRON.	SPATIAL PLAN & DEV
LAND USE MAN.	LOCAL LABOUR FORUM	COUNCIL	MAYORAL COMMITTEE	

APPROVED ITO DELEGATED POWERS: DATE:

MM/ NUMBER ALLOCATED BY CAO – SECRETARIAT MM/

APPROVAL OF EXECUTIVE MAYOR IN TERMS OF DELIGATED POWERS

APPROVED ITO DELEGATED POWERS: DATE:

EM/ NUMBER ALLOCATED BY CAO – SECRETARIAT EM/

515557
MS. R.E RAMELA (11/09/2018)

DIRECTORATE: CORPORATE AND SHARED SERVICES

ITEM:

FILE REF:

REQUEST TO GRANT MS. ME MASEKELA TO CONDUCT RESEARCH WITHIN POLOKWANE MUNICIPALITY

Report of the Director: Corporate and Shared Services

Purpose of the Report

To request the Municipal Manager to grant Ms. ME Masekela to conduct her research at Polokwane Municipality.

Background and Discussion

Ms. ME Masekela sent a letter requesting permission to conduct research at Polokwane Municipality. Her research topic is titled: Assessment of the factors that influence firewood use among household in Ga-Malahlela Village: A Case of Polokwane Local Municipality.

"A copy of the letter from UNISA is attached for reference"

Financial Implication

There is no financial implication.

Recommend

1. That approval be granted to Ms. ME Masekela to conduct her research within Polokwane Municipality.
2. That the findings emanating from the research study be shared with the Municipality before they are published.

Mr. JU Manyama
HR: Manager

Ms. MM Matshivha
Director: Shared & Corporate Services

APPROVED

Mr. DH Makobe
Municipal Manager

Appendix E: Ethical Clearance

UNISA university of south africa

CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 03/12/2018

NHREC Registration # : REC-170616-051
REC Reference # : 2018/CAES/159
Name : Ms ME Masekela
Student #: 55308120

Dear Ms Masekela

Decision: Ethics Approval from 01/12/2018 to 30/11/2019

Researcher(s): Ms ME Masekela
55308120@mylife.unisa.ac.za

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

Working title of research:

Assessment of the factors that influence firewood use among households in Ga-Malahlela village, Limpopo Province

Qualification: MSc Environmental Science

Thank you for the application for research ethics clearance by the CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for a one-year period. After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 30 November 2019

Please note the points below for further action:

1. The researcher is cautioned to note the stipulation in the permission letter from the Polokwane municipality, which requires the researcher to share the findings of the study with it before publication of these findings.
2. The researcher indicates in section D.4.5.4.4 of the ethics application form that she will ask participants that want to withdraw from the study their reasons for doing so. The researcher is cautioned that he may not do so. Participants have the right to withdraw without giving a reason for doing so.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

3. The researcher should consider recording the date when a questionnaire is completed.
4. The data analysis section in the research proposal needs to be expanded beyond the use of descriptive analysis; if the researcher is going to investigate factors influencing the use of wood she needs to include data analysis methods that will assist in achieving this objective.

*The **low risk application** was **reviewed** by the CAES Health Research Ethics Committee on 29 November 2018 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(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. 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.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. 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.
5. 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.
6. 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.
7. 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:

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*The reference number **2018/CAES/159** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof EL Kempen
Chair of CAES Health REC
E-mail: kempeel@unisa.ac.za
Tel: (011) 471-2241

Prof MJ Linington
Executive Dean : CAES
E-mail: lininmj@unisa.ac.za
Tel: (011) 471-3606

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Appendix F: Language Editing Certificate

Fax: 0152682868
Tel. 0152862684
Cell: 0822198060
Rammalaj@ul.ac.za

Dr J R Rammala
440B Mankweng
Box 4019
Sovenga
0727

31 October 2019

EDITORIAL CERTIFICATE

Author: Miss Masekela Mahlodi Esther: MSc Dissertation

Document Title: **Assessment of the factors that influence firewood use among households in Ga-Malahlela village, Limpopo Province**

Dear Sir/Madam

This document certifies that the above proposal was proofread and edited by Dr J R Rammala (PhD, Linguistics). The document was edited for proper English language, grammar, punctuation, spelling and overall style. The editor endeavoured to ensure that the author's intended meaning was not altered during the review. All amendments were tracked with the Microsoft Word "Track Changes" feature. Therefore, the authors had the option to reject or accept each change individually.

Kind regards

Dr J R Rammala

Appendix G: Acknowledgment of results by Polokwane Local Municipality

P.O. Box 111, Polokwane, 0700
Civic Centre, Cnr Landdros Mare & Bodenstein Streets
Polokwane, 0699, South Africa
Tel: +27 15 290 2210
Fax: +27 15 290 2210

MEMO | Corporate Services | Human Resource

Reference Number: LNM007/2020

Date 16 January 2019

Polokwane Local Municipality

P O Box 111

Polokwane

0700

Dear Sir/Madam

Acknowledgement of findings from Ms. ME Masekela

This letter serves as acknowledgment that Ms. Mahlodi Esther Masekela have submitted her findings to Polokwane Municipality regarding research. Her Research Topic was Assessment of the factors that influence firewood use among households in Ga-Malahlela Village.

For any Inquires feel free to contact Mr. Godfrey Khumalo on 015 290 2029 /081 468 3331

Mr. Godfrey Khumalo

Chief Training Office

Appendix H: Acknowledgment of results by Mamabolo Traditional Authority

Unit 8 Henfleur
38 Burger street
Polokwane
0699
04 December 2019

Mamabolo Tribal Authority
P.O Box 725
Leshoane
0724

Findings of a study conducted in Ga-Malahlela Village

Dear Sir/Madam

My name is Masekela Mahlodi Esther, I did research with Miss Semenya Khomotso, a lecturer in the Department of Agriculture and Environmental Sciences towards a Master of Science in Environmental sciences degree at the University of South Africa for a study entitled *Assessment of the factors that influence firewood use among households in Ga – Malahlela Village, Limpopo Province*.

The study was conducted to find out the factors that influence the use of firewood as a source of energy, as not much research has been done on why firewood is still prominent after the provision of the electricity subsidy and the improvement of electrification rates of rural areas in South Africa. Attached is a summary of the study, however, the findings and/or results are outlined as is in the Dissertation, this was done so the reader gets a full and clear understanding of the factors that significantly influence firewood use in Ga-Malahlela. A full copy of the Dissertation will be made available upon request.

Should you want to make any further contact, please contact me on my E-mail mahlodimasekela@gmail.com or cell phone 072 919 7562.

Yours Sincerely
Masekela ME

	Maeckela ME	06/12/2019
Student Signature	Print Name	Date
ML Mamabolo	MAAMOESA	2019.12.06
Village Representative Signature	Print Name	Date
MS Mamabolo	Maakgoale	2019-12-06
Witness Signature	Print Name	Date

MANKWENG TRADITIONAL COUNCIL
PO BOX 403 LESHOANE
0724
2019 -12- 06
MAMABOLO LOCATION
KGOSHI N.S MAMABOLO
LIMPOPO PROVINCE

Appendix I: TURN-IT-IN Digital Receipt

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Mahlodi Masekela
Assignment title:	Revision 2
Submission title:	Masekela ME Dissertation (Final)
File name:	Masekela_ME_55308120_Dissertat...
File size:	11.2M
Page count:	159
Word count:	37,158
Character count:	213,263
Submission date:	13-Feb-2020 01:55PM (UTC+0200)
Submission ID:	1256731994