ASSESSMENT OF FACTORS INFLUENCING THE USE OF DOMESTIC SOLID FUEL IN ERMELO, MPUMALANGA PROVINCE, SOUTH AFRICA

By

MTHEMBU BULELWA NOBUHLE PRECIOUS

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SUPERVISOR: DR. KHOMOTSO SEMENYA

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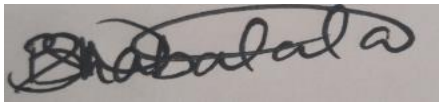
DECLARATION

I Bulelwa Nobuhle Precious Mthembu hereby declare that this research is my own work. All the information used in this research have been recognized by proper referencing and citation. This research has never been submitted by me or any other student to the University of South Africa or to any other university. I agree that I have read and understood the University of South Africa policy regarding plagiarism.



08 November 2021

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Mrs. BNP Mthembu Date

DEDICATION

To God the Almighty, for giving me strength and my husband for his encouragement and endless support.

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ABSTRACT

The use of domestic solid fuel, such as wood, animal dung, coal and charcoal, is common in low-income settlements in South Africa. Domestic solid fuel is commonly used in South Africa due to its affordability and availability. The use of domestic solid fuel contributes to indoor and ambient air pollution which may cause severe health consequences. Although access to electricity has increased in recent years and several government measures have been implemented to encourage low-income households to switch from solid fuel to cleaner fuel, South Africans still rely on domestic solid fuel to meet their primary domestic energy needs. The study aimed at assessing energy sources utilised by households in Ermelo, Mpumalanga, South Africa thus understanding factors influencing these energy preferences. The assessment focused on households' demographics, different energy sources, and factors influencing energy preferences and use as well as knowledge of residents on health risks associated with domestic solid fuel use. A semi-structured questionnaire consisting of both closed and open-ended questions was used to gain a thorough understanding of solid fuel utilisation and determinants of solid fuel use in this area. The data were qualitative and quantitative (nominal and categorical). Frequency tables and graphs were generated to summarise the data and cross-tabulation was done using the SPSS Statistics version 25. For cross-tabulation, the Chi-square (χ^2) test was used to measure the degree of association between two categorical variables.

The study revealed that electricity, firewood and coal are the main sources of fuel used in Ermelo accounting for 59.1% and 36.9% respectively. Socio-economic factors such as level of education, number of employed household members, household size, household income, occupation, type of house and money spent on energy were found to be the main determinants of domestic solid fuel use and were for the selection of a single or multiple energy use at household level, while age of household heads, gender of household heads, marital status, type of food and number of children under five years old were found not to be the determinants of domestic solid fuel use. Out of 198 households participated in the study, 164 had access to electricity. Although most of the households have access to electricity, solid fuels are still used for domestic purposes and its use has not completely stopped. In addition, it was found that 75% of households in Ermelo do not know the negative impacts of domestic solid fuel use on their health and 25% have knowledge of the negative impacts of domestic solid fuel use on their health. Moreover, 54% of households were found to have no knowledge of negative impacts of domestic solid fuel use on their environment and 46% of households have knowledge of negative impacts of domestic solid fuel use on their environment. The study found that 87% of the households are of the opinion that the local municipality is not doing

enough to assist households with the use of solid fuel in a cleaner manner and assisting households with efficient stoves that release less emissions.

It is recommended that Msukaligwa local municipality should also intensify education and awareness-raising throughout the Ermelo area since the study revealed that 75% of households in Ermelo do not know the negative impacts of domestic solid fuel use on their health, while 54% of households were found to have no knowledge of negative impacts of domestic solid fuel use on their environment. Electrified households in Ermelo continue to use solid fuel for domestic purposes because it is easily accessible and affordable. Therefore, if a clean fuel option is implemented to replace domestic solid fuel in low-income settlements, it must be efficient when combusted and it must reduce emissions and consumption. Policymakers should promote economic development in low-income settlements so that members of households in those settlements can find better employment, thus enabling them to afford electricity.

Keywords: low-income settlements, socio-economic factors, human health, environmental degradation

OKUCASHUNIWE

Ukusetshenziswa kokokubasa okuqinile kwasekhaya, okunjengokhuni, ubulongwe bezilwane, amalahle namalahle okhuni, kuvamile ezindaweni zokuhlala abantu abahola kancane eNingizimu Afrika ngenxa yokwazi ukukukhokhela nokutholakala kwako. Ukusetshenziswa kokokubasa okuqinile kwasekhaya kunomthelela ekungcolisweni komoya endlini nasendaweni. Ukungcola komoya kungahle kube nemiphumela emibi kwezempilo. Yize ukutholakala kukagesi kukhuphukile eminyakeni yamuva nje futhi sekuqaliswe nezinyathelo eziningana zikahulumeni zokukhuthaza amakhaya ahola kancane ukuthi ayeke ukusebenzisa okokubasa okuqinile aye kokokubasa okuhlanzekile, abantu baseNingizimu Afrika basathembele kokokubasa oqinile kwasekhaya ukuhlangabezana nezidingo zabo eziyinhloko zasekhaya. Ucwaningo bekuhloswe ngalo ukuhlola izinto ezinomthelela ekusetshenzisweni kokokubasa kwasekhaya okuqinile e-Ermelo, eMpumalanga, eNingizimu Afrika. Ukuhlola kugxile nokuphathelene nesimo sabantu emakhaya. Uhlu lwemibuzo lwezingxoxo ezihleleke kancane olunemibuzo emibili evaliwe nevulelekile lusetshenziselwe ukuthola ukuqonda okuphelele kokusetshenziswa kokokubasa okuqinile kanye nezimpawu zokusetshenziswa kokokubasa okuqinile kule ndawo. Imininingwane ikakhulukazi iqoqiwe futhi yahlaziywa (ngokuqokwa nangokwezigaba). Imvamisa yohlu yenziwe ukufingqa imininingwane futhi nohlu lokubala okuphambene lwenziwa kusetshenziswa Iphakethe le-*software* elisetshenziswe ekuhlaziyeni kwezibalo zemininingwane (SPSS), inguqulo 25. Ngokubala okuphambene, isivivinyo se-*Chi-square* ($\chi 2$) sasetshenziswa ukulinganisa izinga lokuhlangana phakathi kokuguquguqukayo kwezigaba ezimbili.

Ucwaningo luveze ukuthi ugesi, izinkuni zokubasa namalahle yizona zinto zokokubasa ezisetshenziswa kakhulu e-Ermelo. Izici zezenhlalo nezomnotho, ezinjengezinga lemfundo, inani lamalungu omndeni asebenzayo, ubukhulu bendlu, imali engenayo yasendlini, umsebenzi, uhlobo lwendlu nemali esetshenziselwe amandla, kutholakale ukuthi yizona zimpawu ezisemqoka ekusetshenzisweni kokokubasa okuqinile kwasekhaya Yize imindeni emininginingi inamandla kagesi, okokubasa okuqinile kusasetshenziselwa izinjongo zasekhaya futhi akusetshenziswanga ngokuphelele. Ucwaningo luqhubeke lwembula ukuthi akuzona zonke izici zezimpawu ezisemqoka ekusetshenzisweni kwamandla kule mizi. Ngaphezu kwalokho, kwatholakala ukuthi amalungu emindeni awanalo ulwazi ngomthelela ongemuhle wokusetshenziswa kokokubasa okuqinile ezempilweni zabo kanye nendawo ebazungezile. Okokugcina, amalungu emindeni anombono wokuthi umasipala wendawo akenzi lutho ukuwasiza ekwehliseni ukusetshenziswa kokokubasa okuqinile

Kuphakanyiswa ukuthi uMasipala Wendawo uMsukaligwa, kanye nabanye ababambiqhaza, bamukele amasu abhekane nobuphofu bamandla, azokhuthaza ukuphathwa kwemvelo nokusimama komasipala futhi kunciphise nomthelela wokuguquguquka kwesimo sezulu. Umasipala wendawo kufanele futhi uqinise ezemfundo nokuqwashisa endaweni yonke yase-Ermelo njengoba imfundo ingaholela ekuguqulweni kwesimo sengqondo nokuziphatha kwabantu. Imindeni efakelwe ugesi e-Ermelo iyaqhubeka nokusebenzisa okokubasa okuqinile ukufeza izinjongo zasekhaya ngenxa yokuthi iyakwazi ukukukhokhela. Ngakho-ke, uma ukukhetha kokokubasa okuhlanzekile kusetshenziswa ukufaka esikhundleni sokokubasa okuqinile kwasekhaya emakhaya ahola kancane, kufanele bakwazi ukukukhokhela futhi kutholakale kalula endaweni. Abenzi bezinqubomgomo kufanele bakhuthaze ukuthuthukiswa komnotho ezindaweni ezinabantu abahola kancane ukuze amalungu emizi kulezo zindawo athole imisebenzi engcono, okwenza ukuthi akwazi ukukhokhela ugesi.

Amagama asemqoka: okokubasa okuqinile**,** izindawo zokuhlala zabantu abahola kancane**,** iNingizimu Afrika**, i**zici zezenhlalo nezomnotho**, i**mpilo yomuntu**,** ukuwohloka kwemvelo

SICAPHUNO

Kusetjentiswa kwemafutsa lacinile, njengetinkhuni, bulongo betilwane, emalahle kanye neshakholi, kuvamile etindzaweni tekuhlala letihola kancane eNingizimu Afrika ngenca yekutsengeka kwawo kanye nekutfolakala. Kusetjentiswa kwemafutsa lacinile emakhaya kwengeta ekungcoleni kwemoya ngekhatsi endlini nasesibakabhakeni. Ukungcola kwemoya kungaba nemitselela lemibi kakhulu empilweni yemuntfu. Nanobe kufinyeleleka kugezi kukhule kakhulu kuleminyaka futsi kusetjentiswe tindlela tahulumende letinyentana kugcugcutela emakhaya lahola kancane kwekutsi ayekele kusebentisa emafutsa lacinile kodvwa bantfu labanyenti eNingizimu Afrika basatsembele kumafutsa lacinile kuhlangabetana netidzingo tabo tasekhaya letisisekelo. Lesifundvo besihlose kuhlola timbangela letibangela kusetjentiswa kwemafutsa lacinile e-Ermelo, eMpumalanga, eNingizimu Afrika. Loluhlolo belubuke linani lebantfu emakhaya. Luhlamibuto lolungakahleleki ngalokuphelele lolucuketse imibuto yemphendvulo yinye kanye netimphendvulo letinyenti lusetjentisiwe kute kutfolwe kuvisisa ngalokuphelele kwekusetjentiswa kwemafutsa lacinile kanye netimbangela tekusetjentiswa kwemafutsa lacinile kulendzawo. Imininingwane beyingekwebunyenti kakhulu (ngekukhetsa nangekwetigaba). Kudvwetjwe imenyu yekuvama kute kuncishiswe lomniningwane futsi kwakhiwa nelithebula leliphambene ngekusebentisa i-Statistical Package for the Social Sciences (SPSS), umbhalo 25. Kulithebula leliphambene, kusetjentiswe sivivinyo se- Chi-square ($\chi 2$) kulinganisa lizinga lekuhlangana phakatsi kwetigaba letigucukako letimbili.

Lesifundvo sikhombise kwekutsi igezi, tinkhuni kanye nemalahle ngemafutsi lasetjentiswa kakhulu e-Ermelo. Timbangela tetenhlalo netemnotfo, njengemazinga emfundvo, linani lemalunga lasebentako ekhaya, bukhulu belikhaya, umholo welikhaya, umsebenti, luhlobo lwendlu kanye nemali lesetjentiswa kumbani, kutfolwe kwekutsi ngito timbangela letinkhulu tekusetjentiswa kwemafutsa lacinile. Nanobe emakhaya lamanyenti atfola igezi, emafutsa lacinile asasetjentiswa emakhaya futsi asengakayekelwa ngalokuphelele. Lesifundvo sibuye sakhombisa kwekutsi akusito tonkhe timbangela letitinkhomba letiphambili tekusetjentiswa kwembani kulamakhaya. Ngetulu kwaloko, kutfolwe kwekutsi emalunga emakhaya akanalo lwati lwemtselela lomubi wekusetjentiswa kwemafutsa lacinile etimphilweni tabo nasemvelweni yendzawo. Kwekugcina, emalunga emakhaya anembono kwekutsi masipalati wendzawo kute lakwentako kubasita ekunciphiseni kusetjentiswa kwemafutsa lacinile.

Kunconotwa kwekutsi iMsukaligwa Local Municipality, sikanye nalabanye babambimsuka, bemukele emasu ekubukana nebuphuya bembani, lekatawuphindze agcugcutele kuphatfwa

kwemvelo kanye nekusimama kwamasipala nekunciphisa umtselela wekugucuka kwesimo selitulu. Masipalati wendzawo kumele aphindze acinise kufundzisa kanye nekwatisa kuyo yonkhe indzawo yase-Ermelo njengobe kufundzisa kungaholela ekugucukeni kwetimilo nekutiphatsa kwebantfu. Emakhaya lanagezi e-Ermelo ayachubeka ngekusebentisa emafutsa lacinile emakhaya awo ngesizatfu sekutsengeka kwawo. Ngako-ke, nanabga indlela yemafutsa lahlobile isetjentiswa kuva emafutsa lacinile asemakhaya kumakhaya lahola kancane, kumele atsengeke futsi atfolakale malula kulendzawo. Badvwebi betinchubomgomo kumele bagcugcutele kutfutfukiswa kwemnotfo etindzaweni tekuhlala letihola kancane kute kutsi emalunga emakhaya kuletindzawo akhone kutfola umsebenti loncono, kute kutsi bakhone kutsenga igezi.

Emagama lamcoka: emafutsa lacinile, tindzawo tekuhlala letihola kancane, iNingizimu Afrika, timbangela tetenhlalo netemnotfo, imphilo yebantfu, kukhipha imvelo

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ABBREVATIONS

ADB	Asian Development Bank
DEAT	Department of Environmental Affairs and Tourism
DPME	Department of Planning, Monitoring and Evaluation
EACREE	East African Centre of Excellence for Renewable Energy and Efficiency
EICV5	Enquéte Intégrale sur les Conditions de Vie des ménages
ENCOVI	Encuesta Nacional de Condicioness de Vida
FAO	Food and Agriculture Organization,
FBE	Free Basic Electricity
FY -	Financial Year
GACC	Global Alliance for Clean Cookstoves
GPS	Global Positioning System
IDP	Integrated Development Framework
IEA	International Energy Agency
kWh	Kilo Watt per hour
LM	Local Municipality
LPG	Liquefied Petroleum Gas
MoF	Minister of Finance
NBS	National Bureau of Statistics of China
PM	Particulate Matter
SDF	Spatial Development Framework
Stats SA	Statistics South Africa
SPSS	Statistical Package for Social Sciences
UNHCR	United Nations High Commissioners for Refugees
WECS	Water and Energy Commission Secretariat

CHAPTER 1: BACKGROUND OF THE STUDY

1.1 Introduction

Energy is a significant component of human life as it improves socio-economic development, transportation of goods and provision of services to the nation (Nyakone & Waithera, 2016; Msibi & Kornelius, 2017; Nkosi *et al*., 2017; Ateba *et al.*, 2018; Department of Energy, 2019; Manirafasha *et al.*, 2020). Domestic solid fuel such as wood, animal dung, coal and charcoal are common among the low-income settlements in the world, with nearly 3 billion people still depending on solid fuel to meet their domestic fuel needs (Bruce *et al.*, 2015; Jeuland *et al.*, 2015; Makonese, 2015; Wang *et al.*, 2016). It is expected that by 2040 access to electricity will still be a challenge with approximately 2 billion people still relying on domestic solid fuel for domestic purposes (Scheid *et al.*, 2108; WHO, 2019).

In Asia, Bonjour *et al.* (2013) found that over 60% of households use solid fuel for cooking. The World Bank (2017) reported an 8.2% increase in the use of solid fuel in Central America between 1990 and 2015. This was supported by Pachauri *et al*. (2018) who found that without supporting policies, 40-50% of the Central American nations will still be depending on solid fuel by 2030. While the consumption of domestic solid fuel is mostly prevalent in America and Asia, this is also true for Sub-Saharan countries such as Angola, Congo, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Nigeria, South Africa, Tanzania, Zambia and Zimbabwe (Abdul-Hakim & Ibrahim, 2017; Buba *et al.*, 2017; Ebenezer *et al.*, 2018; Makonese *et al.*, 2018; Scheid *et al.*, 2018; Sharma, 2018; Urge & Feyisa, 2018; Semenya & Machete, 2019).

The International Energy Agency (2020) reported that in South Africa 94.3% of the population have access to electricity. Even though the country's electricity access has increased in recent years, South Africans still rely on solid fuels to meet their primary domestic requirements (Language *et al.*, 2016; Kasangana *et al.*, 2017; Statistics South Africa, 2018; Sumbane-Prisloo, 2018; Buthelezi *et al.*, 2019; Semenya & Machete, 2019). Studies by Wernecke *et al.* (2015) and Nkosi *et al.* (2017) in Mpumalanga's low-income settlements where residents are connected to electricity showed that solid fuels such as wood and coal are the main sources of energy. Therefore, access to electricity cannot be taken as an effective solution to minimise the utilisation of solid fuel (Kasangana *et al.*, 2017; Makonese *et al.*, 2018; Nkosi *et al.*, 2018). The increase in the number of people depending on solid fuel poses a challenge in achieving Goal 7 of the United Nations Sustainable Development Goals that focuses on access to clean, cheap and dependable energy sources by 2030.

Socio-economic factors such as affordability, accessibility, household size, level of education and women headed households have been found to influence heavy reliance on solid fuels such as cow dung, coal, charcoal and wood as the primary energy (Yonas *et al.*, 2013; Sepp, 2014; Thomas *et al.*, 2015; Getamesy *et al.*, 2016; Buba *et al.*, 2017; Nkosi *et al.*, 2017; Francioli, 2018; Makonese *et.al.*, 2018; Megbowon *et al.*, 2018; Semenya & Machete, 2019; Danlami, 2019). In addition to socio-economic factors cultural factors such as family social cohesion, protection of thatch from weevils, the use of clay pots and '*chulha'* for better taste and the use of '*mbaula'* to connect to the ancestors and heritage were found to be the main contributors on solid fuel choice in some of the developing countries (Remiogion, 2017; Akintan *et al.*, 2018; Sole & Wagner, 2018; Jurisoo *et al.*, 2019; Ravindra *et al.*, 2019; Martinez *et al.*, 2020; Nyaga, 2020; Sharma *et al.*, 2020; Williams *et al.*, 2020).

The consumption of solid fuel results in adverse impacts such as household air pollution, deforestation, soil erosion, diseases and deaths (Thabethe *et al.*, 2014; Montane, 2014; WHO, 2014; Morakiyo *et al.*, 2017). Solid fuel and fuel oil use can result in high risk of burns where children fall into fires and poisoning where some drink kerosene (Francioli, 2018). Women and children endanger their lives and are faced with the risk of being injured and being violated during solid fuel collection (Preston, 2012; FAO & UNHCR, 2017). Even with these challenges and negative impacts associated with the use of solid fuel, households in developing countries still rely on solid fuel for domestic purposes (Tipre *et al.*, 2019; Sana *et al.*, 2020; Ali *et al.*, 2021). These studies also revealed that communities do not have knowledge on the impact of solid fuel use on their health and that of their children as most women cook whilst carrying infants on their backs. Hence, it is important to assess the factors influencing the use of domestic solid fuel in Ermelo, Mpumalanga Province, South Africa - a settlement where residents are connected to electricity but still use solid fuel for domestic purposes.

1.2 Research Problem

The use of solid fuel is associated with risks and significant impacts such as women and children endangering themselves when collecting solid fuel (FAO & UNHCR, 2017). Solid fuel is usually collected from the fields, purchased from neighbouring businesses or from neighbouring households (Naidoo, 2014). The collection of solid fuel from the fields is usually done by women and children using head load methods or s (Masekoameng *et al.*, 2005; Shackleton *et al.*, 2007; Nkosi *et al.*, 2017). While collecting fuel in these fields, women and children endanger their lives and are faced with risk of injury and violence (Preston, 2012; FAO & UNHCR, 2017).

Thabethe *et al.* (2014) reported that continuous burning of solid fuel result in particulate matter emissions. The impact of particulate matter on human health is ranked as the fourth leading risk factor for good human health (WHO, 2018). Continuous exposure to particulate matter emissions has a significant impact on human health such as asthma, heart attack and lung cancer (Lam *et al.*, 2012; Kelly & Fussell, 2015; Ni *et al*., 2016; James *et al.*, 2020). In addition, low birth weight, anaemia and premature mortality in children were found to be caused by pollutants associated with domestic solid fuel such as nitrous oxide, sulphur dioxide, carbon monoxide (Pate *et al*., 2013; Thabethe *et al.*, 2014; Tipre *et al.*, 2019, Weber *et al*., 2020). The adverse impacts of fine particulate matter and high consumption of solid fuel in Ermelo has resulted in the area being declared as Highveld Priority Area (DEAT, 2007). This is supported by the study by Thabethe *et al.* (2014) that showed that air pollution from solid fuel burning has negative effects on human health within the district.

The dependence on solid fuel by low-income settlements in developing countries causes ambient air pollution in the environment (Rafaj *et al.*, 2018). Bhattacharjee and Behera (2018) indicated that the use of firewood in developing countries has negative impact on the environment contributing severely to deforestation and soil erosion. Feyisa *et al.* (2017) and Francioli (2018) emphasised that the use of firewood result in overexploitation of natural resources, flood risk and increases the probability of occurrence of accidental fires. Overexploitation of natural resources also has severe implications on biodiversity as trees provide habitat and food for fauna (Hainduwa, 2013). Clearing of forest and trees for domestic purposes also leads to extinction of wildlife and severe land degradation (Hussain *et al.*, 2017).

Although there is improvement in low-income settlement accessibility to electricity, South Africans in low-income settlements are still relying on solid fuel for domestic purposes (Kasangana *et al.*, 2017; Sumbane-Prisloo, 2018; Buthelezi *et al.*, 2019; Semenya & Machete, 2019). This was evident in the studies conducted in Mpumalanga by Naidoo (2014) and Nkosi *et al.* (2017) who found that solid fuel is a primary energy source for meeting domestic needs in low-income settlements within this province. Residents in Mpumalanga use solid fuel because they are easily accessible and affordable compared to modern energy (Naidoo, 2014; Language *et al.*, 2016; Nkosi *et al.*, 2017). Transition to modern energy has become a challenge for Mpumalanga residents (Wernecke *et al.*, 2015; Sumbane-Prisloo, 2018; Nkosi *et al*., 2018).

Statistics South Africa (2018) reported that approximately 84% of Msukaligwa Local Municipal households in Mpumalanga Province, South Africa are connected to electricity and poor households within this municipality receive free basic electricity services to reduce the burden of buying expensive electricity. Despite these improvements, poverty and unemployment in the low-income settlements of Ermelo have resulted in many households failing to meet the high cost of electricity and this has made them to depend more on solid fuel for domestic purposes (Msukaligwa IDP, 2020). The use of solid fuel in the low-income settlements is seen as a measure to save electricity which is expensive for most residents (Makonese *et al.*, 2012; Lourens, 2018; Mgwambani *et al.*, 2018).

1.3 Justification

According to Statistics South Africa (2016), 67% of households in Msukaligwa Local Municipality, Mpumalanga Province are connected to electricity, while 32% still rely on solid fuel for domestic purposes. Solid fuel use in low-income settlements assists in minimising energy poverty for these households as it is affordable and easily accessible (Kasangana *et al.*, 2018). Even though access to modern energy has increased in recent years, literature shows that solid fuel is a solution for households that are economically poor and cannot afford modern energy (Lourens 2018; Makonese *et al.*, 2018; Mgwambani *et al.*, 2018). The use and dependency on solid fuel in poor households is likely to increase as the population increases because switching to modern energy is expensive for households in low-income settlements (Wessels *et al*., 2013; Lloyd, 2014).

For complete switch to modern energy by society, it is important to determine the different types of fuel used in households, household patterns of solid fuel use and factors influencing the continued use of solid fuel. Hence, this study seeks to assess and document the underlying factors influencing the use of domestic solid fuel, the knowledge of residents on health and environmental risks associated with the use of solid fuel as well as household patterns of solid fuel use by Ermelo low-income settlements in Msukaligwa Local Municipality, Mpumalanga Province, South Africa. Moreover, the study seeks to address the existing gaps such as cultural barriers and knowledge of households on the health risks associated with the use of domestic solid fuel. This information is necessary for development of effective policies that promote switching from domestic solid fuel to modern fuel. The study can assist policy makers on how they can structure the provision of energy within Ermelo.

1.4 Aim and Objectives

Aim

The aim of the study was to assess energy sources utilised by households in Ermelo, Mpumalanga, South Africa thus understanding factors influencing these energy preferences.

Objectives

i. To evaluate the availability of different energy sources in Ermelo in Msukaligwa Local Municipality, Mpumalanga Province, South Africa;
ii. To assess and document the predominant solid fuel utilisation in comparison to electricity use in Ermelo in Msukaligwa Local Municipality, Mpumalanga Province, South Africa;
iii. To investigate factors influencing solid fuel utilisation in Ermelo in Msukaligwa Local Municipality, Mpumalanga Province, South Africa;
iv. To assess knowledge of residents on health risks associated with solid fuel use.

1.5 Research Outline

This study is organised into five chapters outlined below:

Chapter 1: comprises of the introduction of the study, research problem and justification. It further discusses the aim and the objectives of the study.

Chapter 2: gives an overview of literature on solid fuel utilisation and factors influencing domestic solid fuel use and lastly knowledge of residents on health risks associated with the use of solid fuel.

Chapter 3: describes the methodology of the study.

Chapter 4: provides results of data analysis and key findings.

Chapter 5: concludes the study, provides some discussion, policy recommendations and the opportunities for future research.

CHAPTER 2: LITERATURE REVIEW

This chapter examines the existing literature in reference to the factors influencing domestic solid fuel use. The first section of this chapter defines energy. The second section discusses energy transition in South Africa. The third section examines the importance of domestic solid fuel. The fourth section reviews the disadvantages of domestic solid fuel use. The fifth section traces debates on the factors influencing domestic solid fuel use. The sixth section discusses solid fuel utilisation and the last section examines the knowledge of residents on health risks associated with domestic solid fuel use.

2.1 What is energy?

Energy is defined as ability to do work and can be transformed in different forms such as chemical, electrical, light, heat and motion (Valenti, 2015; EIA, 2020). Energy is a significant component of human life as it improves socio-economic development, transportation of goods and provision of services to the nation (Nyakone & Waithera, 2016; Msibi & Kornelius, 2017; Nkosi *et al.*, 2017; Ateba *et al.*, 2018; Department of Energy, 2019; Manirafasha *et al.*, 2020). According to data derived from the 2019 South African Energy Sector Report (Figure 2.1), in 2016 the industry sector was responsible for 52% of energy consumed followed by transport (19%), commerce and public services (14%), residential (8%), agriculture (6%) and non-specified (1%). For households, energy includes but not limited to electricity, coal, firewood, liquefied petroleum gas (LPG) and charcoal (Truneh, 2014; IEA, 2020). Domestic energy uses include lighting, cooking, water and space heating (Truneh, 2014; IEA, 2020). According to Ntobeng (2007) and IEA (2020) energy utilisation in households is influenced by different factors such as affordability, availability, household' characteristics, income, climate and appliances. Hence, the type of energy consumed and the quantity of energy consumed varies worldwide mostly between developed and developing countries.

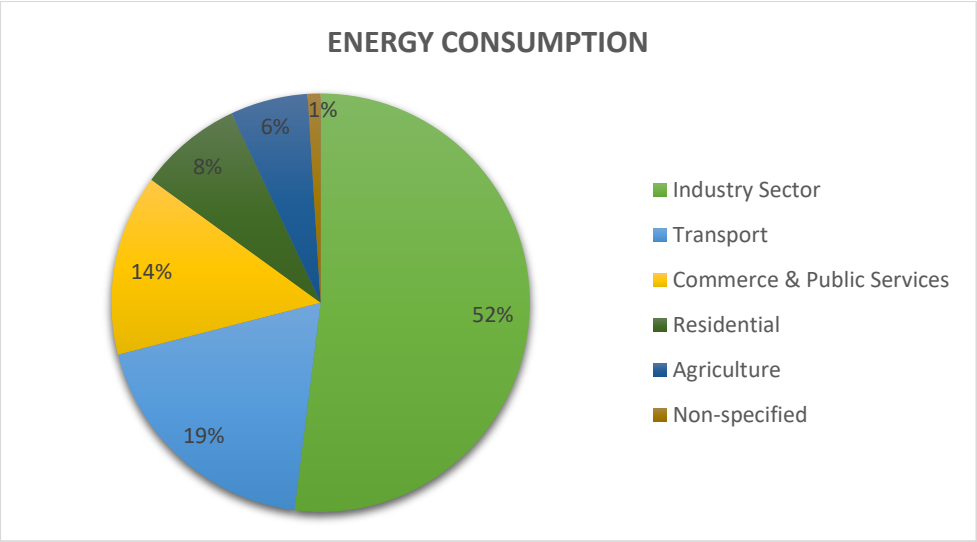

Figure 2. 1: Energy consumption by sector.

Source: Department of Energy (2019)

2.2 Energy transition in South Africa

In South Africa, in the early 1990s there was democratic transition from the apartheid regime which resulted in the formulation of different policies and provision of basic needs such as electricity for all. During apartheid only the minority had access to basic services while the majority of the households were living in the outskirts of major cities and did not have access to basic services like electricity (Spalding-Fecher & Matibe, 2003). This inequity among different population groups caused the majority of households to depend and use other energy sources such as coal, wood and paraffin which are still used by most of the low-income settlements in South Africa (Francioli, 2020). As part of South Africa's development policies, access to electricity for all was identified as one of the priorities of the country in solving the country's historical inequalities while improving the growth of the country's economy (Presidency SA, 2012; DPME, 2014).

During 1994-2000 policies and programmes were developed in order to reduce the basic services inequality within different population groups (Spalding-Fecher & Matibe, 2003). Policies like the Constitution of Republic of South Africa, 1996 and the White Paper on the Energy Policy of the Republic of South Africa, 1998 that recognise the provision of services that are accessible, affordable and distributed in sustainable manner for all were developed. An electrification programme by the Department of Energy, Eskom and the local government called Integrated National Electrification Programme (INEP) was also developed with the aim of improving energy access especially in low-income settlements (Mohlakoana, 2014). After the implementation of INEP, the low-income settlements still had challenges affording

electricity to meet their basic needs. Hence, a Free Basic Electricity policy was introduced by government with the aim of reducing energy poverty in South Africa (Statistics SA, 2013). As per this policy, poor low-income settlements were given free 50 kW/h of free electricity per month to meet their basic needs (Eskom, 2016).

After implementation of these policies and programmes in South Africa, access of electricity increased from 35% of households in 1990 to 58% of households in 1996 (Statistics SA, 2012). While in year 2011 and 2016, access to electricity in households increased by 84% and 86% respectively (World Bank, 2017; DoE, 2017). At least 91.23% of households have access to electricity in South Africa (World Bank, 2020). However, the success of the electrification did not stop reliance on other energy sources such as coal, wood and paraffin for domestic purposes in low-income settlements of South Africa (Manirafasha *et al.*, 2020; Martinez *et al.*, 2020; Nyaga, 2020; Sharma *et al.*, 2020; Williams *et al.*, 2020; Nkosi *et al.*, 2021).

2.3 Access to energy in Ermelo

Electricity is supplied by both the municipality and Eskom with Eskom Camden located in the area (Msukaligwa IDP, 2020). Households registered with the local municipality are connected to electricity and informal settlements are faced with a backlog (Msukaligwa IDP, 2020). Poor households receive 50kWh of electricity from the local municipality as a means of supporting this households. A community survey conducted by Stats SA showed that while the residents in Msukaligwa are connected to electricity, they still use other energy sources for domestic purposes see Table 2.1.

Table 2 1: Distribution of households by source of energy for domestic purposes

Energy for cooking		Energy for lighting		Energy for water heating		Energy for space heating	
Electricity	Other energy sources	Electricity	Other energy sources	Electricity	Other energy sources	Electricity	Other energy sources
63.8%	35.7%	83.2%	16.3%	66.6%	32.9%	52.4%	41.9%

Source: (Stats SA, 2016).

2.3 Importance of domestic solid fuel

South Africa is one of the countries with the greatest number of households connected to electricity (World Bank, 2020). However, households in low-income settlements still depend on solid fuel like coal, fuelwood, charcoal and animal dung to sustain themselves (Msibi, 2015; Danlami, 2019). With implementation of modern energy in low-income households, it was envisaged that the use of domestic solid fuel will decrease (Bohlmann & Inglesi-Lotz, 2018; Danlami, 2019). However, because of its low cost and accessibility domestic solid fuel is still the preferred energy source within low-income households (Matsika *et al.*, 2013; Semenya & Machete, 2019). According to Variawa (2012); Ateba *et al.* (2018) and Burton *et al.* (2018), the consumption of domestic solid fuel plays a vital role in alleviating energy poverty faced by low-income settlements and it has been providing an income as well as sustainable livelihoods for these households. Approximately 30% of coal is exported to other countries and this contributes significantly to the South African economic growth (DoE, 2018). Coal is cheap and costless for some households residing next to the mines and can be used to meet the growing energy demand that the modern energy fails to fulfil efficiently (Lourens, 2018; Adebayo *et al.*, 2021). Local businesses in low-income settlements also use ash from coal to make bricks and construct roadways (Kimemia, 2014; DoE, 2019).

2.4 Disadvantages of domestic solid fuel

2.4.1 Environmental impacts

It is estimated that nearly 3 billion people in the world depend on solid fuel as their main source of energy leading to higher concentration of air pollutants in the environment (Bruce *et al.*, 2015). This is true for low-income settlements in developing countries where households cook with solid fuel stoves that are inefficient and do not have ventilation resulting in higher carbon monoxide and organic compounds emissions (Balakrishnan *et al.*, 2013). Supporting this notion is Smith *et al.* (2014), who found that approximately 10% of ambient fine particulate matter emissions are caused by households cooking and heating with solid fuel. Low-income settlements in Mpumalanga Province are faced with higher concentration of ambient air pollution as this province houses coal-fired power stations and a lot of mines resulting in the high usage of coal by households in this area (Language *et al.*, 2016).

In 2015, the United Nations adopted 17 Sustainable Development Goals and Goal 7 includes access to affordable, sustainable, reliable and modern energy by 2030. The dependence on solid fuel by low-income settlements in developing countries hinders achievement of this goal and causes ambient air pollution in the environment (Rafaj *et al.*, 2018). Bhattacharjee and Behera

(2018) indicated that the use of firewood in developing countries has negative impact on the environment contributing severely to deforestation and soil erosion. This was supported by Feyisa *et al.* (2017) and Francioli (2018) who emphasised that the use of firewood result in overexploitation of natural resources, flood risk and increases the probability of occurrence of accidental fires. Overexploitation of natural resources also has severe implications on biodiversity as trees provide habitat and food for fauna (Hainduwa, 2013). Clearing of forest and trees for domestic purposes also leads to extinction of wildlife and severe land degradation (Hussain *et al.*, 2017).

2.4.2 Socio-economic impacts

Unsustainable harvesting of natural resources has negative impact of economic development (Okia, 2012). By destroying natural resources, the possible future revenue, employment and ecotourism are severely affected (Wessels *et al.*, 2013; Jimena, 2014). Women and children endanger their lives and are faced with risk of injury and violation during solid fuel collection (Preston, 2012; FAO & UNHCR, 2017). According to Hainduwa (2013), collection of solid fuel deprives children quality time with their parents, especially mothers and grandmothers, as they spend a lot of time collecting the fuel. If the population could harvest fuelwood and collect other solid fuel in a sustainable manner, they could continue to supplement their domestic needs and meet the industrial needs for those who rely on of solid fuel (Wessels *et al.*, 2013).

2.5 Factors influencing domestic solid fuel use

Several studies have been conducted on factors influencing the use of solid fuel in sub-Saharan countries. Economic factors such as level of income, household fuel price, affordability and household expenditure were found to be the main determinants. The more expensive the fuel energy, the less consumption of fuel energy by households (Maurice *et al.*, 2015; Karimu 2015; Mensah & Adu, 2015; Nlom & Karimov, 2015; Thomas *et al.*, 2015; Bisu *et al.*, 2016; Chen *et al.*, 2016; Kasangana *et al.*, 2017; Nkosi *et al.*, 2017; Rahut *et al.*, 2017; Uhunamure *et al.*, 2017; Francioli, 2018; Megbowon *et al.*, 2018; Makonese *et al.*, 2018; Wernecke, 2018; Manirafasha, 2020). In addition, social factors such as resident size, type of resident, fuel availability, age and convenience were also found to be influencing the use of solid fuel (Thomas *et al.*, 2015; Getamesy *et al.*, 2016; Buba *et al.*, 2017; Semenya & Machete, 2019).

While this was true for sub-Saharan countries, some studies in developing countries revealed that gender and level of education influence the choice of fuel used (Malla & Timilsina, 2014; Ismail & Khembo, 2015; Onyeneke *et al.*, 2015; Ateba *et al.*, 2018). Women were found to be

responsible for collection of fuelwood and preparation of food, hence the change to modern energy will mean women need to adjust their daily routine and cooking practices (Muneer, 2003, Preston, 2012; Urge & Feyisa, 2018). Although the level of education does not have impact on cooking practices, literature shows that higher level of education results in higher usage of modern energy instead of solid fuel (Massawe *et al.*, 2015; Rahut *et al.*, 2016; Malakar, 2018; Kumar & Igdalsky, 2019). In addition, education provides women with an understanding of social and health risks associated with the use of solid fuel and women who are educated tend to have positive perception of modern energy and cultural change (Massawe *et al.*, 2015; Rahut *et al.*, 2016; Malakar, 2018; Kumar & Igdalsky, 2019).

Studies by Rhodes *et al.* (2014) and Gubler (2017) show that environmental factors such as change of season and weather affects the consumption of solid fuel. They found that households located in cold areas prefer to use solid fuel for domestic purposes as it lasts long and can be used for both cooking and heating at the same time. Whilst other studies found that households living in areas with high rainy seasons prefer modern energy for domestic purposes as it takes a lot of time to start fire with solid fuel and for firewood to dry up in the rain seasons (Martinez-Negrete *et al.*, 2013; Ruiz-Mercado & Masera, 2015; McLean *et al.*, 2019).

Solid fuel use in some countries is influenced by cultural factors (Akintan *et al.*, 2018; Ravindra *et al.*, 2019; Sharma *et al.*, 2020). It was found that households in rural areas prefer to use traditional stoves for cooking as these stoves maintain the traditional taste of their food which may change with the use of modern stoves (Rhodes *et al.*, 2014; Malakar, 2018). The use of solid fuel affords households opportunities for family social cohesion and time to connect with their ancestors and traditional history (Jurissoo *et al.*, 2019; Nyanga, 2020; Williams *et al.*, 2020).

In as much as there is documented literature on factors influencing the use of domestic solid fuel, to date, and to the best of my knowledge, no similar research has been done in Ermelo and limited literature exists on domestic solid fuel use in Ermelo. Therefore, this study seeks to assess the underlying factors affecting the use of domestic solid fuel in Ermelo, Mpumalanga Province, South Africa. Furthermore, the study seeks to fill the gap on solid fuel consumption through systematic evaluation of associations between several descriptive factors and solid fuel use.

Some of the studies conducted on the factors influencing solid fuel use are summarised (Figure 2.2):

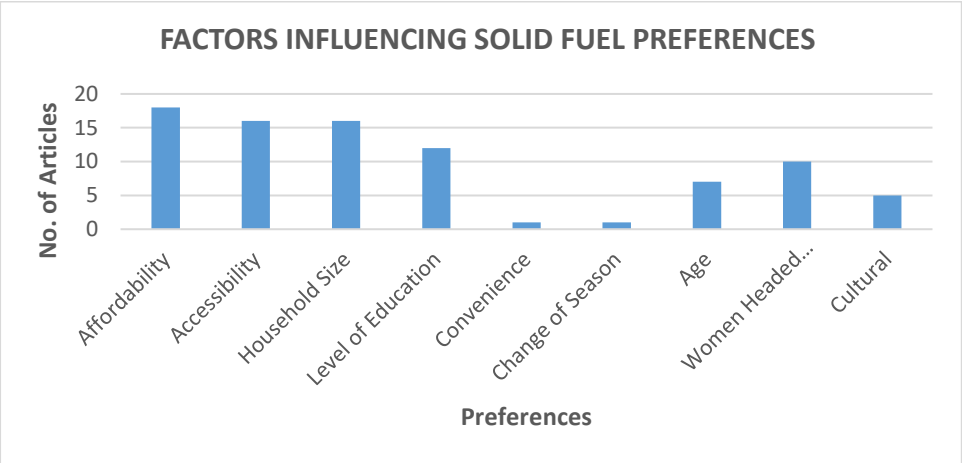

Figure 2. 2: Illustration of factors influencing preferences for solid fuel use.

Source: (Yonas *et al.*, 2013); (Naidoo, 2014); (Sepp, 2014); (Thomas *et al.*, 2015); (Chen *et al.*, 2016); (Getamesy *et al.*, 2016); (Nyakone & Waithera, 2016); (Bisu *et al.*, 2017); (Buba *et al.*, 2017); (Makonese *et al.*, 2018); (Megbowon *et.al.*, 2018); (Sharma, 2018); (Nkosi *et al.*, 2018); (Semenya & Machete, 2019); (Nyaga, 2020); (Martinez *et al.*, 2020); (Williams *et al.*, 2020); (Nkosi *et al.*, 2021).

2.6 Solid Fuel Utilisation

2.6.1 Solid fuel utilisation from an International perspective

2.6.1.1 Central America

According Pachauri *et al.* (2018), Guatemala, Honduras and Nicaragua are among the poorest countries in America. With a population of over 15 million residents, Guatemala is the largest nation in Central America (INAB I-U, 2012). Approximately 90% of households in rural Central America and 50% of households in urban Central America still rely on fuelwood as an energy source for domestic purposes (GACC, 2014; IEA, 2015). Wang *et al.* (2013) reported that 97% of the Nicaragua population rely on fuelwood for cooking purposes. According to (Pachauri *et al.*, 2018), the total number of people using solid fuel has risen over 25 years in Central America. In these three countries, more than half of the national energy consumption was from firewood (World Bank, 2017). Pachauri *et al.* (2018) were of the opinion that the increase in the total number of people depending on solid fuel poses a challenge in achieving Goal 7 of the United Nations Sustainable Development Goals, which focuses on access to clean, cheap and dependable energy sources by 2030 and without supporting policies, half of Guatemala, Honduras and Nicaragua will still be depending of solid fuel by 2030.

2.6.1.2 Brazil

Brazil is a country located in South America with a population size of 190 million people (Gioda, 2019). Nascimento (2013) and Gioda (2019) found that a large portion of households in Brazil utilise both firewood and LPG. Firewood and LPG were mostly used for cooking in Brazil accounting for 93.2% and 3.2% of the energy used for cooking respectively (Gioda, 2019). Even though the use of LPG is encouraged in rural households, fuelwood is still preferred by households accounting for 49% of energy supply (Coelho *et al.*, 2018; Gonçalves & Rodrigues, 2019). The unsustainable way to obtain firewood by households in Brazil has resulted in an increase in deforested and unproductive areas as well as exploitation of local ecosystems such as Caatinga (Gioda, 2019).

2.6.1.3 China

China has a high number of people living in rural areas and 60% of these rural households are dependent on solid fuel for domestic purposes (He *et al.*, 2018). With the increase in economic growth in China, the population from the rural areas is declining while energy usage is increasing rapidly (Yang *et al.*, 2018). Traditional biomass is an important source of fuel for households in China and forms an important aspect of China's energy consumption structure and development (An *et al.*, 2014; Chen, 2017). Factors such as socio-economic conditions, geographical difference and environmental conditions play a significant role in the type of energy that is used by rural households of China (He *et al.*, 2018).

2.6.1.4 Nepal

Approximately 59.3% of households use firewood and 25.8% of households use LPG in Nepal (MoF 2015/2016 FY; WECS, 2017). Due to the increase in people living in Nepal and the increase in economy, electricity and LPG are the least used energy sources in Nepal (Bhattari, 2015). ADB (2017) reported that nearly 81% of the fuel energy needs were fulfilled by biomass energy while oil, coal and hydroelectricity constituted 12%, 4%, and 3% respectively. Sharma (2018) found that firewood is the main energy source used for domestic purposes in Nepal with 84% of households using firewood for domestic purposes followed by LPG, biogas, electricity with 9%, 6% and 1% respectively. It is projected that by 2035, households in Nepal will still be using solid fuel as their source of energy (Bhandari & Pandit, 2018).

2.6.1.5 Pakistan

Energy sources in Pakistan differ across income groups, between people living in rural areas and those in urban areas and by type of households (Mirza & Kemp, 2011). The increase in demand and inadequate provision of clean energy sources is a major policy concern in Pakistan (Moeen *et al.*, 2016). Most households use both solid fuel and clean fuel for different purposes, such as lighting, cooking, heating, and transportation (Jan *et al.*, 2012). Approximately 98% of households in Pakistan villages use electricity for lighting and two-thirds of the households use firewood for cooking and heating while 15% of the households use natural gas for cooking and heating (Moeen *et al.*, 2016).

2.6.1.6 India

India is a country located in South Asia with over 240 million households (Sharma, 2018). Even though LPG is the most used clean fuel in low-income settlements of India, the results from the 2011 Indian Census revealed that only 11% of low-income settlements use LPG as their main source of energy for cooking fuel; the remaining 89% depend mainly on firewood, coal, and dung to meet their domestic needs (Tripathi *et al.*, 2015). Fuelwood is the main source of fuel energy in low-income households of India because it is easily available and simple to use (Dhanai *et al.*, 2015; Hussain *et al.*, 2017). Gould and Urpelainen (2018) showed that LPG is the most used clean fuel within the rural population of India, though fuel price prevents a complete switch from solid fuel to clean fuel in these households.

2.6.2 Solid fuel utilisation from African perspective

2.6.2.1 Nigeria

According to Maurice *et al.* (2015), forestry is a source of energy fuel for many farmers and households in rural Nigeria. About 95% of the total wood harvested as fuelwood is used for domestic needs such as cooking (Ebe, 2014; Danlami, 2019). Abdul-Hakim and Ibrahim (2017) found that 66.3% of households in Kano, a metropolitan area within Nigeria depends on firewood as their main source of fuel energy while 55% have access to electricity. Ebenezer *et al.* (2018) also found that 75% of households in Nigeria rely on firewood for household cooking. The increase in fuelwood dependency is due to rapid urbanization, rural and urban poverty, rising costs of energy alternatives and high cost of electricity (Gatama, 2014; Maurice *et al.*, 2015; Orimoogunje & Asifat, 2015). Extensive use of fuelwood in Nigeria has contributed greatly to desert encroachment, climate change, fuelwood scarcity, and economic burden for poor households as they either purchase fuelwood for a certain price or travel long

distances to the forest in search for fuelwood (Gatama, 2014; Maurice *et al.*, 2015; Danlami, 2019).

2.6.2.2 Kenya

The use of biomass fuel, especially from wood sources is an old practice in Kenya (Nyakone & Waithera, 2016). Studies done in Kenya show that most households do not normally use solar, biogas and electricity as they cannot afford the cost of these energy sources (Ndolo, 2014). According to WPP (2015), fuelwood is harvested in nearby forested areas and its consumption has greatly increased with an increase in population from approximately 5 million in 1950 to about 45 million in 2014. EACREE (2018) reported that charcoal, wood, and crop residues are the main fuel energy used in Kenya with 65% of the energy consumed for cooking and heating. While EICV5 (2018) reported that in rural areas of Kenya firewood is the main source of energy for cooking at the rate of 93%, in urban areas charcoal is used by 65% of households, followed by firewood with 26%. Charcoal (77.6%), gas (20.6%) and firewood (1.9%) are the sources fuel used for cooking in Kenya (Manirafasha *et al.* 2020). Nyakone and Waithera (2016) stated that there are challenges associated with the consumption of charcoal and fuel wood in Kenya such as the reduction of forest resources due to unsustainable and often illegal wood harvesting practices.

2.6.2.3 Tanzania

Although the Tanzania Traditional Energy Development Organization has promoted the use biogas for domestic purposes in Tanzania, it was found that only 0.8% of the households indicated biogas as their primary source of energy for cooking and only 0.3% of the households indicated solar energy (Massawe, 2015). With a population of more than 50 million people, only 2% of that population has access to clean energy and the rest is energy deprived (Scheid *et al.*, 2018). Scheid *et al*. (2018) showed that 81.8% of households in Tanzania use firewood as their main source of energy for cooking while charcoal and sawdust account for 3% of the households. Notwithstanding the availability of various sources of energy in Tanzania, studies show that biomass is still the main source of energy for cooking and failure to use other energy sources for cooking energy might result in deforestation (Massawe, 2015; Scheid *et al.*, 2018).

2.5.2.4 Ethiopia

Ethiopia is one of the countries in the world that have a high percentage of biomass fuel consumption of over 90% of fuel energy utilisation (Alem *et al.*, 2015). According to Tadesse and Teketay (2018), 72% of households in Ethiopia specified that they use biomass as their

source of energy for domestic purposes and they do not have access to clean energy like electricity. Like in many developing countries, households in Ethiopia depend on fuelwood for their domestic needs (Urge & Feyisa, 2018). Dependence of households on solid fuel has resulted in deforestation and land degradation in Ethiopia (Tadesse & Teketay, 2018).

2.6.3 Solid fuel utilisation from South African perspective

In South Africa about 9.8 million tonnes of fuelwood is used every year despite the initiatives by the current government to reduce energy poverty through the provision of electricity to poor households (Nott & Thondhlana, 2017). Below is an overview of some of South African Provinces.

2.6.3.1 Limpopo

Over the years, villages in Limpopo province have been experiencing challenges in sourcing their domestic energy for cooking and heating due to its scarcity (Masekoameng *et al.*, 2005, Chikava & Annegarn, 2013). The rural population in Limpopo Province has the highest fuelwood utilisation in South Africa, with 40% of households in 2014 depending on fuelwood for domestic purposes (Stats SA, 2015). Nott and Thondhlana (2017) and Uhunamure *et al.* (2017) found that solid fuel consumption for domestic purposes remains at 40% in the rural population of Limpopo Province. Semenya and Machete (2019) found that Bapedi households of Senwabarwana Villages in Limpopo Province prefer firewood for water heating (98%), cooking (91%) and space heating (91%). According to Montane (2014) over consumption of fuelwood may lead to problems of deforestation and soil erosion in this province.

2.6.3.2 Gauteng

Gauteng has a significant number of people residing in informal settlements compared to other eight provinces in South Africa (Stats SA, 2015). Kimemia and Annegarn (2011) found that 99% of households in Setswetla – Johannesburg (a city in Gauteng) use paraffin for cooking, 61% use fuelwood for heating and beer making and 83% use candles for lighting. According to Naidoo (2014) people who have electricity in Johannesburg prefer electricity as their source of energy but they also rely on solid fuel for other domestic purposes in winter months and residents without electricity prefer paraffin and gas in warmer months as well wood and coal in colder winter months for cooking and heating activities. Makonese *et al.* (2016) found that coal is still the main fuel used for cooking, water heating and space heating in Johannesburg, while kerosene is mostly used for cooking and lighting, and partly for water heating.

2.6.3.3 Mpumalanga

Kasangana *et al.* (2017) found that 87% of sampled residents in Mpumalanga were connected to electricity whereas 91% were using wood, 57% were using paraffin and 28% were using coal for heating and cooking purposes. Having access to electricity for residents in Mpumalanga does not mean an automatic switch to clean fuel for household activities as some still rely on solid fuel to meet their cooking and heating needs (Mgwambani *et al.*, 2018). According to Wernecke (2018) and Nkosi *et al.* (2018) most households in Mpumalanga, especially in the Highveld area, still rely on coal for heating and cooking purposes because the area is surrounded by coal mines making coal easily obtainable and affordable compared with clean fuel. There is continued dependency on various energy sources in rural communities of Mpumalanga (Kasangana *et al.*, 2017).

2.7 Knowledge of residents on health risks associated with domestic solid fuel use.

The impact of particulate matter on human health is ranked as the fourth leading risk factor for good human health (WHO, 2018). Health problems, such as asthma, heart attack and lung infection, are associated with exposure to particulate matter (Kelly & Fussell, 2015; Ni *et al*., 2016; Chen *et al*., 2016). In addition, low birth weight, anaemia and premature mortality in children were found to be caused by pollutants associated with domestic solid fuel such as nitrous oxide, sulphur dioxide, carbon monoxide (Pate *et al*., 2013; Thabethe *et al.*, 2014; Tipre *et al.*, 2019, Weber *et al*., 2020). Moreover, women were found to be suffering from lung cancer, impaired vision and premature death due to pollutants from solid fuel (Munawer, 2018; Gibbs-Flournoy *et al.*, 2020; James *et al.*, 2020; Patel *et al.*, 2020; Ali *et al.*, 2021).

A study by Wernecke (2018) on ambient and indoor particulate matter concentrations in the Mpumalanga Highveld showed that there is poor air quality in KwaDela and KwaZamokuhle especially in winter months. The concentrations of particulate matter indoors were higher than particulate matter in the ambient environment. Although the risks associated with the consumption of solid fuel are high, households still rely on solid fuel for domestic purposes (Language *et al.*, 2016; Mgwambani *et al.*, 2018; Sole & Wagner, 2018).

Most households in developing countries do not know the health risks associated with the use of domestic solid fuel (Akintan *et al.*, 2018; Sole & Wagner, 2018; Tamire *et al.*, 2018; Sana *et al.*, 2020). Hence, this study also seeks to assess the knowledge of Ermelo residents on health risks associated with the use of domestic solid fuel.

CHAPTER 3: METHODOLOGY

This Chapter discusses the methodology and instruments used in this study.

3.1 Study Area

Ermelo is located in Msukaligwa Local Municipality in Gert Sibande District Municipality. Ermelo is one of the seven towns/units within Msukaligwa Local Municipality (Msukaligwa IDP, 2020). It is located at GPS coordinates $30^{0}00'24.09"$ East and $26^{0}32'24.56"$ South. Ermelo is surrounded by Bethal and Secunda to the west, Chrissiesmeer to the North East, Piet Retief to the South East, Standerton to the South West and Wakkestroom and Volksrust to the South (Figure 3.1). Ermelo can be accessed via N2 i.e., the South Eastern part of the area, N11 (the Southern and Northern parts of the area), N17 (the Western and North Eastern parts of the area) and R39 i.e., the South Western part of the area (Stats SA, 2018; Msukaligwa IDP, 2020).

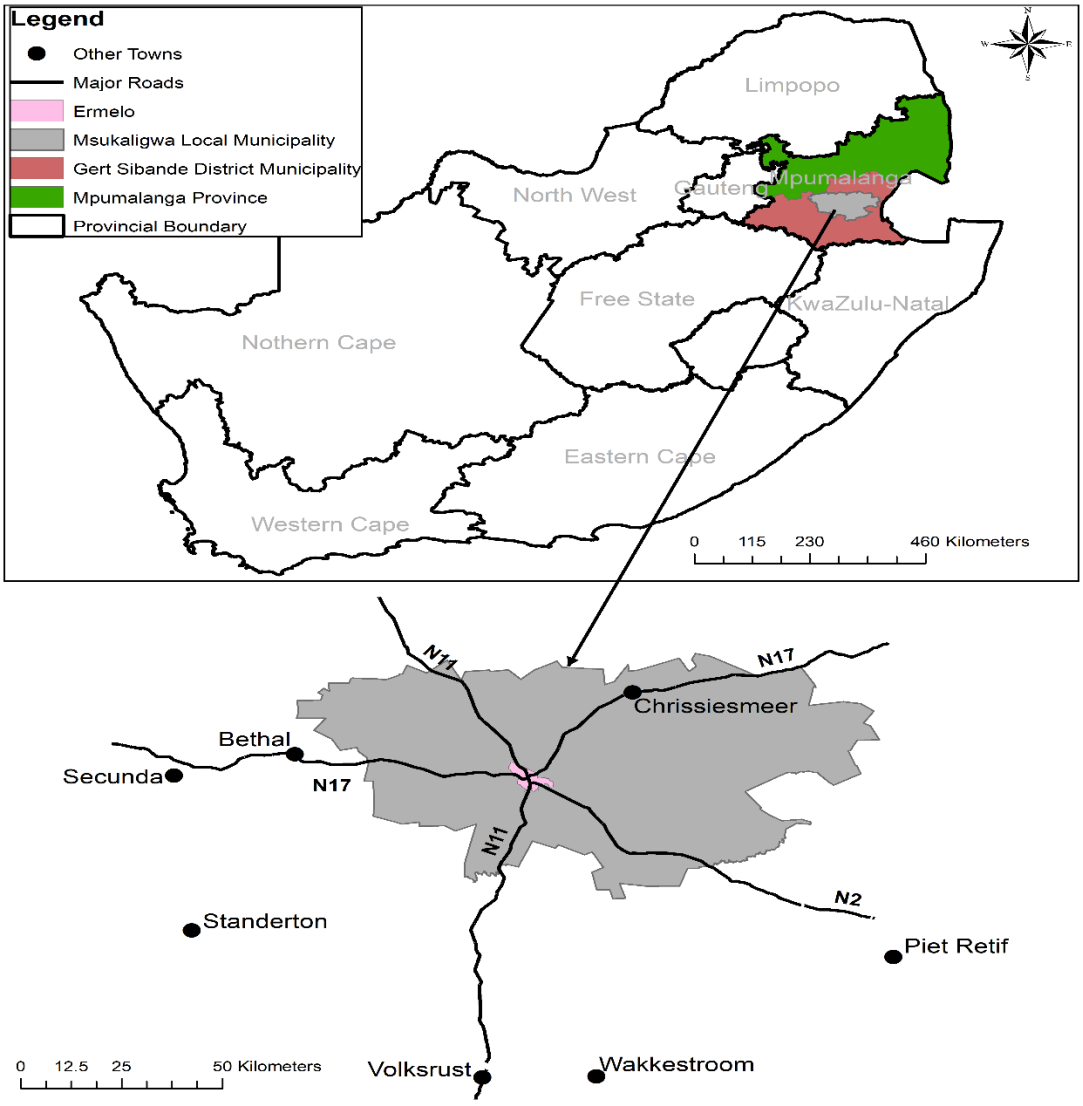

Figure 3. 1: A map showing the study area

*Source: (*Gert Sibande District Municipality GIS, 2021)

3.1.1 Population of the study area

Ermelo has a population of 96 219 and 31 286 households (Msukaligwa IDP, 2020). The population is predominantly Black Africans making 88.1% followed by Whites 9.9% and Coloured/Indians making 1.7%. IsiZulu and SiSwati are the two most dominant languages in this area (Municipal Demarcation Board, 2018).

3.1.2 Topography and Hydrology

The area is characterised by undulating hills with the steep Drakensberg escarpment on the Western side (Gert Sibande District Municipality Bioregional Plan, 2015). The area is also characterised by numerous marshy areas and a number of pans. The river flowing from Ermelo is Vaal-Suikerbosrand and it plays an important role by feeding into many dams within Gert Sibande District Municipality (Mpumalanga Biodiversity Sector Plan, 2014).

3.1.3 Geology and soils

The study area consists of rocks belonging to Karoo Supergroup (Msukaligwa SDF, 2019). It also consists of the Ermelo coal field rocks such as shales and Ecca Group rocks (Gert Sibande District Municipality Bioregional Plan, 2015).

3.1.4 Climate

In Ermelo the highest percentage of rain occurs during summer while in winter the rainfall is much less. In summer, temperature reaches the maximum of 26^0C and in winter the lowest temperature is around 10^0C. Frost is usually experienced in winter months (Msukaligwa SDF, 2019; Msukaligwa IDP, 2020).

3.1.5 Vegetation and Biodiversity

Ermelo is characterised by the Eastern Highveld Grassland (Mpumalanga Biodiversity Sector Plan, 2014). In terms of the Mpumalanga Biodiversity Sector Plan, Ermelo consists of a heavily modified area with less natural environment attributes due to human activities occurring in the area. (Msukaligwa SDF, 2019; Msukaligwa IDP, 2020).

3.1.6 Economic profile

In 2017, the leading employers were the business and mining sectors contributing 20.6% and 15.3% of employment respectively (Mpumalanga Department of Economic Development and Tourism, 2018). The unemployment rate in 2017 was 24.1% while poverty rate was 42.9%

(Mpumalanga Department of Economic Development and Tourism, 2018; Msukaligwa SDF, 2019).

3.2 Research Design

Research design consists of steps on how the researcher will collect and analyse the data (Pandey & Pandey, 2015). The research design that was used for this study included qualitative and quantitative research techniques. Quantitative research techniques was conducted through household survey. The survey approach measures what a person knows (knowledge or information), what a person thinks (attitudes and beliefs) as well as persons' characteristics by asking them questions and numbering their answers (Creswell, 2014). The researcher used household survey approach because this approach gave the researcher an understanding of Ermelo households' culture and lifestyle in using domestic solid fuel (Atanassov, 2010).

It was evident from the literature that some researchers have used random sampling to conduct their studies on factors influencing solid fuel use because random sampling is the simplest form of data collection and require less knowledge and experience in order to complete the research (Massawe *et al.*, 2015; Maurice *et al.*, 2015; Nyaga *et al.*, 2020). However, random sampling can also be time consuming and biased because the researcher must get a full list of the population for the specific area. In the context of Mpumalanga Province, South Africa, researchers have used household surveys to investigate fuel consumption and factors influencing fuel consumption in this province (Kasangana *et al.*, 2017; Nkosi *et al.*, 2017; Mgwambani *et al.*, 2018). This type of method can be used in large populations, households can be anonymous, it's inexpensive to administer, and inflow of data is quick and can be run online as well as on mobile devices (Leedy & Ormrod, 2015). According to Creswell and Creswell (2018), survey designs assist researchers to respond on descriptive questions, questions about the relationships between variables and questions about predictive relationships between variables over time. The advantages of using survey designs are that they are cheap, households can complete the questionnaire in their own time, the inflow of data is quick, and households' anonymity can be assured (Leedy & Ormrod, 2015) Hence, this study used survey method for data collection.

3.2.1 Research Tools

Research tools are the tools that guides the researcher on how to collect and analyse data for a specific study (Pandey & Pandey, 2015). Semi-structured questionnaire was used to collect data for this study.

3.2.1.1 Semi-structured questionnaires

A questionnaire is an organised set of questions that are prepared and distributed to a sampling population from which data is desired. Questionnaires depend on written information supplied by households (Pandey & Pandey, 2015). A semi structured questionnaire was used in this study. According to de Vos *et al.* (2005) a semi-structured questionnaire is a mix of unstructured and structured questions where some questions and their sequence are planned, whereas others are developed as the discussion proceeds. The semi-structured questionnaire that was used for this study included both closed and open-ended questions (Annexure 4). The use of both closed and open-ended questions allowed the researcher to ask questions that are not restricted and the participant to give more information that is not included in the questionnaire (de Vos *et al.*, 2005). A consent form (Annexure 3) was included in each questionnaire and four people were involved in the process of signing the consent form that is, the participant, witness for the participant, the researcher and witness for the researcher.

The household survey was conducted from March 2021 to April 2021. The questionnaires were distributed to 198 household heads within Ermelo, each questionnaire took 30 minutes to fill in and included seven sections that is:

- Section A: Respondent Details (gender, age, race and marital status)
- Section B: Type of fuel used for cooking, heating and lighting (electricity, coal and firewood, paraffin, liquefied petroleum gas and solar);
- Section C: Type of stove used (electric stove, coal and firewood stove, liquefied petroleum gas stove, paraffin stove, ethanol stove, Imbawula and three-legged pot fire stove);
- Section D: Socio-economic information of the household (household head, household size, education level, type of house, cost of energy);
- Section E: Socio-cultural information of the household (taste and preferences);
- Section F: Knowledge on health and environmental effects of solid fuel use; and
- Section G: Willingness to pay for clean/modern fuel.

During household survey the researcher adhered to safety measures (in terms of COVID-19 regulations). Social distance was kept between the participants and the researcher. The researcher was always wearing a face mask and frequently applied sanitising solution.

3.2.1.2 Participant observation

The focus of participant observation was to pay attention to the manner in which households use domestic solid fuel as opposed to what they say (De Vos *et al.*, 2005). The researcher as a participant observer wanted to observe, engage, record data on participants ongoing activities and behaviour.

3.2.1.3 Documentation

Documents such as newspapers, journals, academic books, government gazettes, government reports, and published and unpublished articles on factors influencing the use of domestic solid fuel were used for this study. These documents were analysed and integrated to the data obtained from questionnaires.

3.2.2 Sampling method and sampling size

Sampling is the process of selecting several participants from a selected population to represent the community in a study (Pandey & Pandey, 2015; Creswell & Creswell, 2018). Probability sampling was used for this study. Probability sampling is a method that provides the possibilities of a sample to represent the population and everyone in that population has an equal chance to be selected (Pandey & Pandey, 2015). There are different types of probability sampling and for this study systematic sampling was used. According to de Vos *et al.* (2005) systematic sampling involves the selection of every subject in the population based on a system of interval of every n^{th}, for example, every 5^{th}. In this study, the households were systemically selected in a numerical order of 1 in every 5^{th} household. Slovin's formula was used where the households were systematically sampled in a numerical order of 1 in every fifth household with 50% proportion of the total households. Ermelo has 31 286 households. The sample was obtained as follows:

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

Where:

n= sample size

N= household size

e= error tolerance (level)

At 95% level of confidence: p=0.05 precision

Therefore:

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

$$n = \frac{31286}{1 + 31286\ (0.05)^2}$$

$$n = \frac{31286}{1 + 78.215}$$

$$= 395\ households$$

Since households were systematically sampled in an interval of 1 in every fifth household then:

$$\frac{395}{100} \times 50$$

$$= 198\ households$$

A systematic sample of 1 in every 5th of the 395 households = 198. Therefore, the total questionnaires that were distributed to households were 198.

3.2.3 Data analysis

Data analysis involves ordering, organizing and interpreting raw data so that patterns, relationships, or trends can be extracted from it (Islam, 2020). Descriptive analysis was used to analyse data collected. Descriptive statistics summarise the overall trends or tendencies in the data collected, provide an understanding of how varied the scores might be and provide insight into where one score stands in comparison with the other (Creswell, 2012). Questionnaires were distributed to 198 households in Ermelo. The researcher made sure that all questionnaires were filled and those questionnaires that were incomplete were sent back to the households for amendments and/ or addition. Once all the questionnaires were completed, the researcher entered the data from the questionnaires into a Microsoft Excel spread. The data from Microsoft Excel was then coded, underwent quality control checks and then processed using the SPSS Statistics version 25. The data was mainly quantitative (nominal and categorical data). Therefore, the frequency menu was used to summarise the data and the cross-tabulation menu in the SPSS Statistics version 25 was used to evaluate the association between 2 categorical variables. Specifically, the Chi-square (χ^2) test was used to measure the degree of association between two categorical variables. If the p-value is less than 0.05, there is a significant association between variables i.e., the variables explain each other:

Chi-square (χ^2) is formulated as follows:

$$x^2 = \varepsilon \frac{(o - e)^2}{e}$$

The square of the difference between observed (o) and expected (e) values divided by the expected value. SPSS was selected for analysing data because it is easily operated, can accept data from almost any type of file and utilise the data to create reports in the form of tables, charts, plots of distributions and trends (Levesque & Balabanov, 2017). The results were reported in tables that summarise statistical information and figures that portray variables and their relationship. To ensure confirmability, the questionnaires used for data collection, data captured from the questionnaires and results from data analysis were submitted to the supervisor.

3.2.4 Data validity and reliability

According to Price *et al.* (2015) reliability refers to the consistency of a measure and validity is the extent to which the scores from a measure represent the variable they are intended to. A triangulation method was used for this study, where different sources of data were used for data collection to double check whether the data required for this study was available and valid and also to check for the consistency and inconsistence of the data collected. Creswell (2014) and Leedy and Ormrod (2015) stated that in triangulation, different sources of data are used during data collection to build a coherent reasoning that will support the theory. To ensure reliability preliminary pilot questionnaires were distributed to 10 households with the aim of assessing the feasibility of the approach to be used, the length of the questionnaire and its impact on the response rate as well as examining the need to amend the questionnaires to make sure that mistakes are identified early and corrected. After the pilot study, amendments were made in some sections of the questionnaire. To ensure validity of the study, the researcher designed and conducted the study in a way that confirms with literature and achieves the aim and objectives of the study. To ensure confirmability, the questionnaires used for data collection, data captured from the questionnaires and results from data analysis were submitted to the supervisor. Quantitative and qualitative data from semi-structured questionnaires were checked for data integrity, completeness and consistency before entry and subsequent analysis in SPSS.

3.2.5 Ethical Considerations

The researcher applied and obtained ethical clearance from University of South Africa (Annexure 6). The study was conducted in accordance with ethical and professional guidelines as set out by Ethics Committee of University of South Africa. A request from Msukaligwa Local Municipality to conduct a study in Ermelo was submitted to the Municipal Manager and the researcher received an approval letter form the Municipal Manager of Msukaligwa Local Municipality to go ahead with the study (Annexure 1). Permission was requested from

participants and the purpose and procedure of the study was explained to each participant (Annexure 2). A consent form was given to the participant before the commencement of the interview (Annexure 3). The participants were notified that the information from the study will be treated with strict confidentiality and anonymity. The participants were also notified that they can withdraw from the study anytime they feel uncomfortable and that it could not affect them in anyway. There were two versions of the same questionnaire where one was written in English (Annexure 4) and the other in iSiZulu (Annexure 5). This was meant to make sure that every participant understands the questions and fills the questionnaire based on the language he/she is comfortable with. The consent form was signed by four people (researcher, research's witness, participant and participants' witness).

3.2.6 Project limitations

The focus of the study is on the factors influencing solid fuel use in low-income settlements within Ermelo. It does not assess factors like indoor pollution associated with solid fuel use. Additionally, the study is limited to Ermelo low-income settlements and cannot be generalised to other townships.

CHAPTER 4: DATA PRESENTATION AND DISCUSSION

This Chapter provides the results of data analysis and key findings of the study.

4.1 Socio-economic characteristics of the sampled population

The following sub-sections discusses the socio-economic characteristics of the households in Ermelo.

4.1.1 Gender of household heads

Most of the interviewees were females accounting for 60% while males accounted for 40% of the sampled population (Figure 4.1). This could be as a result of the fact that females are responsible for cooking and are more involved in deciding and sourcing fuel for domestic purposes. These results are similar to the findings of the literature which showed that women are entrusted with performing domestic errands and are responsible for making decisions on fuel use (FAO & UNHCR, 2017; Nkosi *et al.*, 2017; Francioli, 2018).

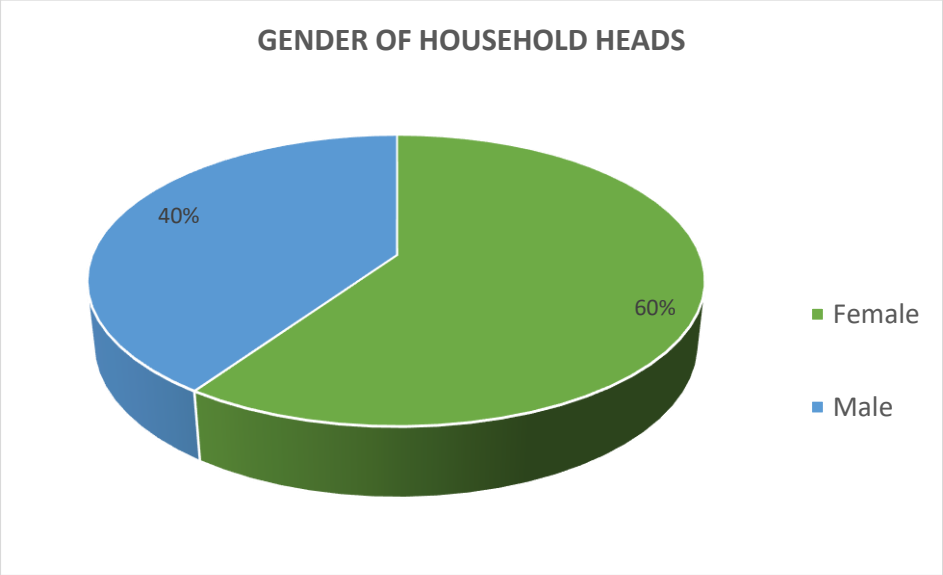

Figure 4. 1: Gender of household heads

4.1.2 Age of household heads

The households that were interviewed are headed by people of the age group between 36-59 years (49%) followed by the age group between 18-35 years and >60 years accounting for (40%) and (11%) respectively (Figure 4.2). It was found that as the heads of households get older, they tend to prefer using domestic solid fuel because they are resistant to change and some prefer domestic solid fuel because it makes food taste better. This was supported by Gatama (2014) and Semenya and Machete (2019) who found that households headed by older people prefer to utilise solid fuel unlike younger people who prefer modern energy.

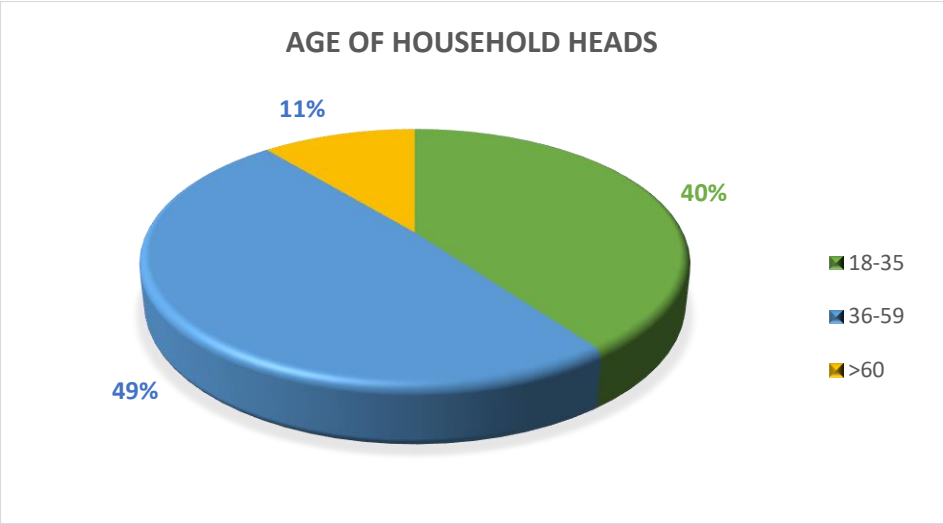

Figure 4. 2: Age of household heads

4.1.3 Marital Status

The study revealed that 73% of household heads are single (living without a partner or living with a partner but not married per se) followed by married household heads (21%). Widowed household heads and divorced household heads accounted for 5% and 1% of the sampled population respectively (Figure 4.3). This indicates that Ermelo households are headed mostly by single individuals. Household heads who are single are more likely to face socio-economic difficulties compared to household heads who are married. According to Khembi (2015) household heads who are married are likely to combine their income and share domestic expenses.

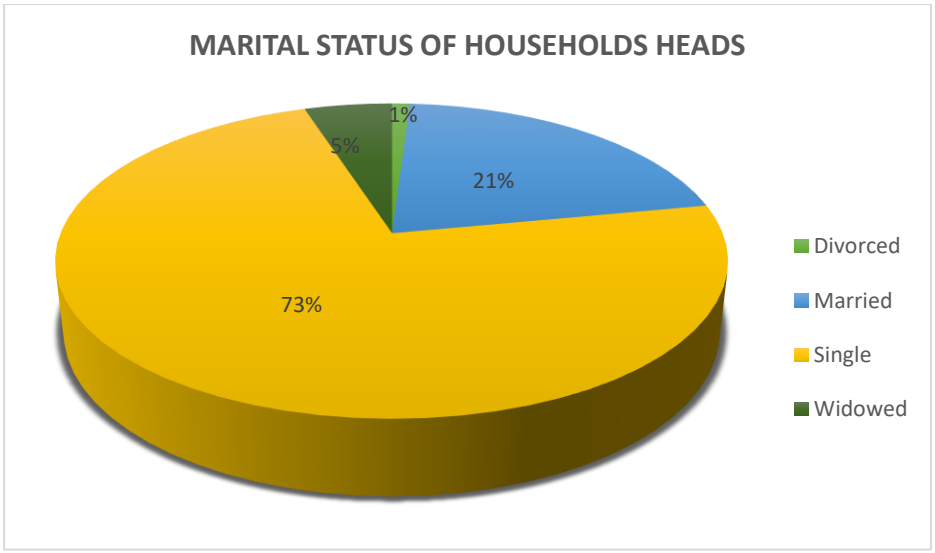

Figure 4. 3: Marital status of household heads

4.1.4 Level of education of household heads

The study found that 56.1% of household heads had secondary education followed by college education (25.1%), primary education (7.6%), university education (6.1%) and no schooling (5.1%) (Figure 4.4). Post matric qualifications are a minimum requirements for better employment opportunities with higher income and better benefits. A higher level of education does not only provide better employment opportunities but also allows household heads to be able to afford modern energy like electricity and be well-informed on the impacts of solid fuel on their health and environment (Ateba *et al.*, 2018). Household heads with post matric qualifications believe in conserving the environment and protecting their own health and thus prefer to use electricity, while household heads with no post matric qualifications prefer to use solid fuel (Uhunamure *et al.*, 2017).

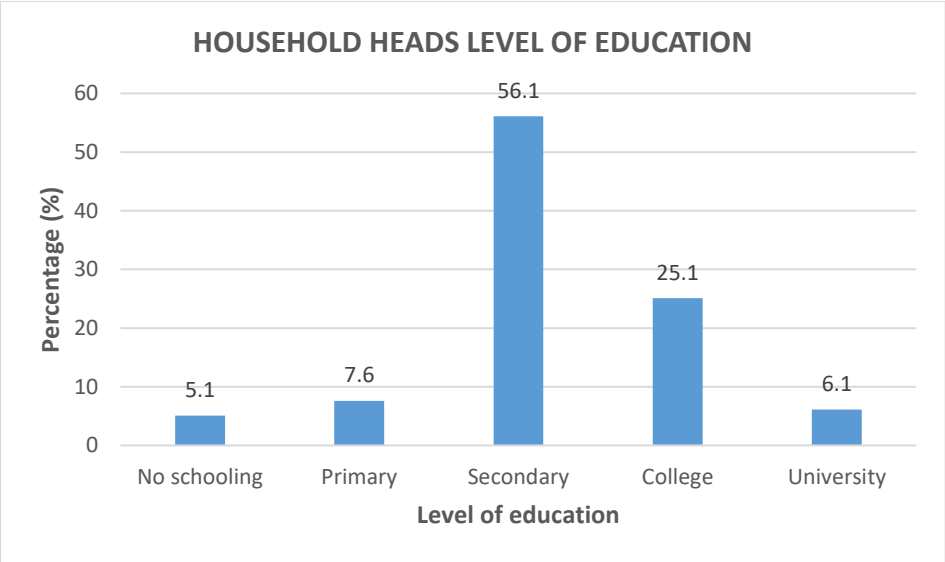

Figure 4. 4: Level of education of household heads

4.1.5 Number of employed household members

The study found that 44.9% of households have only one member of the family who is employed followed by households with all members being unemployed (35.4%), families with two members who are employed accounting for (16.2%) and families with more than two members who are employed accounting for 3.5% (Figure 4.5). It was found that households with employed members are able to afford modern energy because they share responsibilities and expenses within the household while those without employed members choose to rely on solid fuel because they do not share responsibilities and expenses. Members of households that are employed are well educated thus prefer to use cleaner energy as compare to the members that are not employed.

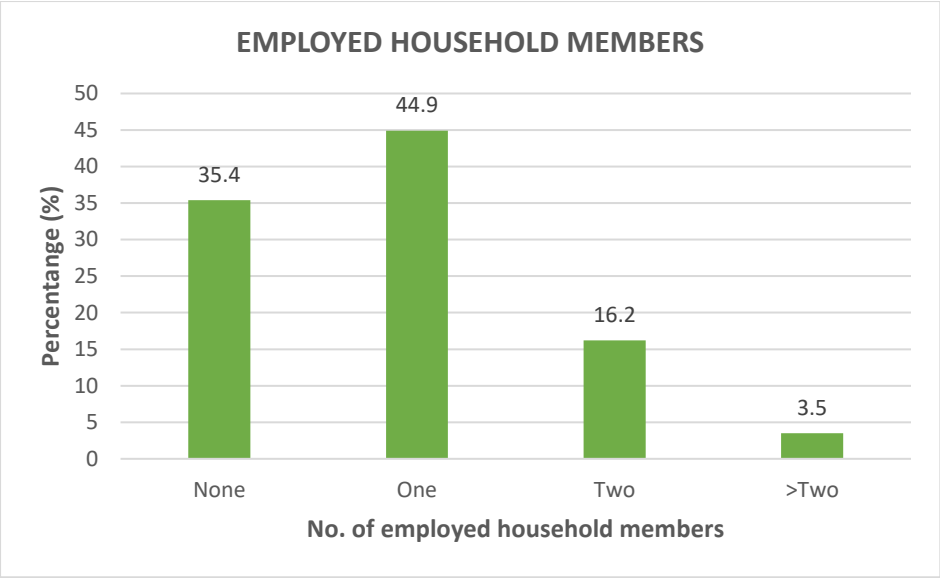

Figure 4. 5: Number of employed household members

4.1.6 Monthly income

The results in Figure 4.6 showed that 49% of household heads earn between R1001-R5000 followed by those earning between R5001-R10000 (21.2%) and those earning between R501-R1000 (16.2%). In addition, 6.6% earn between R10001-R15000, 6.5% earn less than R500 and 0.5% earn between R15001-R20000.

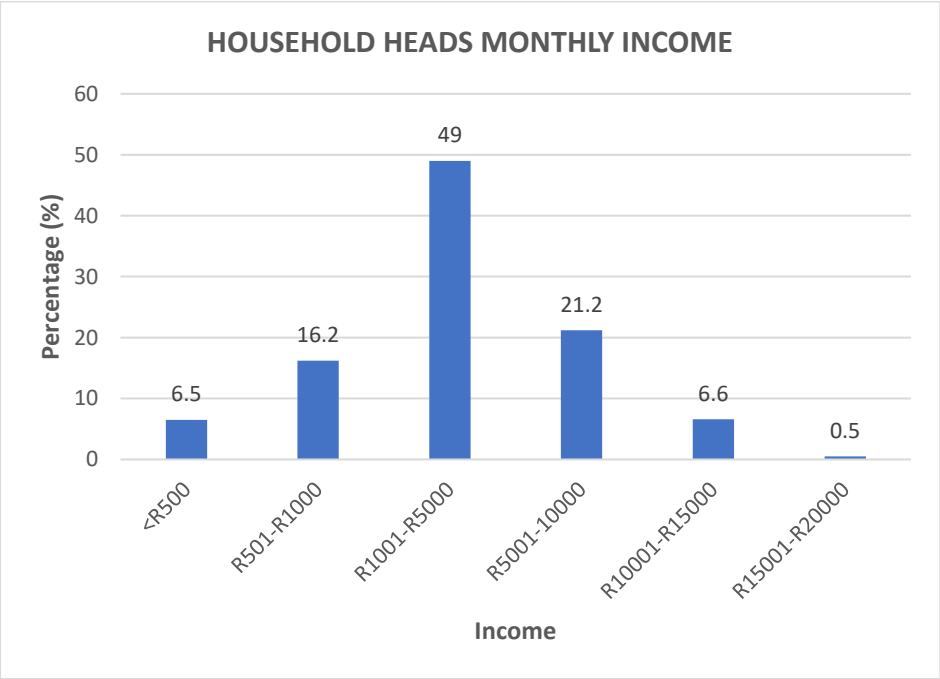

Figure 4. 6: Monthly income of household heads

Most households in Ermelo were found to be recipients of the social grants. It was also found that households with high income use modern energy like electricity because they can afford it whilst households with low income use solid fuel because of limited financial resources. These findings are similar to the findings of Mensah and Adu (2013), who found that household income influences a household's decision to utilise modern energy and lowers the possibility of utilising solid fuel.

4.2 Characterising the community energy matrix

The following sub-sections discuss the energy matrix of Ermelo households.

4.2.1 Access to electricity

Results showed that 83% of households have access to electricity while 17% do not have access to electricity (Figure 4.7). Households indicated that even though they have access to electricity due to affordability and load shedding they end up using solid fuel for domestic purposes. These findings are consistent with the findings of earlier studies, for example, Kasangana *et al.* (2017); Makonese *et al.* (2018) and Nkosi *et al.* (2018) who found that access to electricity does not mean an automatic change to the use of modern energy in low-income settlements.

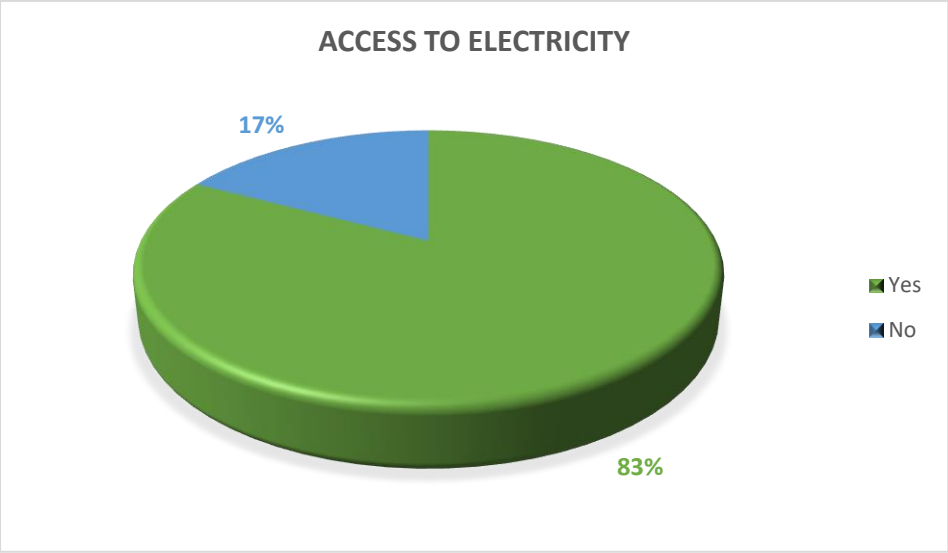

Figure 4. 7: Number of households with access to electricity

4.2.2 Main source of energy

The study found that 59.1% of households use electricity as their main source of energy followed by 36.9% who use firewood and coal, 2.5% who use paraffin and 1.5% who use LPG as their main source of energy (Figure 4.8). It was observed that some of households harvest fuelwood in their own yards and in the forest whereby they wait for the fuelwood to dry up before using it for domestic purposes while coal is purchased from neighbouring households at a price of R100 per 50kg.

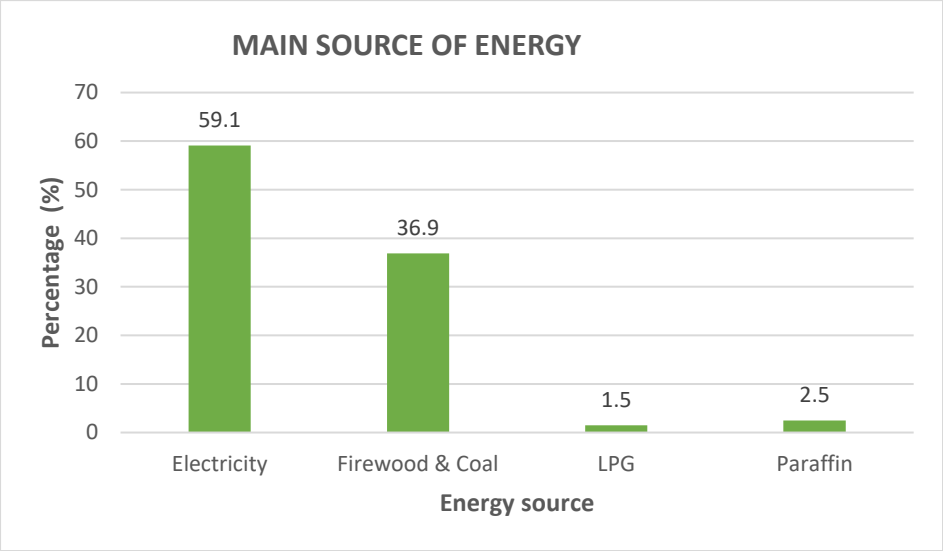

Figure 4. 8: Main source of energy for households

4.2.3 Reasons for preference of the main source of energy

Various reasons have been cited for preferring an energy source. These include affordability, convenience, cultural beliefs, easy access, pot preferences, taste of food, type of food, type of house and safety (Figure 4.9). Most households preferred electricity because it is accessible to them while others preferred firewood and coal because of it is cheap compare to electricity. Very few households preferred LPG and paraffin because of affordability. It was also observed that some households prefers firewood or coal as they only spend R100 for a 50kg of firewood or coal which last them approximately three weeks, while R100 electricity only last them one week.

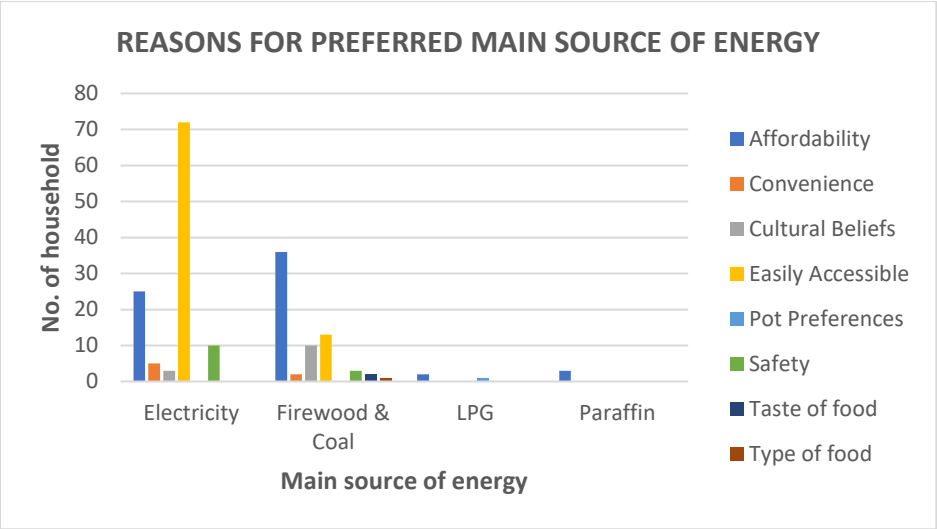

Figure 4. 9: Reasons for preferred main source of energy

4.2.4 Type of energy for cooking

The study found that 53.5% of households prefer electricity for cooking followed by 42.9% who prefer firewood and coal, 2% who prefer paraffin and 1.5% who prefer LPG (Figure 4.10). This is contrary to earlier studies which found that households in low-income settlements prefer solid fuel for cooking.

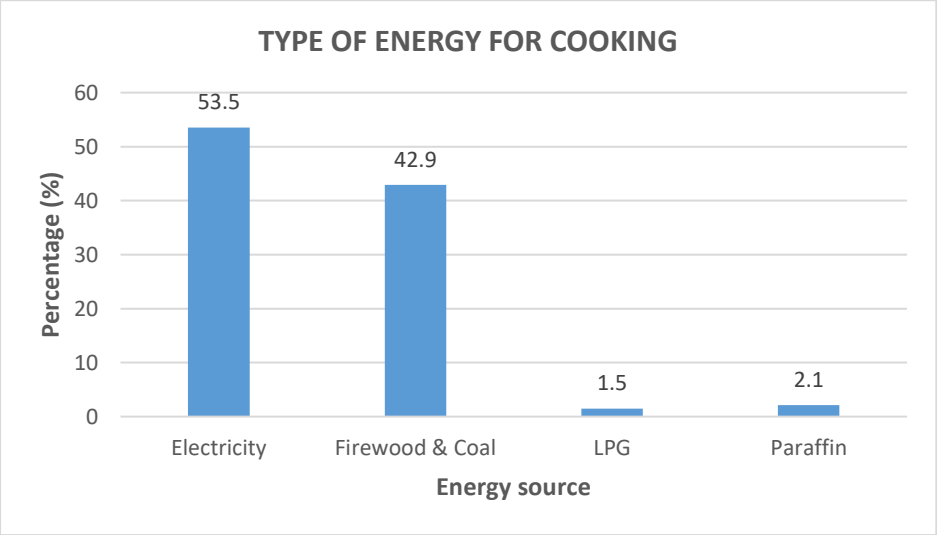

Figure 4. 10: Type of energy used for cooking

4.2.5 Type of stove used for cooking

The study found that 52% of households use electric stoves for cooking followed by 44.4% who use firewood and coal stoves then 2%, 1% and 0.5% of the households who use gas stoves, paraffin stoves and Imbawula respectively (Figure 4.11).

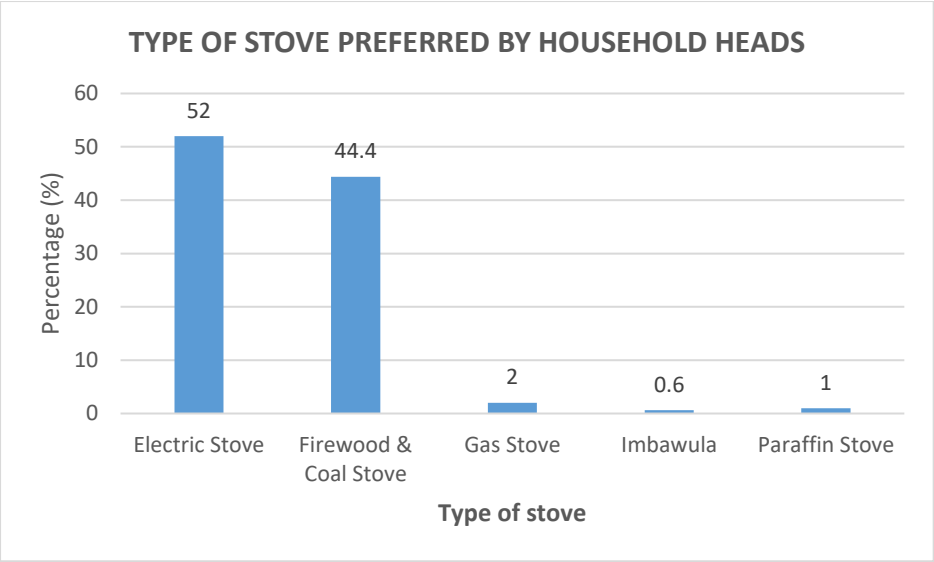

Figure 4. 11: Type of stove preferred by household heads

4.2.6 Type of energy used for heating

The study found that 63.6% of households use firewood and coal for heating followed by electricity (26.8%), LPG (4%) and blankets (3.6%) (Figure 4.12). During data collection it was observed that Ermelo have a large number of coal mines and for the households within Ermelo coal is cheap and easily accessible them. The results agree with literature which found that households prefer to use solid fuel for heating because it lasts long and is cheap compare to electricity (Rhodes *et al.*, 2014; Smith *et al.*, 2014; Gubler, 2017; Semenya & Machete, 2019; IEA, 2020).

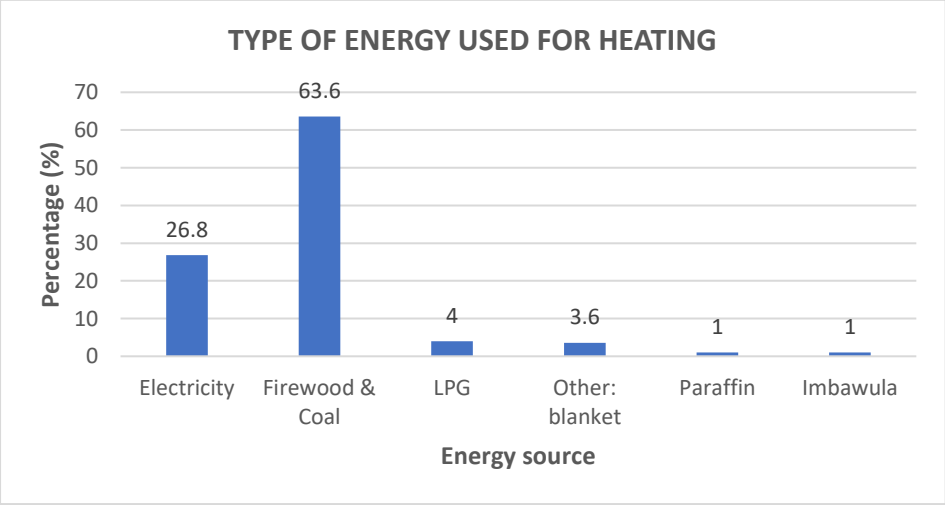

Figure 4. 12: Type of used energy for heating

4.2.7 Reasons for the preferred energy for heating

The results showed that most of the households prefer to use firewood and coal for heating because of its affordability. This was followed by electricity because of its accessibility then Imbawula and LPG because of their affordability (Figure 4.13). Mostly firewood and coal are used for heating. There is a strong association between the type of energy used for heating and the reason why the energy source is used for heating ($X^2 = 84.123$, $p = 0.0$). This is consistent to earlier studies that found that households use solid fuel for heating because of its affordability (Nkosi *et al.*, 2017; Makonese *et al.*, 2018; Semenya & Machete, 2019).

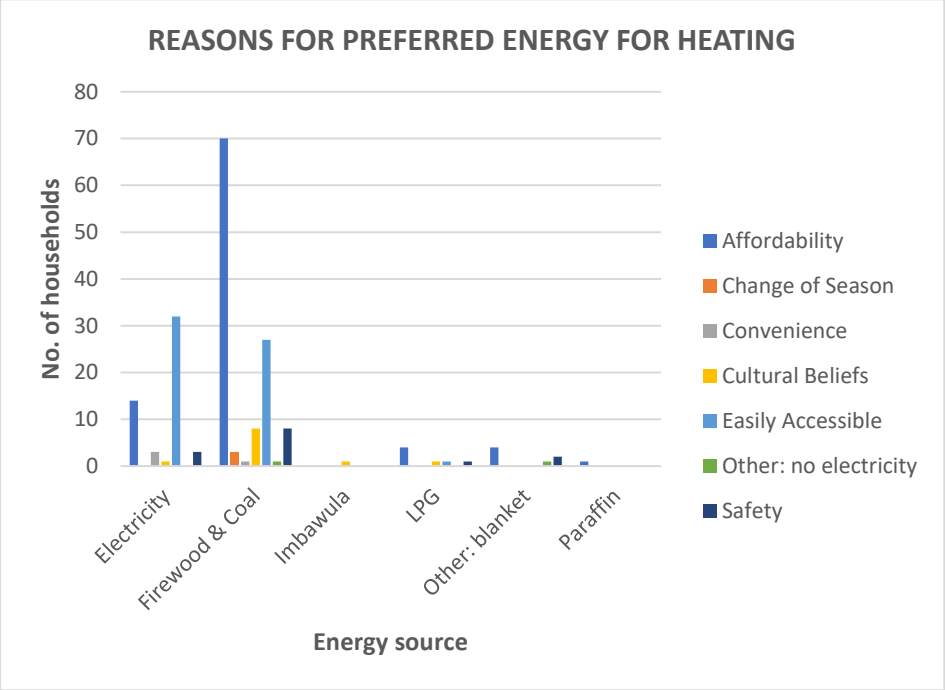

Figure 4. 13: Reasons for preferred energy for heating

4.2.8 Type of energy used for lighting

The study found that 81.3% of the households use electricity for lighting followed by candles (14.1%) which are used mostly by people without electricity (Figure 4.14). In electrified households, candles are used due to load shedding or where households cannot afford to buy electricity.

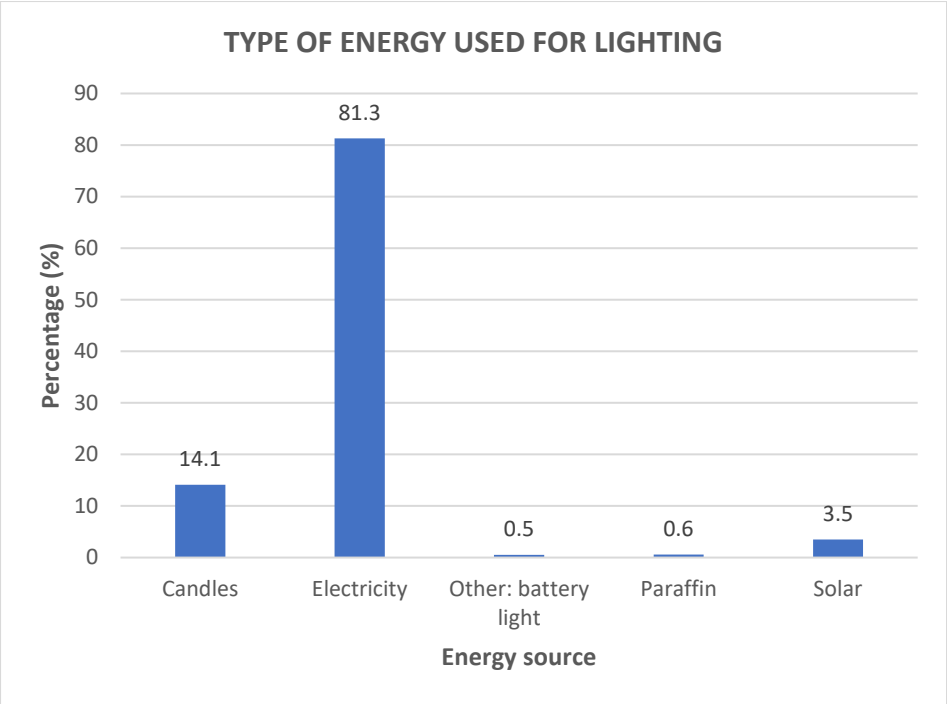

Figure 4. 14: Type of used energy used for lighting

4.2.9 Reasons for the preferred energy for lighting

The results showed that households use electricity for lighting because it is accessible to them with 83% of households having access to electricity. Electricity is also preferred as a source of lighting because according to the respondents it is safe compared to candles and paraffin. (Figure 4.15). The reason why electricity is preferred for its safety is because other energy sources like candles have resulted cases of accidental fires. These fires sometimes lead to injury, death or even burning the house down. Other reasons for households to use electricity are affordability and convenience.

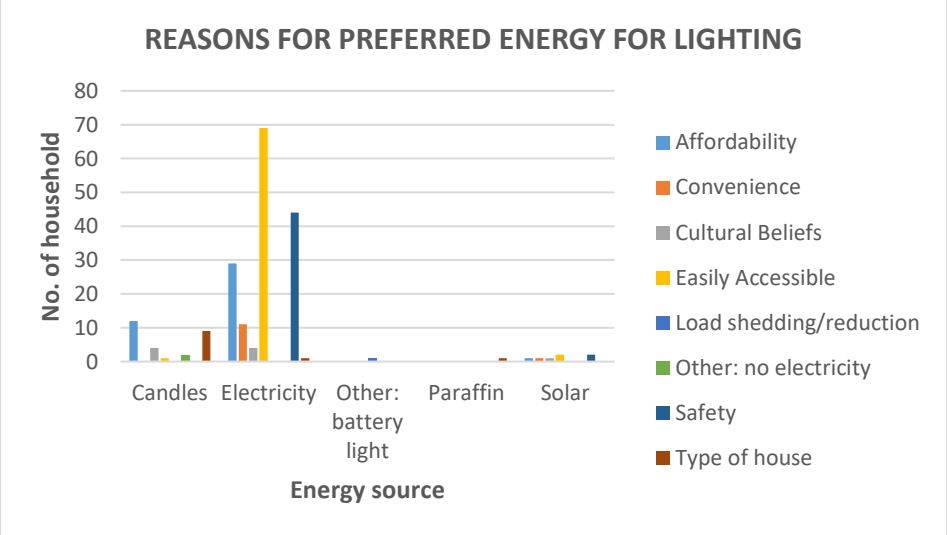

Figure 4. 15: Reasons for preferred energy for lighting

4.2.10 Energy payment responsibility

The study found that the fathers are mainly responsible for energy payments in households accounting for 43.9% followed by mothers who account for 41.4% and older siblings who account for 6.6% (Figure 4.16). The results show that the energy payment responsibility mostly lies with fathers and mothers as they are the heads of households. In some households, grandmothers (5.6%) and grandfathers (2%) were found to be responsible for energy payment as they were sole breadwinners and heads of these households.

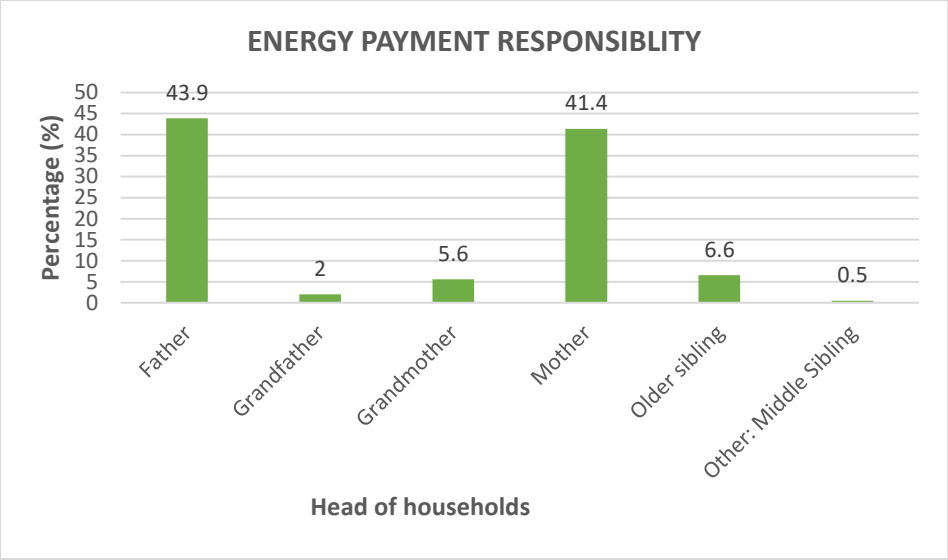

Figure 4. 16: Energy payment responsibility

4.2.11 Impact of energy used on the taste of food

The study found that 53% of the households believe that the type of energy used does not influence the taste of food while 47% believe that the type of energy used influences the taste of food (Figure 4.17). Households indicated that traditional food like pap, samp and *mugodu* (tripe) are usually cooked using solid fuel because they taste better when cooked with solid fuel compared to modern energy.

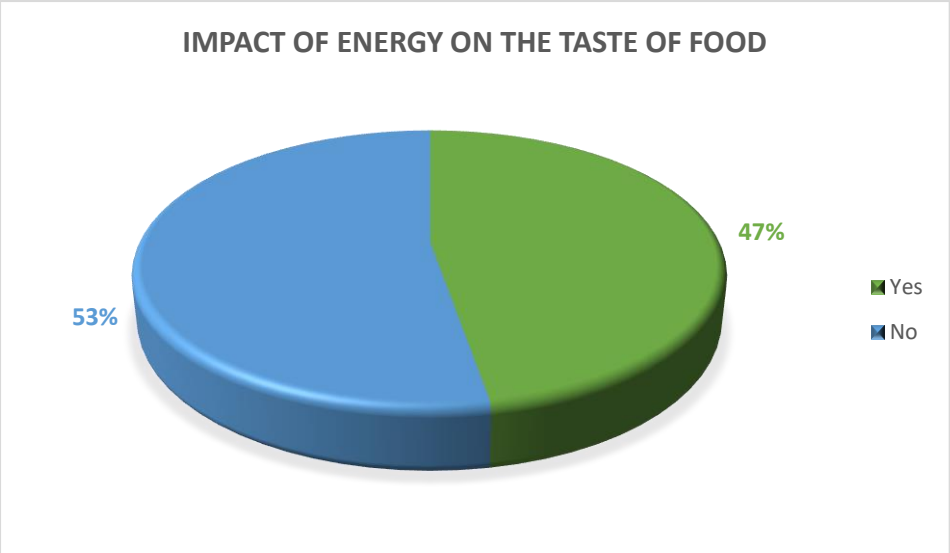

Figure 4. 17: The impact of energy on the taste of food

4.3 An evaluation of factors influencing the community energy matrix

The following sub-sections discuss the findings on factors influencing energy use in Ermelo. The Chi-square (χ^2) test was used to measure the degree of association between two categorical variables through cross-tabulation. If the p-value is less than 0.05, there is a significant association between the variables under consideration, i.e., the variables explain each other.

4.3.1 Age group and main source of energy

A Chi-square test was done between age group and main source of energy used by households to determine the relationship between these variables (Table 4.1).

Table 4. 1: Relationship between age group and main source of energy

		Age group			Total	p-value
		18-35	36-59	60+		
Main source of energy	Electricity	47	56	14	117	0.929
	Firewood & Coal	28	37	8	73	
	LPG	2	1	0	3	
	Paraffin	2	3	0	5	
Total		79	97	22	198	

The results showed that there is no statistically significant association between age group and main source of energy used by households in Ermelo (Chi-square = 1.899, p = 0.929). $p > 0.05$

meaning the p-value is higher than the significance level. Therefore, the age group of household heads in Ermelo cannot explain the main source of energy used and does not influence the source of energy used by Ermelo households (Figure 4.18).

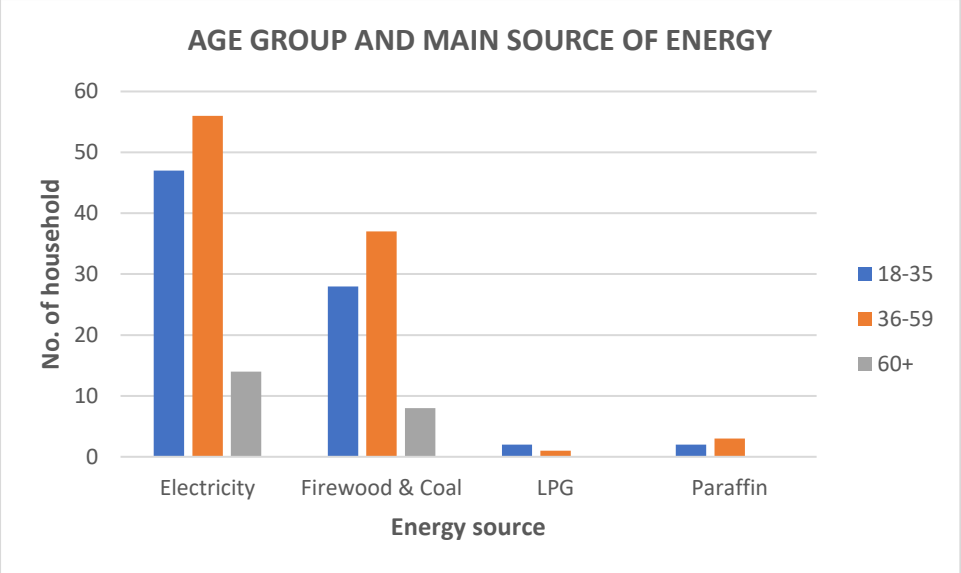

Figure 4. 18: Relationship between age group and main source of energy

4.3.2 Gender and main source of energy

A Chi-square test was done between gender and the main source of energy used by households to determine the relationship between them (Table 4.2).

Table 4. 2: Relationship between gender category and source of energy

		Gender		Total	p-value
		Female	Male		
Main source of energy	Electricity	66	51	117	0.074
	Firewood & Coal	48	25	73	
	LPG	3	0	3	
	Paraffin	1	4	5	
Total		118	80	198	

The results showed that there is no statistically significant association between gender and main source of energy used by households in Ermelo (Chi-square = 6.932, p = 0.074). p > 0.05 meaning the p-value is higher than the significance level. Therefore, the gender of households head in Ermelo cannot explain the source of energy used and does not influence the source of energy used by Ermelo households (Figure 4.19).

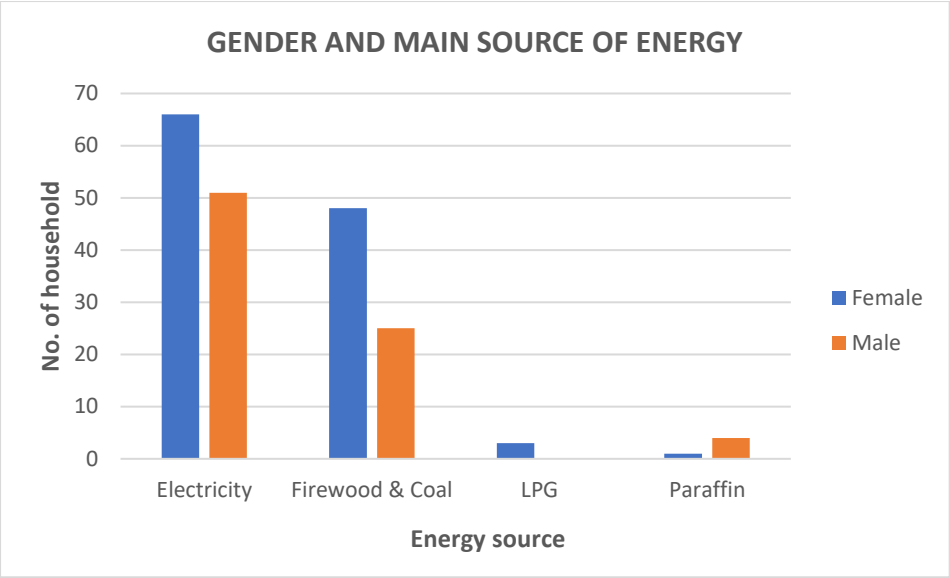

Figure 4. 19: Relationship between gender and main source of energy

4.3.3 Marital status and main source of energy

A Chi-square test was done to determine the relationship between the marital status and main source of energy used by Ermelo households (Table 4.3).

Table 4. 3: Relationship between marital status and source of energy

		Marital Status				Total	p-value
		Divorced	Married	Single	Widowed		
Main source of energy	Electricity	1	31	81	4	117	0.423
	Firewood & Coal	0	9	59	5	73	
	LPG	0	1	2	0	3	
	Paraffin	0	0	5	0	5	
Total		1	41	147	9	198	

The results showed that there is no statistically significant association between marital status and main source of energy used by households in Ermelo (Chi-square = 9.161, p = 0.423). p > 0.05 meaning the p-value is higher than the significance level. Therefore, the marital status cannot explain the source of energy used and does not influence the source of energy used by Ermelo households (Figure 4.20). The study revealed that households headed by married

couple are less likely to use solid fuel as they may share income and be able to afford modern energy and also share expenditure responsibilities.

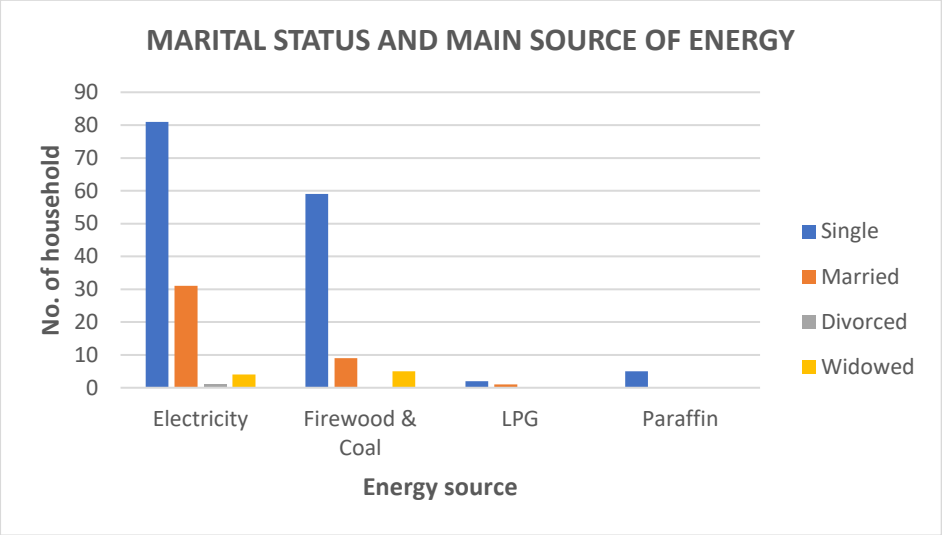

Figure 4. 20: Relationship between marital status and main source of energy

4.3.4 Household heads level of education and main source of energy

A Chi-square test was done to determine the relationship between household heads level of education and main source of energy used by households in Ermelo (Table 4.4).

Table 4. 4: Relationship between household heads level of education and source of energy

		Household heads level of education					Total	p-value
		University	College	Secondary	Primary	No schooling		
Main source of energy	Electricity	7	41	58	8	3	117	0.04
	Firewood & Coal	5	9	45	7	7	73	
	LPG	0	0	3	0	0	3	
	Paraffin	0	0	5	0	0	5	
Total		12	50	111	15	10	198	

The results showed that there is a statistically significant association between household heads level of education and main source of energy used by households in Ermelo (Chi-square = 21.784, $p = 0.04$). $p < 0.05$ meaning the p-value is less than the significance level. Therefore, the level of education can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.21). This is attributed mainly to affordability. Post matric qualifications are a minimum requirements for better employment opportunities with higher income and better benefits. A higher level of education does not only provide better

employment opportunities but also allows household heads to be able to afford modern energy like electricity and be well-informed on the impacts of solid fuel on their health and environment (Ateba *et al.*, 2018). Household heads with post matric qualifications believe in conserving the environment and protecting their own health and thus prefer to use electricity, while household heads with no post matric qualifications prefer to use solid fuel (Uhunamure *et al.*, 2017).

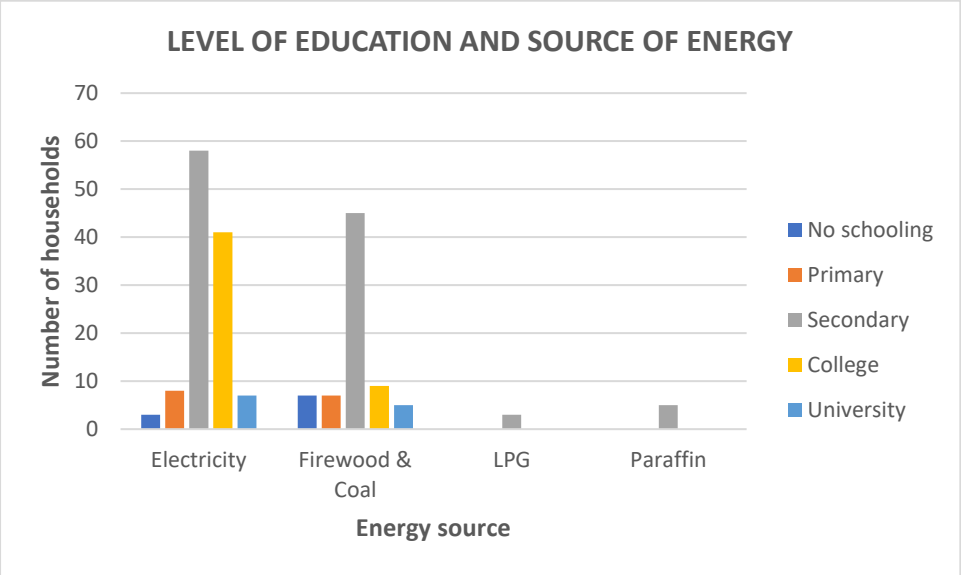

Figure 4. 21: Relationship between household heads level of education and main source of energy

4.3.5 Number of employed household members and main source of energy

A Chi-square test was done to determine the relationship between the number of employed household members and main source of energy used by Ermelo households (Table 4.5).

Table 4. 5: Relationship between numbers of employed household members and source of energy

		Number of employed household members				Total	p-value
		>Two	None	One	Two		
Main source of energy	Electricity	5	28	63	21	117	0.0007
	Firewood & Coal	2	35	25	11	73	
	LPG	0	2	1	0	3	
	Paraffin	0	5	0	0	5	
Total		7	70	89	32	198	

The results showed that there is a statistically significant association between number of employed household members and main source of energy used by households in Ermelo (Chi-square = 22.764, p = 0.0007). p< 0.05 meaning the p-value is less than the significance level. Therefore, the number of employed household members can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.22). It was found that households with employed members are able to afford modern energy because they share responsibilities and expenses within the household while those without employed members choose to rely on solid fuel because they do not share responsibilities and expenses. Members of households that are employed are well educated thus prefer to use cleaner energy as compare to the members that are not employed.

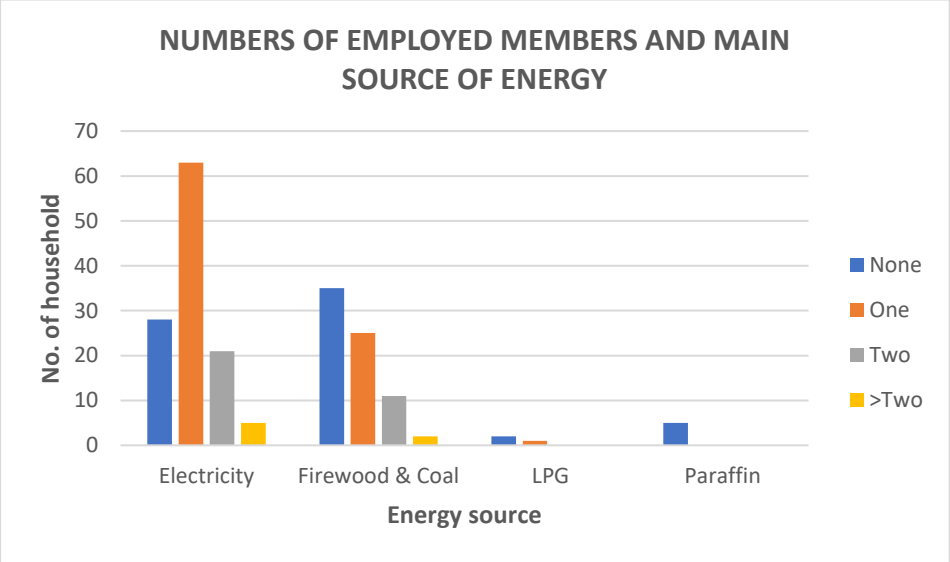

Figure 4. 22: Relationship between numbers of employed household members and main source of energy

4.3.6 Size of household members and main source of energy

A Chi-square test was done to determine the relationship between the size of household members and main source of energy used by Ermelo (Table 4.6).

Table 4. 6: Relationship between size of household members and main source of energy

		Size of household members						Total	p-value
		>Five	Five	Four	One	Three	Two		
Main source of energy	Electricity	23	18	24	6	27	19	117	0.011
	Firewood & Coal	23	16	15	5	10	4	73	
	LPG	0	0	1	0	0	2	3	
	Paraffin	0	0	0	0	2	3	5	
Total		46	34	40	11	39	28	198	

The results showed that there is a statistically significant association between size of household members and main source of energy used by households in Ermelo (Chi-square = 30.356, p = 0.011). $p < 0.05$ meaning the p-value is less than the significance level. Therefore, household size can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.23). The results indicate that households with more members can combine income and be able to afford modern energy, while small households tend to use solid fuel because of few people having income. The study agrees with the findings by Thomas *et al.* (2015) and Danlami (2019) that found that household size is one of the factors influencing solid fuel use in households.

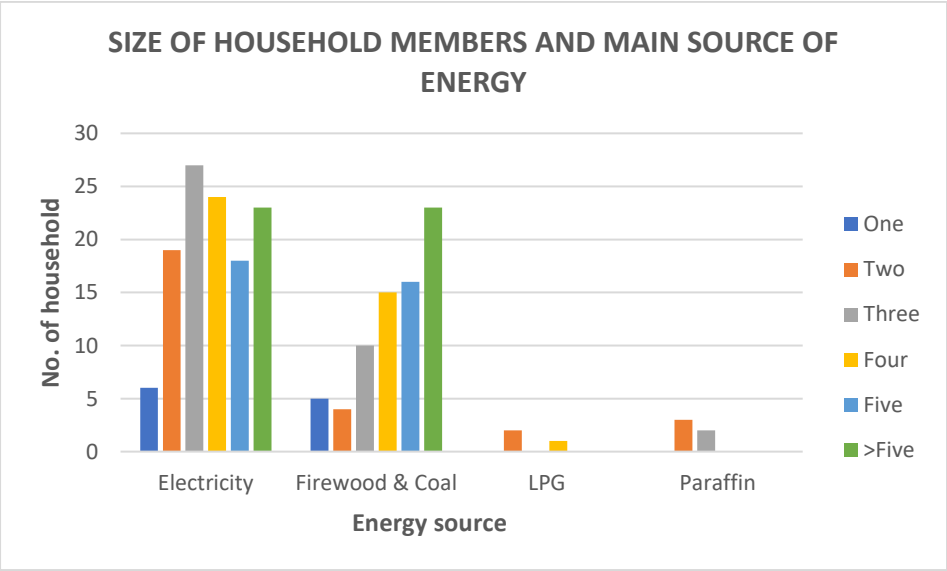

Figure 4. 23: Relationship between size of household members and main source of energy

4.3.7 Household income and main source of energy

A Chi-square test was done to determine the relationship between household income and main source of energy used by households in Ermelo (Table 4.7).

Table 4. 7: Relationship between household income and main source of energy

		Household Income						Total	p-value
		<R500	R10001-15000	R1001-5000	R15001-20000	R5001-10000	R501-1000		
Main source of energy	Electricity	2	13	51	0	40	11	117	0.000
	Firewood & Coal	10	0	44	1	2	16	73	
	LPG	0	0	1	0	0	2	3	
	Paraffin	1	0	1	0	0	3	5	
Total		13	13	97	1	42	32	198	

The results showed that there is a statistically significant association between household income and main source of energy used by households in Ermelo (Chi-square = 63.957, p = 0.000). $p < 0.05$ meaning the p-value is less than the significance level. Therefore, household income can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.24). The study indicates that households with high income (earning between R10001-R20000) and middle income earners (R1001-R10000) prefer to use electricity followed by firewood and coal. High and middle income earners are associated with the use of modern energy, while low-income earners (earning <R500-R1000) are associated with the use of solid fuel because they cannot afford modern energy such as electricity due to low-income in their households. Most low-income earners were found to be receiving grants and pensions from government. These findings agree with earlier studies which found that household income influences the consumption of solid fuel in households (Uhunamure *et al.*, 2017; Wernecke, 2018; Manirafasha, 2020; IEA, 2020).

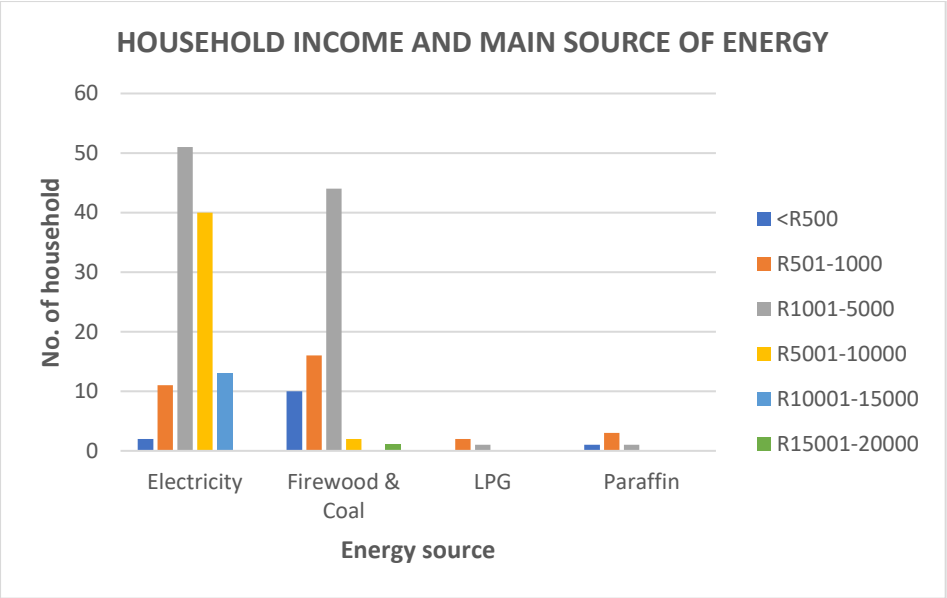

Figure 4. 24: Relationship between household income and main source of energy

4.3.8 Occupation and main source of energy

A Chi-square test was done to determine the relationship between occupation and main source of energy used by Ermelo households (Table 4.8).

Table 4. 8: Relationship between occupation and main source of energy

		Occupation							Total	p-value
		Managerial	Not working	Partially Skilled	Professional	Self-employed	Skilled	Unskilled		
Main source of energy	Electricity	7	26	3	24	14	29	14	117	0.001
	Firewood & Coal	0	34	0	0	8	18	13	73	
	LPG	0	2	0	0	0	1	0	3	
	Paraffin	0	5	0	0	0	0	0	5	
Total		7	67	3	24	22	48	27	198	

The results showed that there is a statistically significant association between occupation and main source of energy used by households in Ermelo (Chi-square = 43.691, p = 0.001). $p < 0.05$ meaning the p-value is less than the significance level. Therefore, occupation can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.25). The study indicates that people who are professional and working tend to have higher levels of income, thus can afford modern energy in their households. Whilst those

household heads who are not working or unskilled have low income resulting in the higher usage of solid fuel which is cheap and easily available to them as they harvest it from the forest or their backyards or buy them at a less from the neighbouring business.

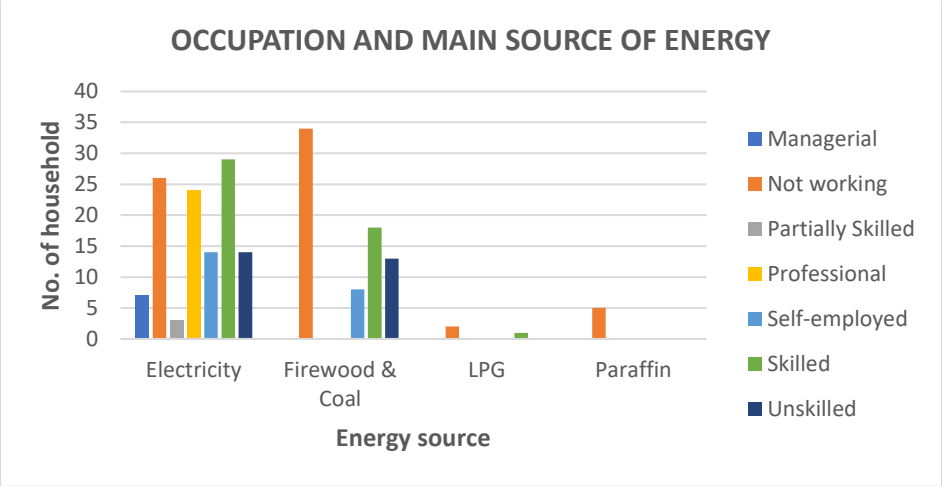

Figure 4. 25: Relationship between occupation and main source of energy

4.3.9 Household head and main source of energy

A Chi-square test was done to determine the relationship between household head and main source of energy used by Ermelo households (Table 4.9).

Table 4. 9: Relationship between household head and source of energy

		Household head						Total	p-value
		Father	Grand father	Grand mother	Mother	Older sibling	Other: Middle Sibling		
Main source of energy	Electricity	61	3	4	45	4	0	117	0.552
	Firewood & Coal	25	2	9	31	5	1	73	
	LPG	1	0	0	2	0	0	3	
	Paraffin	3	0	0	2	0	0	5	
Total		90	5	13	80	9	1	198	

The results showed that there is no statistically significant association between household head and main source of energy used by household in Ermelo (Chi-square = 13.649, p = 0.552). p > 0.05 meaning the p-value is higher than the significance level (Figure 4.26). Therefore, the household head categories cannot explain the source of energy used and do not influence the source of energy used by Ermelo households.

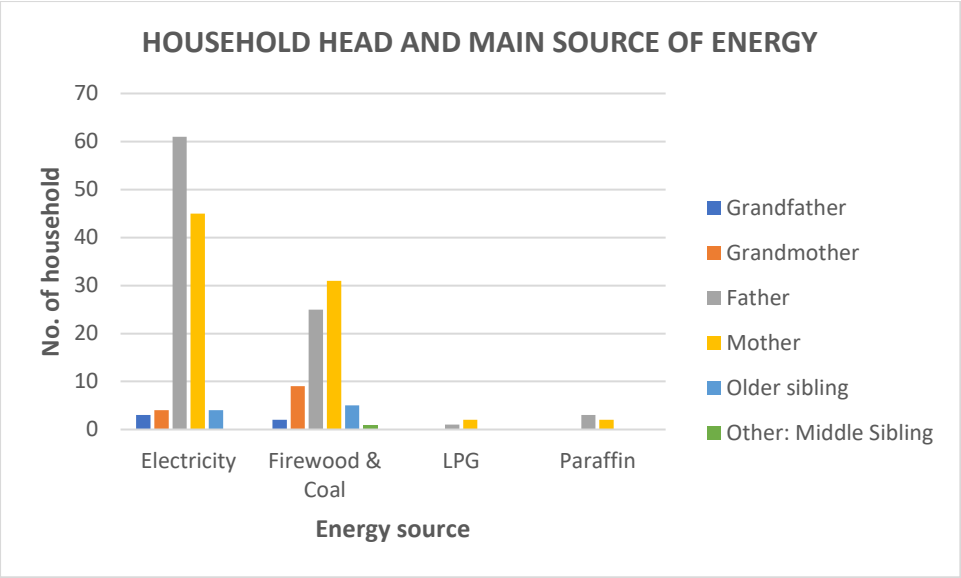

Figure 4. 26: Relationship between household head and main source of energy

4.3.10 Type of house and main source of energy

A Chi-square test was done to determine the relationship between type of house and main source of energy used by Ermelo households (Table 4.10).

Table 4. 10: Relationship between type of house and main source of energy

		Type of house			Total	p-value
		High Class	Low Class	Middle Class		
Main source of energy	Electricity	1	26	90	117	0.000
	Firewood & Coal	1	53	19	73	
	LPG	0	3	0	3	
	Paraffin	0	5	0	5	
Total		2	87	109	198	

The results showed that there is a statistically significant association between type of house and main source of energy used by households in Ermelo (Chi-square = 57.874, p = 0.000). $p < 0.05$ meaning the p-values is less than the significant level. Therefore, the type of house can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.27). The findings imply that households with high class houses (5 bedroom house or more) and medium class houses (3 to 4 bedroom house) tend to use modern energy because they have high income level and can afford modern energy. While those leaving in low class houses (shacks and RDPs) tend to use solid fuel because some of them do not work

and cannot afford modern energy and as a result use solid fuel which readily available and cheap compare to modern energy.

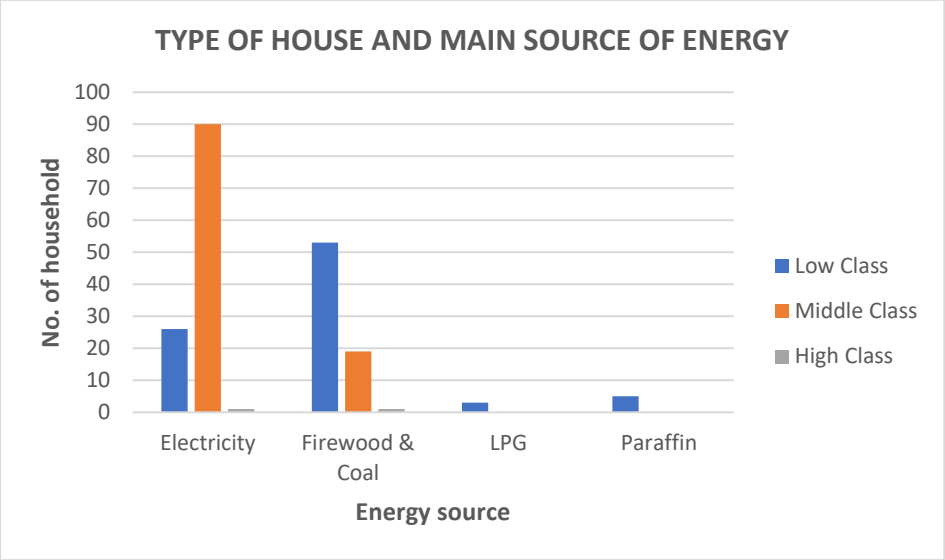

Figure 4. 27: Relationship between type of house and main source of energy

4.3.11 Number of children under 5 years in a household and main source of energy

A Chi-square test was done to determine the relationship between number of children under 5 years in a household and source of energy used by households in Ermelo (Table 4.11).

Table 4. 11: Relationship between number of children under 5 years in a household and main source of energy

		Number of children under 5 years in a household							Total	p-value
		>Five	Five	Four	None	One	Three	Two		
Main source of energy	Electricity	3	2	1	51	35	5	20	117	0.978
	Firewood & Coal	1	0	1	30	23	4	14	73	
	LPG	0	0	0	3	0	0	0	3	
	Paraffin	0	0	0	2	1	0	2	5	
Total		4	2	2	86	59	9	36	198	

The results showed that there is no statistically significant association between number of children under 5 years in a household and main source of energy used by households in Ermelo (Chi-square = 8.009, p = 0.978). p > 0.05 meaning the p-value is higher than the significance level. Therefore, the number of children under 5 years in a household cannot explain the source

of energy used and does not influence the source of energy used by Ermelo households (Figure 4.28).

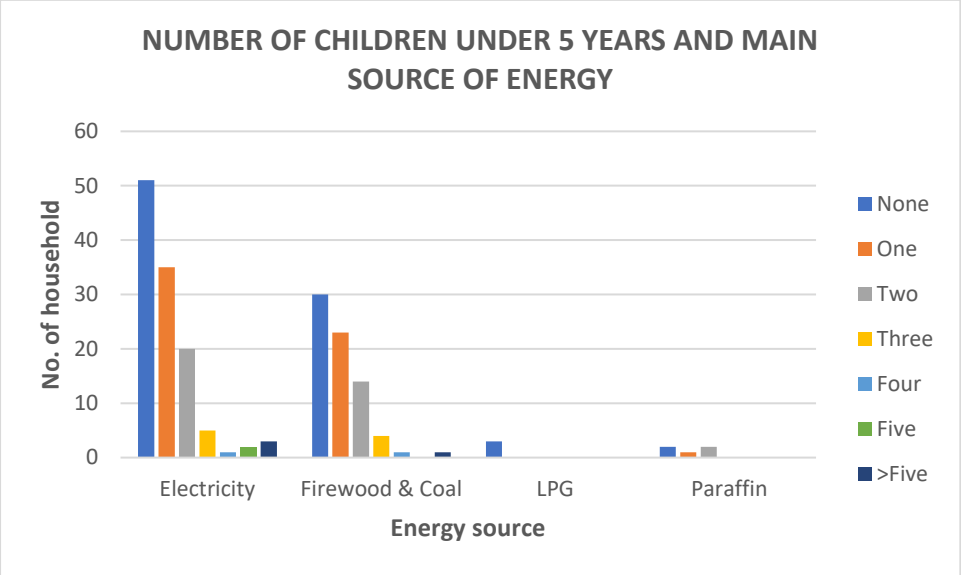

Figure 4. 28: Relationship between number of children under 5 years in a household and main source of energy

4.3.12 Amount of money spent and source of energy

A Chi-square test was done to determine the relationship between amount of money spent on source of energy and main source of energy used by households in Ermelo (Table 4.12).

Table 4. 12: Relationship between amounts of money spent on source of energy and main source of energy

		Amount of money spent on the source of energy						Total	p-value
		<R200	R1000	R201-400	R401-600	R601-800	R801-1000		
Main source of energy	Electricity	23	5	43	32	8	6	117	0.027
	Firewood & Coal	22	1	25	12	11	2	73	
	LPG	2	0	1	0	0	0	3	
	Paraffin	5	0	0	0	0	0	5	
Total		52	6	69	44	19	8	198	

The study found that there is a statistically significant association between amount of money spent on the source of energy and main source of energy used by households in Ermelo (Chi-square = 27.160, p = 0.027). p < 0.05 meaning the p-value is less than the significance level. Therefore, amount of money spent can explain the source of energy used and influences the source of energy used by Ermelo households (Figure 4.29).

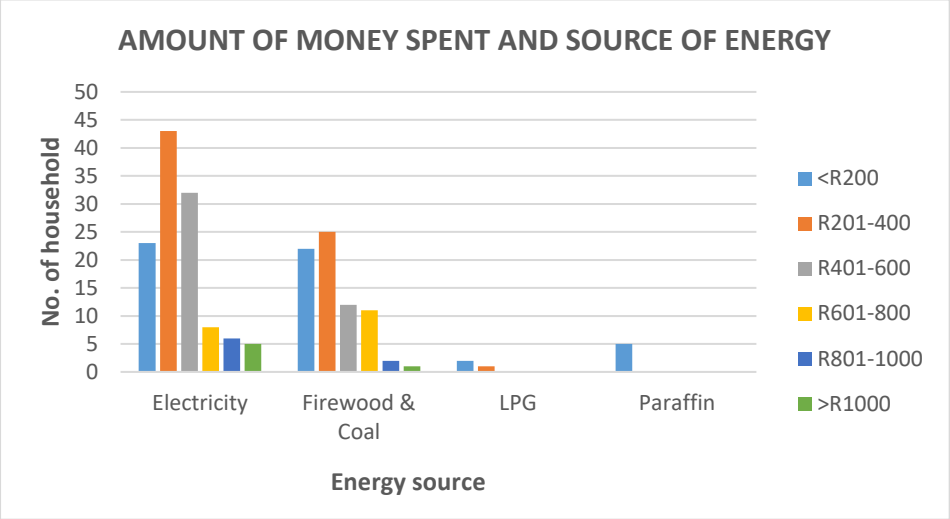

Figure 4. 29: Relationship between amounts of money spent on sour e of energy and source of energy

4.3.13 Type of food and main source of energy

A Chi-square test was done to determine the relationship between type of food prepared and main source of energy used in Ermelo (Table 4.13).

Table 4. 13: Relationship between type of food and main source of energy

		Type of food		Total	p-value
		Modern food (rice, spaghetti, sausages etc.)	Traditional food (samp, mogodu, steam bread etc.)		
Main source of energy	Electricity	106	11	117	0.451
	Firewood & Coal	64	9	73	
	LPG	2	1	3	
	Paraffin	5	0	5	
Total		177	21	198	

The results showed that there is no statistically significant association between type of food and main source of energy used by households in Ermelo (Chi-square = 2.635, p = 0.451). p > 0.05 meaning the p-value is higher than the significance level (Figure 4.30). Therefore, the type of food to be prepared cannot explain the source of energy used and does not influence the source of energy used by households in Ermelo. This contradicts with the findings by Uhunamure *et al.* (2017) that found that selection of fuel type is influenced by type of food cooked.

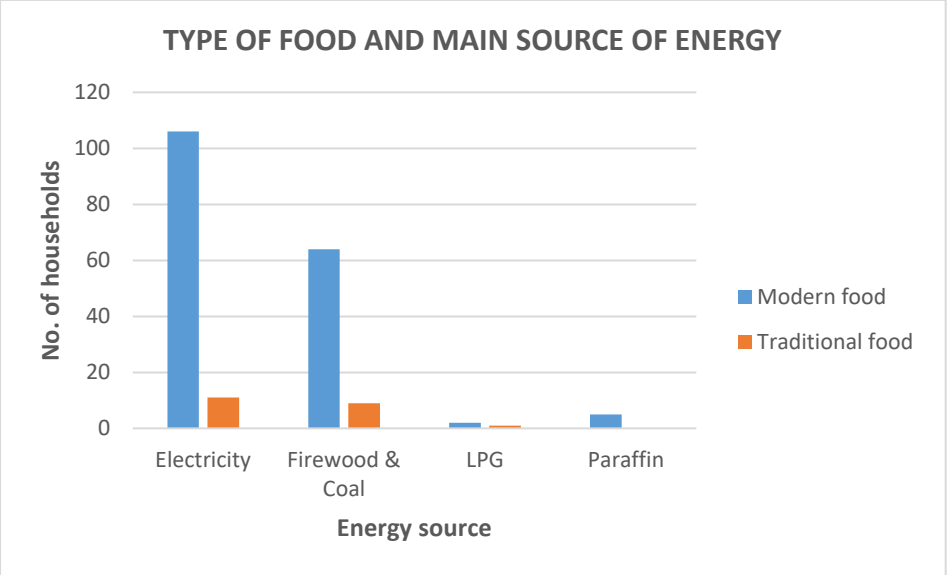

Figure 4. 30: Relationship between type of food and main source of energy

4.3.14 Outdoor cooking in households

The study found that 50% of households cook outdoor in open fire using domestic solid fuel, while the other 50% do not cook outdoor in the open fire (Figure 4.31). The fuels used in the open fire release harmful particles in the atmosphere as they burn. When they are inhaled on regular basis they may affect the participants' health as well as the environment.

Figure 4. 31: Outdoor cooking in open fire using domestic solid fuel

4.3.15 Reasons for outdoor cooking in households

The study found that 50% of households do not cook outdoor in the open fire. Equally so, the other 50% of households cook outdoor in the open fire using domestic solid fuel. Of the 50% that cook outdoor, 28% indicated traditional/cultural beliefs as a reason for cooking outdoor followed by load shedding/reduction at 16%, affordability and pot preferences at 3% and 1.5% respectively. The findings of this study are similar to the findings of earlier studies that found that cultural beliefs influence the consumption of solid fuel in households (Martinez *et al.*, 2020; Nyaga, 2020; Sharma *et al.*, 2020; Williams *et al.*, 2020).

Figure 4. 32: Reasons for outdoor cooking in open fire using domestic solid fuel

4.4 Knowledge of risks associated with solid fuel

The following sub-sections discuss the findings on knowledge of Ermelo residents in relation to the negative impact of solid fuel use on human health and environment.

4.4.1 Knowledge of impact of solid fuel on human health

The study found that 75% of households do not know the impact of solid fuel use on their health and 25% of households know the impacts of solid fuel use on their health (Figure 4.33). Therefore, this implies that Ermelo households consume solid fuel for domestic purposes, but they do not know the impact of solid fuel on their health.

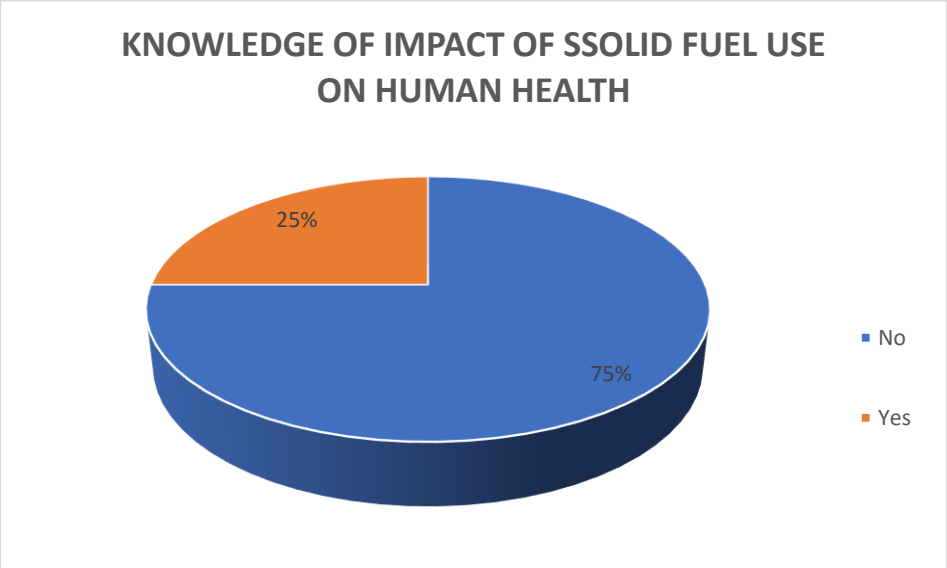

Figure 4. 33: Knowledge of the impact of solid fuel use on human health

4.4.2 Knowledge of impact of solid fuel on environment

The study found that 54% of households do not know the impact of solid fuel use on the environment and 46% of households know the impact of solid fuel use on the environment (Figure 4.34). Therefore, this implies that majority Ermelo households consume solid fuel for domestic purposes, but they do not know the impacts of this solid fuel on the environment.

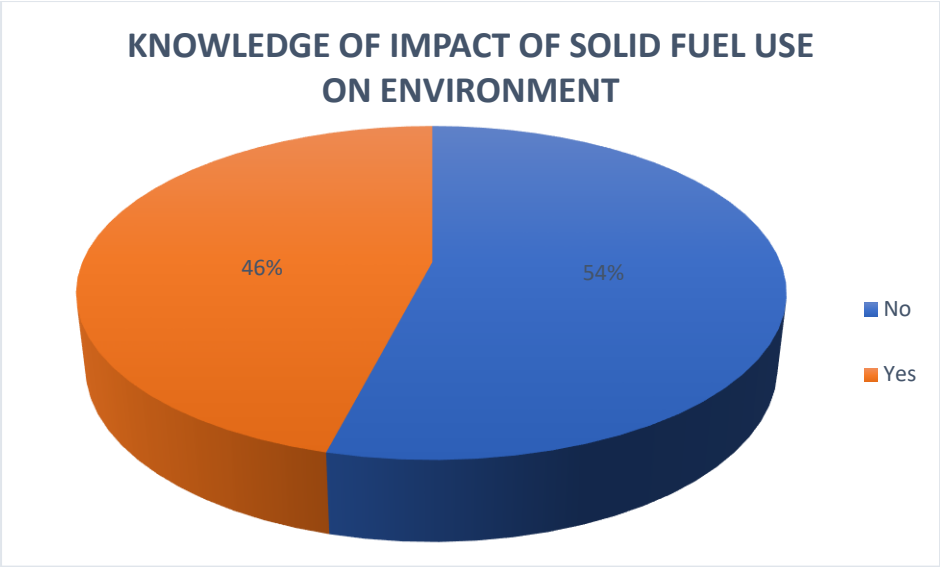

Figure 4. 34: Knowledge of the impact of solid fuel use on environment

4.5 Willingness to use modern/ clean energy in future

The results showed that 81% of households are willing to use modern energy in future while 19% of households are not willing to use modern energy in the future (Figure 4.35). Therefore, this implies that most of Ermelo households are willing to use modern energy in future but because of the reasons or factors mentioned above, some of these households cannot currently use or rely on modern energy.

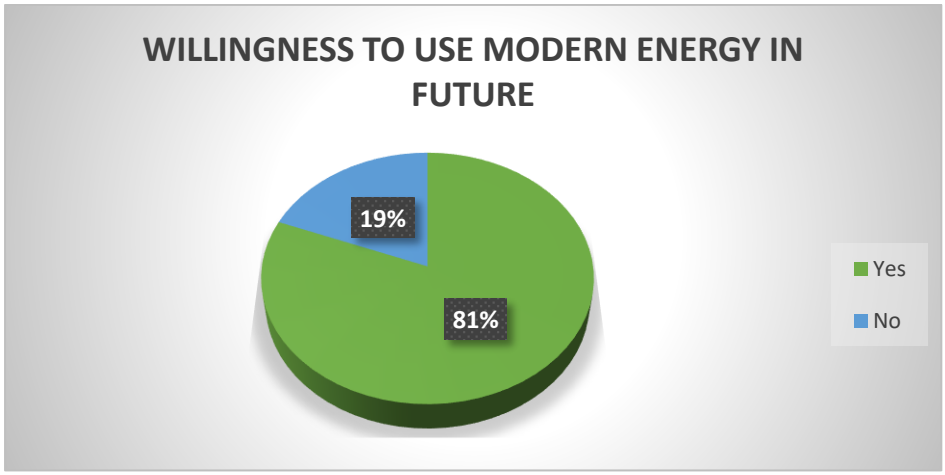

Figure 4. 35: Willingness to use modern energy in future

4.6 Opinion on municipal action

The study found that 87% of the households are of the opinion that the local municipality is not doing enough to assist households with the use solid fuel in a cleaner manner and assisting households with efficient stoves while 13% of households believe that the local municipality

is doing enough. It was observed that some household have meter boxes that are broken and not working. According to the households this was reported to the local municipality but nothing has been done about it, hence they use solid fuel for domestic purposes. According to some households the interventions done by local municipality in Ermelo include providing low-income settlements with free basic electricity monthly (Figure 4.36).

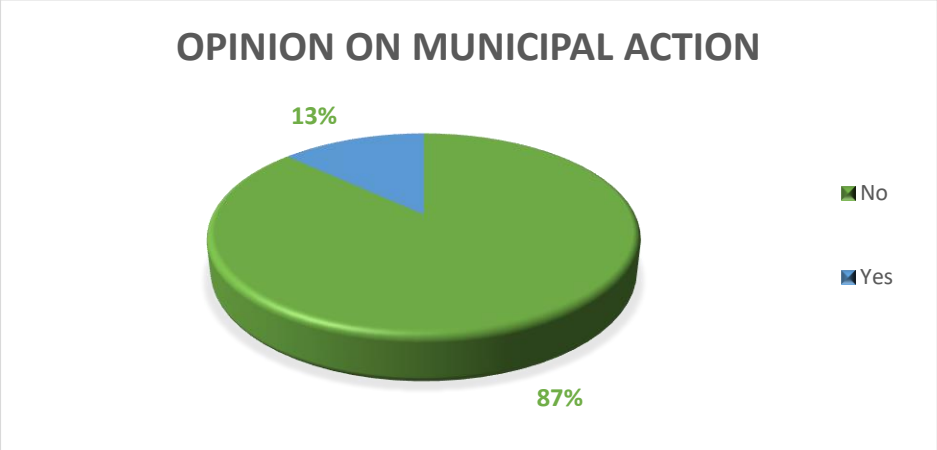

Figure 4. 36: Opinion on municipal action

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter summarizes the main findings of domestic solid fuel use in Ermelo, Mpumalanga Province, South Africa. This chapter also draws on conclusions from the results and makes recommendation and opportunities for future research.

5.1 Conclusion

The aim of the study was to assess factors influencing the use of domestic solid fuel in Ermelo in Msukaligwa Local Municipality, Mpumalanga Province, South Africa. Socio-economic characteristics like age group, gender, marital status, level of education, occupation, and amount of money spent on energy were assessed in relation to solid fuel use. Cultural characteristics such as type of food, taste of food, pot preferences, and traditional beliefs were also considered in this study.

5.1.1 Evaluate availability of different energy sources

The findings of the study in figure 4.8, 4.12 and 4.14 showed that Ermelo households use electricity, firewood & coal, LPG, paraffin, solar, candles and imbawula as sources of energy. These energy sources are used for different purposes like cooking, heating and lighting. Electricity access was found to be approximately 83% within households (Figure 4.7). This is due to the electrification programme that was introduced, hence there is a lot of progress on access to electricity within households. Even though 83% of households have access to electricity, the study found that electrified households still rely on other sources of energy such as firewood, coal, candles, paraffin, LPG and imbawula for domestic purposes. The other 17% with no access to electricity were also found to be depending on firewood, coal, candles, imbawula and paraffin. It was also observed that some of the households harvest fuelwood in their own yards and in forest whereby they wait for the fuelwood to dry up before using it for domestic purposes while coal is purchased in the neighbouring households at a price of R100 per 50kg.

5.1.2 Assess and document the predominant solid fuel utilisation in comparison with electricity use

The study in figure 4.10 showed that 53.5% of households prefer electricity for cooking whilst approximately 42.9% of households use firewood and coal for cooking. Other alternative sources of energy such paraffin and LPG are used by 2.1% and 1.5% of households respectively for cooking. This is influenced by factors such as level of education, number of employed household members, household size, household income, type of occupation, type of house and amount of money spent on energy. The study also found that 63.6% of households in Ermelo are using firewood and coal for heating due to affordability and accessibility (Figure 4.12 and Figure 4.13). Households indicated that access to coal is easy as Ermelo and its surroundings have a large number of coal mines. For lighting, 81.3% of households prefer to use electricity and only 14.1% use candles for lighting.

These findings are consistent and similar to the literature which found that electrified households in low-income settlements rely on solid fuel for domestic purposes and having access to electricity does not mean households will automatically switch to modern energy (Kasangana *et al.*, 2017; Makonese *et al.*, 2018; Nkosi *et al.*, 2018; Nkosi *et al.*, 2021). Affordability and accessibility were given as the main reasons why households continue to use solid fuel for domestic purposes even though they are connected to electricity.

5.1.3 Investigate factors influencing the solid fuel utilisation

Level of education plays a major role on the well-being of the households as indicated in section 4.3.4. The study revealed that households who went to school and have post-matric qualifications prefer to use electricity while households with no schooling prefer to use firewood and coal. Amongst the factors that were discussed, household income is another influential factor that determines the use of energy within households as shown by the study in section 4.3.6. The study also showed that households with an income of R<R500 – R1000 (low income earners) prefer to use solid fuel while households with an income of R1001 – R20000 (middle and higher income earners) prefer to use electricity. Low income earners prefer solid fuel because these are cheap and affordable for them. Occupation was also found to influence the use of solid fuel in households. The study revealed that household heads who are professional and working tend to have higher level of income thus can afford modern energy while Whilst those household heads who are not working or unskilled have low income resulting in the higher usage of solid fuel which is cheap and easily available to them as they

harvest it from the forest or their backyards or buy them at a less from the neighbouring business.

Moreover, the results of this study in section 4.3.1, 4.3.2, 4.3.3, 4.3.9 and 4.3.11 demonstrated that not all the factors addressed in literature influence domestic solid fuel use in Ermelo. The Chi-square test results showed that factors such as age, gender, marital status, gender, household head, the number of children under 5 years in a household and type of food were not major determinants of solid fuel use. These factors had a p-value of >0.05 which is higher than the significant level.

5.1.4 Assess knowledge of residents on health risks associated with solid fuel use

The findings of the study (Figure 4.33 and Figure 4.34) indicated that 75% of households in Ermelo do not know the negative impacts of domestic solid fuel use on their health and 25% have knowledge of the negative impacts of domestic solid fuel use on their health. Moreover, 54% of households were found to have no knowledge of negative impacts of domestic solid fuel use on their environment and 46% of households have knowledge of negative impacts of domestic solid fuel use on their environment. Furthermore, the study found that most households were of the opinion that the local municipality is not doing enough to assist households with the use solid fuel in a cleaner manner and assisting households with efficient stoves while 13% of households believe that the local municipality is doing enough.

In conclusion, the study used results of the study to conclude that although 83% of the households have access to electricity, solid fuel is still used for domestic purposes such as cooking and heating because of its affordability and accessibility. Furthermore, harvesting fuelwood in the forest and coal in the nearby mines is a threat to the community of Ermelo because of the dangers associated with harvesting fuelwood and the impacts of coal on health and environment. The policy makers need to stay informed about the socio-economic aspects and use of solid fuel by households within Ermelo so that they will be able to make an informed decision on energy sources that are efficient for everyone as well as awareness on the negative impacts of solid fuel use on human health and the environment.

5.2 Recommendations

The recommendations are proposed based on the key findings of the study. This study recommends the following mitigation measures that could be utilised for efficient use of domestic solid fuel within Ermelo, Mpumalanga Province, South Africa.

5.2.1 Increase access to free basic electricity

The introduction of electrification programme in Ermelo has made a difference in terms of access to electricity within area. Even though this programme was implemented, the study revealed that only 83% of households have access to electricity and those that do not have access to electricity are compelled to use domestic solid fuel for domestic purposes. The study also found that the electrification program did not eliminate the use of domestic solid fuel because some of the electrified households still use solid fuel for domestic purposes post-electrification programme.

Some of the households indicated that they receive 50kWh FBE subsidy from the local municipality. While others complained that even though they qualify for this subsidy, the local municipality has not approved their application for subsidy. The study also revealed that most of the household heads receives grants from government, hence they qualify for free basic electricity. When implementing and/or identifying homes deserving of free basic services, the Msukaligwa Local Municipality should take into account the qualifying households that do not receive the subsidy. This will ensure that all of the household's energy requirements are covered. More research is needed in order to identify the amount of electricity utilised by households. This would assist in determining if the 50kWh subsidy is sufficient for domestic purposes of an average household. Fighting the use of domestic solid fuel assist in environmental management, municipal sustainability as well as reduce impacts of climate change.

5.2.2 Increase access to affordable electricity

As mentioned earlier, the study revealed that 83% of households in Ermelo are connected to electricity, but continue to use mixed fuel including firewood, coal and paraffin due to the high cost of electricity. The study also showed that access to electricity does not mean automatic switch to electricity as households continue to use solid fuel while they are connected to electricity. Household income was also found to be a contributing factor in using solid fuel as households that cannot afford electricity tend to depend on domestic solid fuel. Therefore, if a clean fuel option is implemented to replace domestic solid fuel in low-income settlements, it

must be efficient when combusted and it must reduce emissions and consumption. It is also recommended that policymakers should promote economic development in low-income settlements so that households in low-income settlement can get better jobs and be able to afford electricity.

5.2.3 Awareness on the negative impact of domestic solid fuel

There is a need for education and awareness on the impacts of domestic solid fuel use on human health and the environment within Ermelo. Level of education was one of the factors influencing solid fuel use in this area. Raising awareness on the negative impacts of solid fuel on human health and the environment through education can lead to attitude and behavioural change and lead to a shift away from the use of dirty fuel to the use of clean and modern fuel. It is recommended that Msukaligwa local municipality should also intensify education and awareness-raising throughout the Ermelo area since the study revealed that 75% of households in Ermelo do not know the negative impacts of domestic solid fuel use on their health, while 54% of households were found to have no knowledge of negative impacts of domestic solid fuel use on their environment.

During the data collection process, meter boxes that are broken and not working properly were observed in some households and this was one of the reasons why household use solid fuel. The local municipality should address these issues since this extensive utilisation of solid fuel is in contradiction with the principles of sustainable development as well as the right to an environment that is not harmful to human health.

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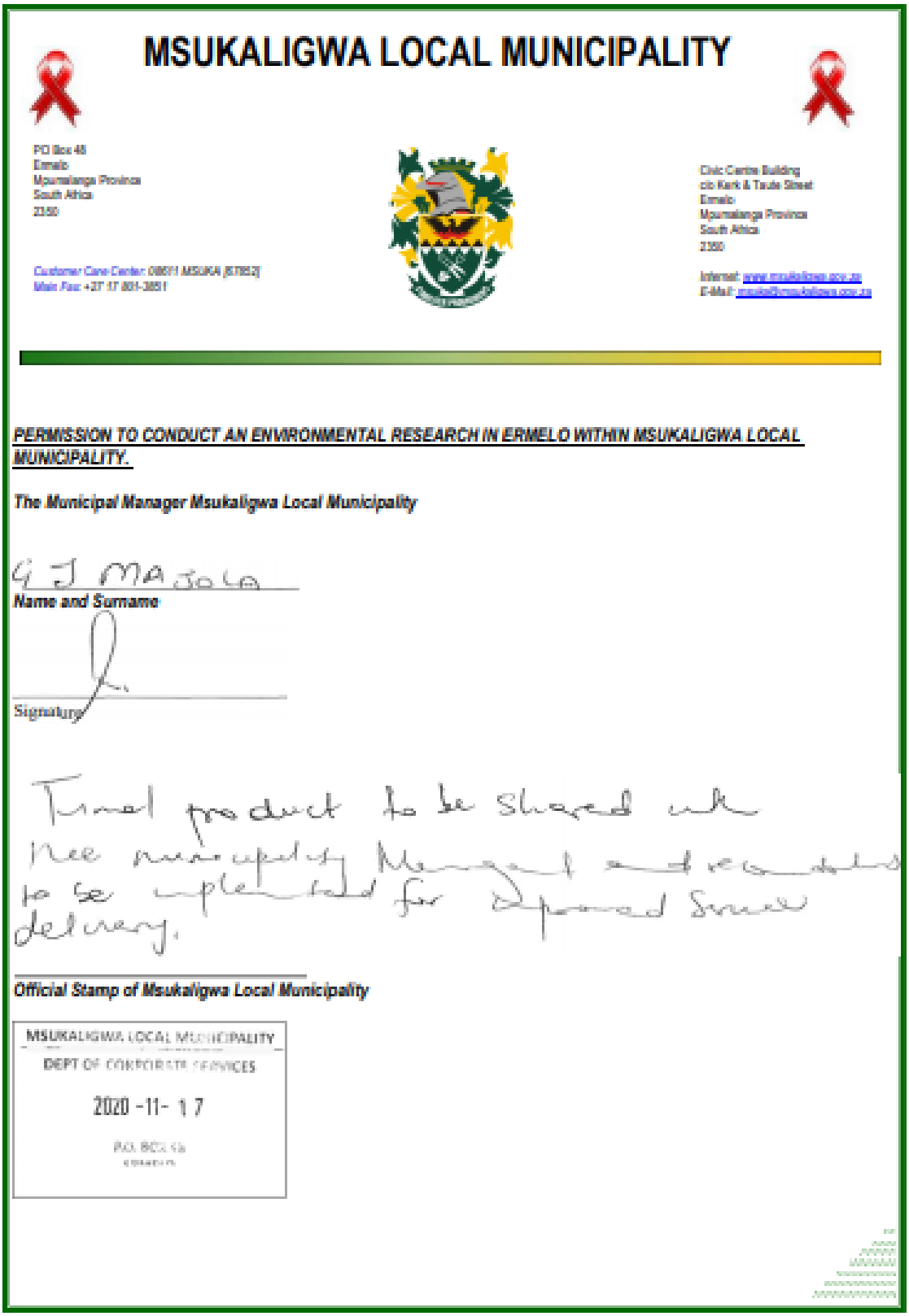
LIST OF ANNEXURES

Annexure 1: Approval letter from Msukaligwa Local Municipality



MSUKALIGWA LOCAL MUNICIPALITY

PO Box 48
Ermelo
Mpumalanga Province
South Africa
2350

Customer Care Center: 08011 MSUKA (67852)
Main Fax: +27 17 801-3851

Civic Centre Building
c/o Kerk & Taute Street
Ermelo
Mpumalanga Province
South Africa
2350

Internet: www.msukaligwa.gov.za
E-Mail: msuka@msukaligwa.gov.za

PERMISSION TO CONDUCT AN ENVIRONMENTAL RESEARCH IN ERMELO WITHIN MSUKALIGWA LOCAL MUNICIPALITY.

The Municipal Manager Msukaligwa Local Municipality

G J Majola
Name and Surname

Signature

Final product to be shared with the municipality Manager and relevant officials to be implemented for improved service delivery.

Official Stamp of Msukaligwa Local Municipality

MSUKALIGWA LOCAL MUNICIPALITY
DEPT OF CORPORATE SERVICES
2020 -11- 17
P.O. BOX 48
ERMELO

Annexure 2: Participant Leaflet

PARTICIPANT LEAFLET

Dear participant

My name is Bulelwa Mthembu, and I am a Master's student in the College of Agriculture and Environmental Sciences at the University of South Africa. I am conducting a research in assessment of factors influencing the use of domestic solid fuel use in Ermelo, Mpumalanga Province, South Africa.

You are requested to take part in this research project. The information obtained from you will assist the researcher to understand the factors influencing solid fuel use and also to understand the main reason behind high dependence on solid fuel despite most household being connected to the national electricity grid and also what actions are taken by the residences to mitigate high levels of solid fuel utilisation.

This leaflet gives you the relevant information regarding the study and helps you to make an informed decision regarding your participation in this study and you should read it thoroughly. Should you have any question please feel free to ask the researcher. Please respond to the questionnaires provided and it will take approximately 30 minutes to fill up the questionnaires. All personal information collected and used will be strictly confidential. You can also withdraw anytime from this study should you feel uncomfortable.

Your assistance is highly appreciated

Kind regards
Bulelwa Mthembu

Contact details : 074 435 4313
Email address : shabalalabulelwa@gmail.com

Annexure 3: Participant Consent Form

CONSENT TO PARTICIPATE IN THIS STUDY

- I consent that the interviewer has explained the aim of the study, confidentiality of the study and other relevant information of the study.
- I have read the abovementioned information and understood it.
- I know that the information from the study such as personal information will be treated with strict confidentiality and anonymity.
- I am taking part voluntary and have agreed that the interviewer can record the interview using audio device.
- I have asked questions in the relation to the study and I am satisfied with the procedure.
- I understand I cannot continue to take part in this study whenever I feel uncomfortable and this cannot affect me in anyway.
- I know I can request this leaflet whenever I need it.

Participant's signature…….. Date……

Researcher's signature…….. Date……..

Witness's signature……... Date…….

Annexure 4: Semi-structured questionnaire (English)

SEMI-STRUCTURED QUESTIONNAIRE FOR RESIDENTS

Guidance in answering questions

Please make with an X the appropriate box or boxes and where necessary fill in the space as indicated

Date: _____

Residential address:_____

Section A: Household Details

1. Gender

Female	Male

2. Age

<18	18-35	36-59	60+

3. Race

African	Coloured	Asian	Indians	White

4. Marital Status

Single	Married	Divorced	Widowed

Section B: Type of main fuel used

5. Is your household connected to electricity?

Yes	No

6. What is the main source of energy used in your household?

Electricity	Firewood and Coal	Paraffin	LPG	Other

If other, please specify:_____

7. What is the reason for choosing the main source of energy?

Affordable	Easily accessible	Type of food	Pot preferences	Cultural beliefs	Taste of food	Convenience	Safety	Type of house

8. What type of energy do you use for cooking?

Electricity	Firewood and Coal	Paraffin	LPG	Ethanol	Other

If other, please specify:_____

9. How often do you use this main fuel energy source for cooking?

Daily	Weekly	Monthly	Other

If other, please specify:_____

10. How many times do you cook in a day?

Once	Twice	Three times	>three times

11. What type of energy do you use for heating?

Electricity	Firewood	Coal	Paraffin	LPG	Ethanol	Other

If other, please specify:_____

12. Why do you use this energy source for heating?

Affordable	Easily Accessible	Cultural beliefs	Change of Season	Convenience	Safety	Type of house	Other

If other, please specify:_____

13. What type of energy do you use for lighting?

Electricity	Candles	Paraffin	Solar	Other

If other, please specify:_____

14. How often do you use this energy source for lighting?

Daily	Weekly	Monthly	Other

If other, please specify:_____

15. Why do you use this energy source for lighting?

Affordable	Easily Accessible	Cultural beliefs	Change of Season	Convenience	Safety	Type of house	Other

If other, please specify:_____

Section C: Type of main stove used

16. What type of stove does your household use?

Electric stove	Gas stove	Coal & firewood stove	Ethanol stove	Imbawula	Three legged pot fire	Paraffin stove

17. How long have you been using the stove?

<One year	One year	Two years	Three years	Four years	>Four years

18. Will you buy the same stove in future? Provide reasons?

_____

_____

_____

Section D: Socio-economic information of the household

Household Head

19. Who is the head of the family?

Father	Mother	Grandfather	Grandmother	Older Sibling	Other

If other, please specify:_____

20. Who provide money for buying of energy source used?

Father	Mother	Grandfather	Grandmother	Older Sibling	Other

If other, please specify:_____

Household Size

21. How many members does your household have?

One	Two	Three	Four	Five	>Five

22. Number of children under 5 years old.

None	One	Two	Three	Four	Five	>Five

Education level of the household

23. What is the highest education level in the household?

Primary	Secondary	College	University	No schooling

24. How many people are employed in the household?

None	One	Two	More than two

25. Occupation

Professional	Managerial	Skilled	Partially Skilled	Unskilled	Self-employed	Not working

26. Monthly Income (R) of the household

<R500	R501-R1 000	R1001-R5000	R5001-R10 000	R10 001-R15 000	R15 001-R20 000

Type of house

27. What type of house do you have?

High Class	Middle Class	Low Class

Cost of energy source

28. How much does the household spend on the main energy source per month?

<R200	R201-R400	R401-R600	R601-R800	R801-R1 000	>R1 000

29. If the main energy source is depleted, does the household have an alternative energy source to use?

Yes	No

30. How much do you spend on this alternative energy source?

<R200	R201-R400	R401-R600	R601-R800	R801-R1 000	N/A

Section E: Socio-cultural information of the household

Taste and preferences

31. Does the type of food determine the type of fuel and stove to be used?

If yes, please specify:

_____

_____

32. Does type of fuel and stove used have impact on the taste of food?

Yes	No	Sometimes

If yes, please specify:

_____

_____

33. Does your household cooks outdoor in the open fire?

Yes	No	Sometimes

34. Reasons for outdoor cooking

Affordable	Load Shedding or reduction	Traditional or cultural beliefs	Pot preferences	Taste of food	Social Cohesion	N/A

Section F: Knowledge of health effects of solid fuel use

35. In your opinion, does solid fuel use have negative impact on your health?

If yes, please specify:

_____

_____

_____

_____

_____

36. In your opinion, does solid fuel use have negative impact on environment?
If yes, please specify:

_____

_____

_____

_____

Section G: Willingness to pay for clean/modern fuel

37. Can you use modern/clean fuel as the main source of energy for your household in future?

Yes	No

38. Which modern/clean fuel would you prefer for your household in future?

Electricity	LPG	N/A

39. Do you think the local municipality is doing enough to reduce the use of solid fuel in households? If yes, please specify

_____

_____

_____

Annexure 5: Semi-structured questionnaire (iSiZulu)

IMIBUZO YABAHLALI

Isiqondiso ekuphenduleni imibuzo

Sicela ubhale u-X kwibhokisi noma amabhokisi afanele futhi lapho kudingeka khona ugcwalise isikhala gcwalisa njengoba kukhonjisiwe

Usuku: _____

Ikheli ohlala kulo:_____

Isigaba A: Imininigwane yomphenduli

1. Ubulili

Owesifazane	Owesilisa

2. Iminyaka

<18	18-35	36-59	60+

3. Uhlanga

African	Coloured	Asian	Indians	White

4. Isimo sakho somshado

Awushadile	Ushadile	Uhlukanisile	Washonelwa umyeni or nkosikazi

Isigaba B: Izinhlobo ozisebenzisa uma upheka, ukhanyisa noma uzifudumeza

5. Ninawo yini ugesi?

Yebo	Cha

6. Yikuphi okusebenzisa ekhaya kakhulu kulokhu okulandelayo?

Ugesi	Izinkuni namalahle	Paraffin	Igesi-LPG (gas)	Solar	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

7. Kungani usebenzisa lokhu okukhethe kumbuzo no 6?

Kuyathengeka	Kutholakala kalula	Kuphephile	Amabhodwe engiwasebenzisayo	Ngikhule ngisebenzisa khona	Kwenza ukudla kubemnandi

8. Ubasa ini uma upheka?

Ugesi	Izinkuni namalahle	Paraffin	Igesi-LPG (gas)	Ethanol	Okunye

Uma okunye, ngicela ucacise:_____

9. Ubasa kangaki uma upheka?

Nsukuzonke	Kanye evikini	Kanye enyangeni	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

10. Upheka kangaki ngelanga?

Kanye	Kabili	Kathathu	Ngaphezu kokuthathu

11. Ubasa ini uma kubanda, uma ufuna ukuzifudumeza endlini?

Ugesi	Izinkuni namalahle	Paraffin	Igesi-LPG (gas)	Ethanol	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

12. Kungani ubasa lokhu okukhethile ukufudumeza indlu?

Kuyathengeka	Kutholakala kalula	Kuphephile	Ngenxa kokwakheka kwendlu	Ngikhule ngisebenzisa khona	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

13. Usebenzisa ini ukukhanyisa endlini?

Ugesi	Amakhandlela	Isibani sa-paraffin	I-Solar	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

14. Ukhanyisa kangaki endlini?

Nsukuzonke	Kanye evikini	Kanye enyangeni	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

15. Kungani ukhethe ukukhanyisa ngalokhu okubale ngenhla?

Kuyathengeka	Kutholakala kalula	Kuphephile	Ngenxa kokwakheka kwendlu	Ngikhule ngisebenzisa khona	Okunye

Uma ukhethe okunye, ngicela ucacise:_____

Isigaba C: Uhlobo lwesitofu enisisebenzisayo

16. Uhlobo luni lwesitofu osisebenzisayo?

Isitofu sikagesi	Isitofu se-gas	Isitofu samalahle nezinkuni	Isitofu se-ethanol	Imbawula	Umlilo waphansi

17. Unesikhathi esingakanani usebenzisa lesisitofu esikumbuzo 16?

Kungaphansi konyaka	Unyaka owodwa	Iminyaka emibili	Iminyaka emithathu	Iminyaka emine	Ngaphezu kweminyaka emine

18. Ingabe ungasithenga isitofu esifana nalesi onaso ngokuzayo? Nikeza izizathu?

_____

_____

Isigaba D: Imininingwane yezenhlalo nezomnotho yomndeni

Inhloko yekhaya

19. Ubani inhloko yekhaya?

Ubaba	Umama	Umkhulu	Ugogo	Abanye basekhaya

20. Ubani othenga okokubasa okusetshenziswa ekhaya?

Baba	Mama	Umkhulu	Ugogo	Abanye basekhaya

Inani lamalungu omndeni

21. Mangaki amalunga omndeni ekhaya?

1	2	3	4	5	>5

22. Zingaki izingane ezingaphansi kweminyaka engu 5.

0	1	2	3	4	5	>5

Izinga lemfundo yasekhaya

23. Yiliphi izinga lemfundo eliphakeme eninalo ekhaya?

I-Primary	I-Secondary	I-College	I-University	Akekho ofundile

24. Bangaki abasebenzayo ekhaya?

0	1	2	>2

25. Wenza noma benza umsebenzi onjani?

Uchwepheshe	Umphathi	Amakhono ezandla	Ongenamakhono ezandla	Uyazisebenza	Akasebenzi

26. Ingakanani imali engena ekhaya ngenyanga (R)

<R500	R501-R1 000	R1001-R5000	R5001-R10 000	R10 001-R15 000	R15 001-R20 000

Inhlobo yendlu enihlala kuyo

27. Uhlobo olunjani lwendlu enihlala kulo?

Eyezinga eliphezulu	Eyezinga eliphakathi	Eyezinga eliphansi

Kubiza malini lokhu okusebenzisa uma upheka, ukhanyisa noma uzifudumeza

28. Kulokhu okusebenzisa kumbuzo no 6, kubiza malini ngenyanga?

<R200	R201-R400	R401-R600	R601-R800	R801-R1 000	>R1 000

29. Uma kuphelile okusebenzisa kumbuzo no. 6, kukhona yini okunye enikusebenzisayo?

Yes	No

30. Uma ukhethe uyebo kumbuzo no 29, malini oyisebenzisayo ukwengeza ?

<R200	R201-R400	R401-R600	R601-R800	R801-R1 000	>R1 000

Isigaba E: Imininingwane yezenhlalo namasiko omndeni

Ukunambitheka kokudla

31. Ingabe usebenzisa izitofu ezihlukene ukupheka ukudla okuhlukene?

Uma ukhethe uyebo, ngicela ucacise:

_____

_____

32. Ingabe lokhu okusebenzisa kumbuzo no 6, kunawo yini umtheleo ekunambithekeni kokudla?

Yes	No	Sometimes

Uma ukhethe uyebo, ngicela ucacise:

_____

_____

33. Kuyenzeka niphekele ngaphandle?

Yebo	Cha	Mhlawumbe

34. Isiphi isizathu sokuphekela ngaphandle?

Kushibhile	Load shedding or reduction	Ngenxa yesintu nokudla kwesintu esikuphekayo	Uma senze umsebenzi	Ukunambitheka kokudla	Okunye

Uma ukhethe okunye, ngicela ucacise:

_____

_____

Isigaba F: Ulwazi ngemithelelo yalokhu okusebenzisa uma upheka, ukhanyisa noma uzifudumeza empilweni yakho

35. Ngokwakho ukucabanga, ngabe ukusetshenziswa kwamalahle nezinkuni kunomthelela omubi yini empilweni yomuntu?
Uma ukhethe uyebo, ngicela ucacise:

_____

_____

36. Ngokwakho ukucabanga, ngabe ukusetshenziswa kwamalahle nezinkuni kunomthelela omubi yini kwimvelo noma kumoya osewuphefumelayo?
Uma ukhethe uyebo, ngicela ucacise:

_____

_____

_____

_____

Isigaba G: Ukuzimisela ukukhokhela nokusebenzisa uhlobo oluhlanzekile lokupheka, lokukhanyisa noma lokuzifudumeza

37. Ungavuma yini ukusebenzisa ugesi noma LPG (gas) kuphela ekhaya lakho?

Yebo	Cha

38. Ikuphi ongakukhetha kulokhu okungenzansi

Ugesi	I-gas	Akukho

39. Ngokwakho ukucabanga ngabe umasipala kukhona yini akwenzayo ukulekelela umphakathi ukuthi bayeke noma banciphise ukusebenzisa amalahle nezinkuni?
Uma ukhethe uyebo, ngicela ungicacise:

_____

_____

_____

Annexure 6: Ethical Clearance

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 22/01/2021

NHREC Registration # : REC-170616-051
REC Reference # : 2021/CAES_HREC/005
Name : Ms BNP Mthembu
Student #: 46345965

Dear Ms Mthembu

Decision: Ethics Approval from 21/01/2021 to 31/01/2024

Researcher(s): Ms BNP Mthembu
46345965@mylife.unisa.ac.za

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

Working title of research:

Assessment of factors influencing the use of domestic solid fuel in Ermelo, Mpumalanga Province, South Africa

Qualification: MSc Environmental Management

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

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

Due date for progress report: 31 January 2022

Please note the points below for further action:

1. The sampling procedure is confusing and needs to be clarified. What is the motivation for the use of systematic sampling? Usually this approach is used as a proxy for simple random sampling and when the population is homogenous. Is the population

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

homogenous in this instance? Furthermore, the sample size calculation was done incorrectly and needs to be reconsidered.

2. More detail is required on the statistical analysis – will descriptive statistics be used for all the objectives? The researcher should indicate how the data for each objective will be analysed – what statistical model will be used, and what variables will be applied for each model?

*The **low risk application** was **reviewed** by the UNISA-CAES Health Research Ethics Committee on 21 January 2021 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.

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8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2021/CAES_HREC/005** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

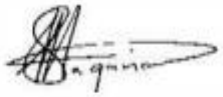
Yours sincerely,

Prof MA Antwi

Chair of UNISA-CAES Health REC

E-mail: antwima@unisa.ac.za

Tel: (011) 670-9391



Prof SR Magano

Acting Executive Dean : CAES

E-mail: magansr@unisa.ac.za

Tel: (011) 471-3649

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

Annexure 7: Turnitin report

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:	B N MTHEMBU
Assignment title:	Revision 1
Submission title:	Draft thesis
File name:	Bulelwa_Draft_Thesis_19_July_2021.docx
File size:	1.6M
Page count:	119
Word count:	25,905
Character count:	149,650
Submission date:	19-Jul-2021 10:02AM (UTC+0200)
Submission ID:	1621501549

ASSESSMENT OF FACTORS INFLUENCING THE USE OF DOMESTIC SOLID FUEL IN ERMELO, MPUMALANGA PROVINCE, SOUTH AFRICA

By

MTHEMBU BULELWA NOBUBLE PRECIOUS

submitted in accordance with the requirements for the degree of

MASTER OF SCIENCE

in the subject

ENVIRONMENTAL MANAGEMENT

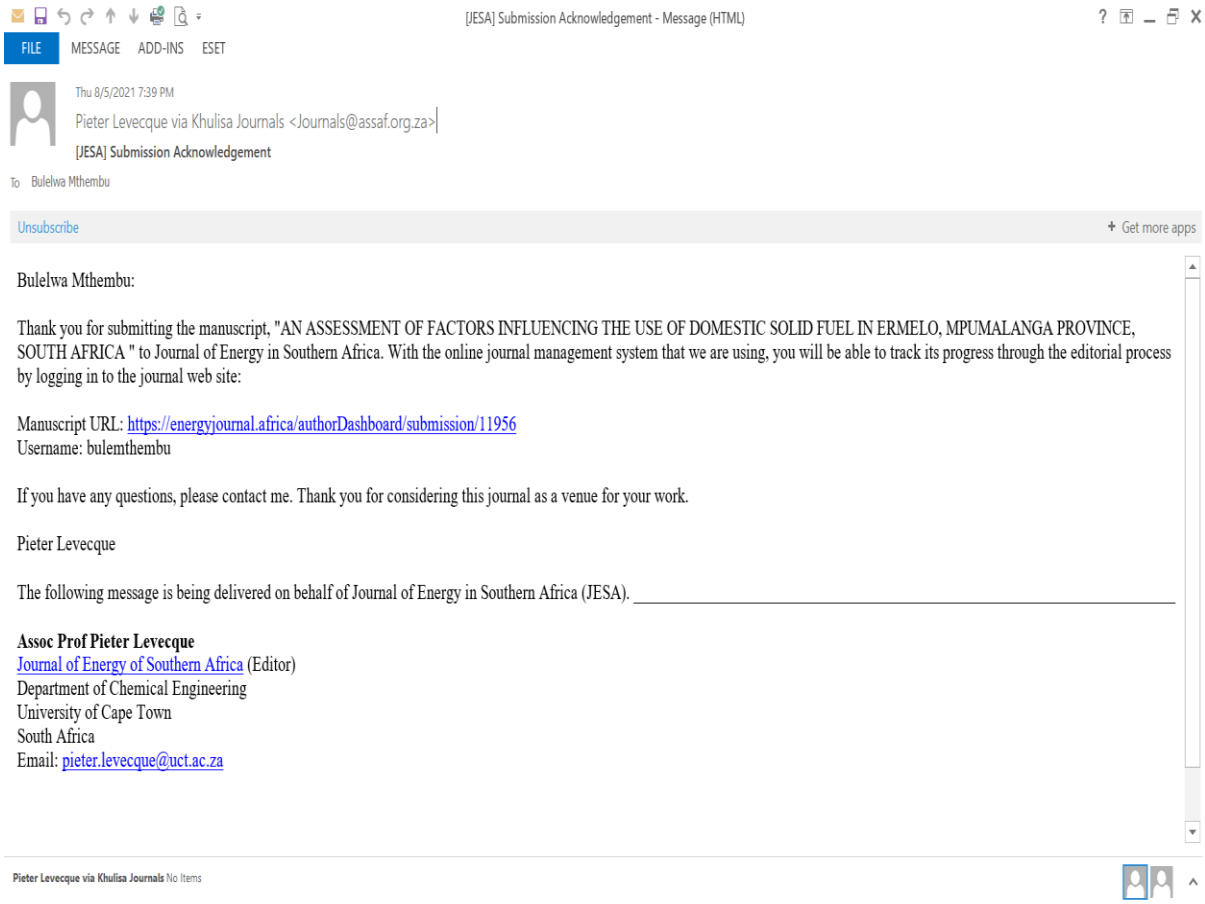
at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: DR. KHOMOTSO SEMENYA

July 2021

Annexure 8: Proof of article submission



[JESA] Submission Acknowledgement - Message (HTML)

FILE MESSAGE ADD-INS ESET

Thu 8/5/2021 7:39 PM

Pieter Levecque via Khulisa Journals <Journals@assaf.org.za>

[JESA] Submission Acknowledgement

To Bulelwa Mthembu

Unsubscribe + Get more apps

Bulelwa Mthembu:

Thank you for submitting the manuscript, "AN ASSESSMENT OF FACTORS INFLUENCING THE USE OF DOMESTIC SOLID FUEL IN ERMELO, MPUMALANGA PROVINCE, SOUTH AFRICA " to Journal of Energy in Southern Africa. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL: https://energyjournal.africa/authorDashboard/submission/11956
Username: bulemthembu

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Pieter Levecque

The following message is being delivered on behalf of Journal of Energy in Southern Africa (JESA).

Assoc Prof Pieter Levecque
Journal of Energy of Southern Africa (Editor)
Department of Chemical Engineering
University of Cape Town
South Africa
Email: pieter.levecque@uct.ac.za

Pieter Levecque via Khulisa Journals No Items