1 CHAPTER 1: INTRODUCTION

Access to sustainable energy is important for all human beings to sustain life (Borok *et al.*, 2013). Energy is used in all areas of life: in the home, in vehicles, and in the workplace, as a source of heat, light, power for vehicles, equipment and appliances (Vermeulen *et al.*, 2000). The provision of a sustainable supply of modern energy continues to be a challenge for most developing countries, particularly in rural areas (Shyu, 2014). There is no doubt that there are strong inter-linkages between energy and sustainable development, energy and poverty as well as energy and climate change (Birol, 2007; IEA, 2010; Chakravarty and Tavoni, 2013). The Millennium Development Goals (MDGs) are global development goals set for the eradication of poverty in the developing world (Clarke and Feeny, 2011). The central themes to the MDGs are health, education and environment, all of which require the provision a sustainable supply of energy in order for them to be achieved (Bazilian *et al.*, 2012). Historically, sustainable energy has not been appropriately recognised as a significant factor in the development agenda; however, recent developments have recognised the important role of sustainable energy in supporting development (IEA, 2013).

Most African countries depend on natural resources to support livelihoods and importantly as a source of energy (Shackleton *et al.*, 2007; Kepe, 2008). Natural resources such as water and biodiversity are sensitive to the impacts of climate change (IPCC, 2007; Stringer *et al.*, 2009; Manyatsi and Hlophe, 2010; Cole *et al.*, 2014). Science shows that global warming and the resultant climate change are now a reality and further predicts a global temperature increase of up to 3ºC by 2050 (IPCC, 2007). There are also projections of considerable average temperature increases in southern Africa (Munasinghe and Swart 2005; Lumsden *et al.*, 2009; Nkondze *et al.*, 2014). It is reported that Africa has already experienced warming of about 0.5ºC per century (Hulme *et al.*, 2001). One of the biggest challenges faced by developing countries, including Swaziland, is the need to adapt to the impacts of climate change (IPCC, 2007; GOS, 2012). Africa is likely to experience warming which is higher than the global annual mean warming, and subtropical regions will likely be more affected than the tropics (Kusangaya *et al.*, 2014). Increased climate variability affects water resource availability, impacting agriculture and energy production from hydro power (Faramarzi *et al.*, 2013). The generation and use of energy, globally contributes significantly to greenhouse gas (GHG) emissions, however, from a developing context the impact of these projections on the energy sector are a concern, particularly where energy is generated from hydropower and biomass burning (Chakravarty and Tavoni, 2013; Cole *et al.*, 2014). The energy mix in developing countries constitutes energy sources such as electricity, liquefied petroleum gas (LPG), firewood and charcoal paraffin, candles and to a small extent solar energy (Karekezi and Turyareeba, 1995; Marufu 1997; Thom, 2000). Firewood and charcoal are typical biomass fuels used for cooking in African rural households (Soussan, 1992; Johnson and Bryden, 2012). Although multiple sources of energy sources exist in developing countries, there are still challenges with modern energy access, quality of energy supply and high energy prices (Bhattacharyya, 2012; IEA, 2013; Bazilian, *et al.*, 2012). This has led to a dominance in the use of traditional fuels such as biomass, particularly woodfuel and charcoal in the developing world (Hiemstra-van der Horst and Hovorka, 2009).

Over 70% of households in sub-Saharan Africa rely on some form of biomass for cooking (Bazilian *et al.*, 2012). The associated challenges with such a high dominance are that annually between 0.8 and 2.4 million deaths in women and children are reported from inhalation of smoke from indoor air pollution (Smith and Ashwin, 1994; Kees and Feldmann, 2011). In addition, the unsustainable harvesting and use of woodfuel is one of the main causes of the increasing rate of deforestation in Africa (Brouwer *et al.*, 1997). Charcoal production and trade has been identified as one of the biggest culprits due to its uncontrolled and inefficient production process (Cuvilas *et al.*, 2010). The introduction of rural electrification programmes in developing countries has not succeeded in reducing the use of traditional fuel sources such as woodfuel (Thom, 2000; Bhattacharyya, 2012). Rural households still cook with biomass on open fires and other basic cookstoves (Foell *et al.*, 2011). The persistent challenge of poverty and low income in Africa calls for a wider approach to address energy poverty. Sustainable subsidies have been proposed as one of the means to enable low income households to access modern fuels such as LPG and electricity (Gundimeda and Köhlin, 2008). Clean cookstove programmes provide another approach which addresses the efficient use of biomass resources for millions of households which are unable to move up the energy ladder (Troncoso *et al.*, 2007; Bailis *et al., 2*009). Clean cookstoves, if appropriately designed, afford the user with a cleaner and quicker cooking experience (Smith *et al.*, 1993; Kishore and Ramana, 2002; Burwen and Levine, 2012). It is for this reason that clean cookstove programmes are being implemented in many developing countries with varying successes, depending on method of implementation and consideration of various environmental and socio-economic factors (Troncoso *et al.*, 2011). Factors affecting the choice of energy sources and cooking technologies vary within communities and countries (Hiemstra-van der Horst and Hovorka, 2008). This makes it necessary to identify rural household perceptions on the use of modern energy sources and improved cookstove technology interventions, prior to the roll out of such initiatives (Lambe and Atteridge, 2012).

This dissertation explores important themes around sustainable energy beginning with the review of the variances in energy access around the world, focusing on electricity access and use of biomass as a measure. The lack of access to modern energy has an impact on development. The relationships of energy access with poverty, water and climate change were therefore explored for a better understanding of the energy-water and climate change nexus in the context of development and poverty reduction. Literature on energy access in Africa and other developing parts of the world was readily available, portraying a high percentage of the population relying on biomass for their primary energy needs as well as the resultant challenges. One of the technologies explored which address this high dependence on biomass was clean cooking technologies and this research explored the various approaches to implementation of clean cookstove programmes around the world investigating the critical factors which play a critical role in the choice of fuel and cooking device.

The information obtained through the review of literature was used as a benchmark to compare with Swaziland's situation and this enabled the identification of a research gap. Swaziland like many developing nations has a high dependence on biomass which prompted the introduction of a clean cookstoves programme to promote the efficient use of the biomass resources (Dlamini, 2013). Poverty levels in Swaziland are estimated at 63% of the population which 88% are found in the rural areas (GOS, 2011). Poverty levels in Swaziland are highest among women who are responsible for cooking and providing households with their daily meals (GOS, 2011, Burwen and Levine, 2012). No literature could be found on the assessment of the effectiveness of Swaziland's clean cookstove programme and factors influencing its implementation as identified in literature, which therefore presented an opportunity to investigate the impact of perception of rural households on the clean cookstoves programme. This research was conducted in the Siphofaneni area, in Swaziland, to investigate the impact of rural perceptions on the adoption of clean cookstoves as alternative and improved cooking technologies in rural households to enhance the sustained use of woodfuel in Swaziland as well as the barriers hindering the uptake of clean cookstoves in rural Swaziland.

1.1 RESEARCH QUESTIONS

To achieve the purpose and objectives of this study, the following research questions guided the research:

i. What different fuels and technologies are used for cooking in households in the Siphofaneni area?
ii. What is the level of uptake of clean and more efficient cookstove technologies in the Siphofaneni area?
iii. What is the attitude of Siphofaneni households towards the use of clean cookstoves?
iv. What barriers exist prohibiting the uptake of clean and more efficient cookstoves?

1.2 AIMS AND OBJECTIVES OF THE STUDY

This study aims to investigate how rural perceptions impact on the adoption of clean cookstove technologies as an alternative energy resources contributing towards sustainable development in rural Swaziland. It further highlights barriers that exist to the purchase and use of improved and cleaner cookstoves. This research will be beneficial to the Government of Swaziland in identifying gaps in clean cookstove programme implementation and thereafter contribute to the development of strategies for improving access to sustainable energy solutions for rural households. The study focuses on three objectives which are to:

a) Identify current cooking fuels and technologies being used in the Siphofaneni area;
b) Assess how much knowledge households in the Siphofaneni area have of clean cookstove technologies and cooking fuels;
c) Undertake an analysis of the acceptance of clean cookstoves in the Siphofaneni area.

1.3 METHODOLOGICAL CONSIDERATIONS

A survey was conducted through the dissemination of a questionnaire to households in the Lower Usuthu Sustainable Land Management (LUSLM) project area, in Siphofaneni, Swaziland, to collect primary data on household demographics, household energy use patterns, cooking technologies used as well as knowledge of and attitude towards cleaner cookstoves. The primary data were substantiated with findings from other studies, policies and similar programmes conducted in other developing countries.

This research focused on household stove users in six chiefdoms in the LUSLM project area, in Siphofaneni, Swaziland. The target participants were women who are mostly responsible for cooking in Swazi homes. However, in cases where the women were not available, men were interviewed; particularly single men or those men involved in some way or another in the cooking process. The Swaziland Household Income and Expenditure Surveys covering the years 2000–2001 and 2010–2011 revealed that sources of energy in rural households include woodfuel, electricity, LPG, coal and biomass residues, used mainly for cooking and lighting. This research project focuses on energy for cooking, and in particular the use of woodfuel (GOS, 2001; GOS 2011).

The scope of this study did not permit an examination of all Chiefdoms in the LUSLM project area, which would have required additional time and financial resources to fund enumerators and transport. Interviewing child headed households is sensitive and additional authorisation and monitoring would have been required from community leadership which would have increases the data collection timeframe beyond what was acceptable to the LUSLM project for this research. Furthermore, the socio-economic issues affecting the Chiefdoms, such as lack of water and employment, were not dealt with, even though it is acknowledged that such issues were raised in some responses and are therefore important to focus on in future research.

1.4 DISSERTATION OUTLINE

This dissertation consists of seven chapters. The first chapter introduces the research, outlining its aims and objectives. The second chapter gives a profile of Swaziland, including the study area in terms of geographic location and characteristics of the energy sector. Chapter three proceeds to describe the methods and approached followed throughout the research process. The literature review in chapter four gives more context to the research, discussing previous relevant research to this study. The research results are then presented in chapter five, outlining the important findings and trends, which are further analysed in chapter six. The research is concluded in chapter seven, which also provides recommendations for further study. The following chapter gives an outline of Swaziland, focusing on the study area while also providing an overview of the energy sector in Swaziland.

2 CHAPTER 2: COUNTRY PROFILE

This study was conducted in the Siphofaneni area, situated in the Lubombo region in Swaziland. This chapter aims to profile Swaziland with more focus on the study area. Swaziland is a landlocked country in southern Africa, located between the 25^{th} and 28^{th} parallels and longitudes 31º and 32º east. Swaziland is bordered by Mozambique in the east and South Africa in the north, west and south (Stringer *et al.*, 2007). The approximate geographic area of the country is 17, 360km^2 (Matondo *et al.*, 2005). Swaziland has four administrative regions which are Hhohho, Lubombo, Manzini and Shiselweni (GOS, 2007b). Swaziland's population was estimated at approximately 1.08 million people in 2007 (GOS, 2007b). Seventy seven percent of the total households in Swaziland are located in rural areas and acquire land through traditional structures (Manyatsi and Hlophe, 2010). There are two land tenure systems in Swaziland which are Swazi Nation Land (SNL) and Title Deed Land (TDL) (Mabuza *et al.*, 2013; Nkondze *et al.*, 2014).

Approximately 74% of the total land in Swaziland is SNL which has multiple purposes which include leasing to private companies for agribusiness for export commodities such as sugarcane, pineapple, citrus, beef, dairy, poultry and timber production (Mabuza *et al.* 2013). The largest portion of SNL, about 50% of total land area, is land which is held under customary tenure and is where the rural population build their homesteads, are allocated fields for agricultural activities as well as having access to communal grazing land (SEA, 2002). These households do not own the land but merely have permission to use which means SNL cannot be used as collateral for loans prohibiting a majority of individual households and communities from accessing financing for commercial activities on their land (Mkhabela, 2006). SNL therefore despite being the largest share of land in Swaziland, has a significantly low contribution to Swaziland's Gross Domestic Product (GDP) which hinders development as 75% of Swaziland's rural population is classified as living below the poverty line and are therefore not able to access finance for improved technologies (Terry, 2007). The limited size of arable land allocated to each family also informs decision making on the type of technology to be adopted while also impacting profitability of agricultural production due to economies of scale (Mabuza *et al*., 2013). A concern that arises is therefore is what happens as the population increases and land availability decreases?

2.1 SWAZILAND'S AGRO-ECOLOGICAL ZONES

Swaziland's physical landscape is categorised into four agro-ecological regions which are the highveld, middleveld, lowveld and Lubombo. The highveld is located in the western part of the country, at altitude ranging from ~1000 to 1200 metres above sea level (m.a.s.l.) (Loffler and Loffler, 2005). The altitude of the middleveld is between 400 to 900 m.a.s.l. and it characterised by a steep to gentle sloping landscape. The middleveld is divided into the upper middleveld (600-900 m.a.s.l.) and lower middleveld (400-600 m.a.s.l.) (UNISWA-CTC, 2008). The lowveld is low lying and gentle sloping with an altitude ranging from 200-400 m.a.s.l. The lowveld is also divided into two sub-regions: the western lowveld (200-400 m.a.s.l.) and the eastern lowveld (100-250 m.a.s.l.). This part of the country is relatively dry, with *Acacia* woodlands (UNISWA-CTC, 2008). Large quantities of woodfuel are harvested in this region for household use, where piles are sold along the roadside (UNISWA-CTC, 2008; Loffler and Loffler, 2005). The Lubombo region lies at an altitude of about 250-600 m.a.s.l., with a steep escarpment of the Lebombo Mountain Range to the west and gentle undulating plateau to the east. This region has also experienced reduced canopy cover and veld fires sometimes penetrate deeper into the forests (Loffler and Loffler, 2005).

Swaziland has a sub-tropical climate, characterised by spatial and temporal variation in rainfall and temperature across the physiographic regions (Stringer *et al.,* 2007). The western parts of the country are temperate and the eastern regions are subtropical. The mean annual rainfall ranges between 1500mm in the highveld to 500mm in the lowveld (GOS, 2012). Most of the country's rainfall occurs during the summer season (GOS, 2012). The highveld is generally cooler with a mean maximum summer temperature of about 25^{o}C and mean minimum winter temperature of 10^{o}C. The lowveld has higher temperatures, reaching up to 40°C in summer and a minimum of 5^{o}C in winter (GOS, 2012). Potential for solar technologies to thrive are very high in the lowveld and the Swaziland Electricity Companies has announced the inclusion of solar in the utility's power generation plan (SEC, 2015). The climatic pattern in Swaziland has become unpredictable and erratic, and like many other developing countries, Swaziland is also vulnerable to the impacts of climate change (IPCC, 2007; GOS, 2012). Swaziland's most vulnerable sectors were identified as agriculture and food security, water, health, natural resources and biodiversity (Manyatsi *et al.,* 2010; Nkondze *et al.*, 2014). The country has also experienced persistent drought, high temperatures and changes in rainfall patterns which are critical factors for hydropower generation, and thus make long term planning for increased hydropower a challenge. In addition, occurrences of cyclones, hailstorms, windstorms, wildfires and water shortages have negatively affected biodiversity and agricultural productivity and projections suggest increased vulnerability into the future (Manyatsi *et al.,* 2010; GOS, 2012).

Climate change impacts are expected to be felt in the agricultural sector, which is a major contributor to many African economies, including Swaziland (van Waveren, 2007). Some of the Swaziland's main agricultural activities include sugarcane production in the lowveld, citrus fruit, maize, cotton, managed forests and livestock production (Nkonde *et al.*, 2014). The subtropical climate in the eastern part of the country, particularly in the Lubombo region, is well suited for sugar production (Knox *et al*., 2010). Recent changes in climatic patterns however have necessitated sugar companies to adopt more efficient agricultural practices in irrigation while sugar companies are diversifying into power generation using bagasse (Knox *et al*., 2010; SERA, 2014). Sugar companies have therefore also become power companies and with the introduction of the Swaziland Electricity Company Act (2007), companies such as sugar companies can now become Independent Power Producers and sell power to the national grid (SERA, 2014). Similar developments are being seen in the timber sector where timber plantations occur in the Piggs Peak (Highveld), Bhunya (middleveld) and Nhlangano area (Highveld). Timber companies are also diversifying into power production from woodchips through the introduction of new technologies such as stainless steel boilers (SEC, 2015).

Swaziland has seven drainage basins which include the Lomati, Komati, Mbuluzi, Usutu, Ngwavuma, Pongola and Lubombo; two of which (Komati and Usutu basins) originate in South Africa (Matondo *et al.*, 2005). Projections based on water availability and abstraction on the Komati river basin suggested a reduction in water availability by 2015 (Nkomo and van der Zaag, 2004). At a regional level however, further projections suggest an increase in precipitation in eastern regions of southern Africa (Lumden *et al.*, 2009). Further studies undertaken by Matondo *et al.* (2004a; 2004b; 2004c; 2005) and Knox *et al.* (2010) took into consideration the impact of climate change on the water sector and the results show increased evaporation and decreased precipitation, which points to a decrease in the availability of water for irrigation in future. This is a concern for Swaziland as the agricultural sector in

Swaziland, particularly sugarcane in the Lowveld, is the major consumer of water for irrigation (Knox *et al.*, 2010) while local power base load generation is mainly from hydropower (SERA, 2014; SEC, 2015). Local power generation in Swaziland is from hydropower (60.4MW) and from biomass in the sugar sector (31MW) (SERA, 2014). The impacts of climate change on the water sector will therefore not only impact the agricultural sector, but also impact the energy sector. The 2012 National Energy Balance (Figure 2.1) showed that biomass constituted 53% of the energy consumption in Swaziland in 2012 where 30% was woodfuel used mainly in households and 23% was from bagassed used in the sugar sector. Other energy sources were petroleum products (23%), coal (16%), electricity (7%) and the balance constituted by other undefined sources (GOS, 2012).

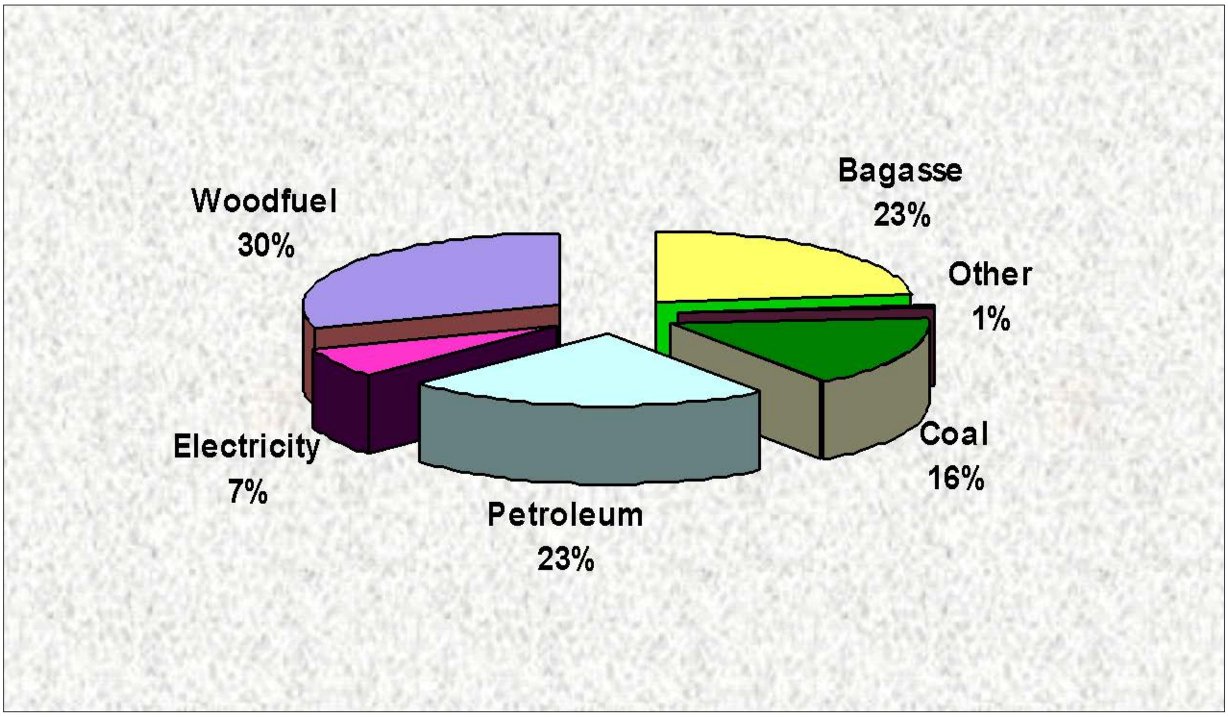

Figure 2.1: Swaziland's Energy Mix in 2012 (GOS, 2012).

The electricity access rate in Swaziland was estimated at 61%, with the rural access rate estimated to be 55% (GOS, 2013b). Regions such as Latin America, the Middle East and North Africa have electricity access rates which range between 80 and 90%, while average access rates in sub-Saharan African are estimated at 30% (Szabó *et al.*, 2013). Data quality tends to be questionable in some African countries; however, the average electricity access rate for South Africa was estimated at 66% in 2010, while in Mauritius it was already at 100% (Brew-Hammond, 2010). Countries such as Rwanda, Sierra Leone, Uganda, Somalia and Chad were estimated at less than 10% (Brew-Hammond, 2010). Statistics derived from the national census conducted in 2007 and the Energy Access Survey conducted in 2013 reveal over 60% of the Swazi population sill use traditional cooking fuels such as woodfuel for cooking (GOS, 2007b; GOS, 2013b). The proportion of the population using solid fuels for cooking decreased from 62.1% in 1997 to 53.2% in 2010 and is further projected to decrease to 50% in 2015 (GOS, 2012). Swaziland's 2012 Millennium Development Goal report also highlighted the rural urban divide where 77.2% of the rural population relies on wood and coal for cooking while 12.9% of the urban of the urban proportion use woodfuel for cooking (GOS, 2012).

Similar high usage rates were found in countries such as India, Indonesia and Sub-Saharan Africa (Brew-Hammond, 2010). In Sub-Saharan Africa, countries such as Burundi, Kenya, Rwanda, Tanzania and Uganda have a woodfuel reliance which is greater than 90% (Mazimpaka, 2014). With population growth and changes in land-use patterns, the availability of trees and shrubs in Swaziland is becoming increasingly threatened (Manyatsi, 1999). Local forests are not only a source of woodfuel, but also medicinal plants and timber (Manyatsi and Hlophe, 2010). The dominant use of woodfuel as a source of fuel for cooking has led to shortages of resources and forced some communities to purchase woodfuel (Madubansi and Shackleton, 2006). Woodfuel in Swaziland is also a commodity and can be sold for an income exceeding US$ 67 per month (Manyatsi and Hlophe, 2010).

Approximately 90% of household energy needs, particularly in rural areas, are for cooking and heating (Bhattacharyya, 2012). The high consumption of woodfuel, coupled with the negative health impacts associated with the burning of woodfuel, has led to the introduction of improved cookstove initiatives in many developing countries, including Swaziland (Grieshop *et al.*, 2011). Having a sustainable supply of energy is important for development and drives economic growth in most economies (Groh, 2014). This is evident through the recent pronunciation of the years 2014 to 2024 being the "Decade of Sustainable Energy for All" by the UN General Assembly (UN, 2013). This has also seen the launch of the Sustainable Energy for All initiative (Szabó *et al.*, 2013). Securing energy supply and energy access for all Swazi citizens is a strategic objective in the National Energy Policy (GOS, 2003). In response to the energy sector needs, Swaziland is engaged in rural electrification initiatives and has developed a Sustainable Energy for All Action Plan to stimulate investment into clean energy, energy efficiency and energy access (GOS, 2014).

2.2 SOCIO-ECONOMIC OUTLOOK ON SWAZILAND

The Swaziland Population and Housing Census revealed that Swaziland's population was estimated at approximately 1.080 million people with an estimated annual growth rate of 0.9% (GOS, 2007b). The Swaziland population growth experienced negative population growth between 1997 and 2007 which was attributed to the relatively high prevalence of HIV/AIDS estimated at about 25.9% of the population in the 15 to 49 year age group while life time expectancy was recorded as 43 years in 2007 (GOS, 2007b). Swaziland has 40.3% of the population in between the ages of 0-14 years make up which those between 15 to 64 years make up 56% of the population and the remainder constituted by age group 65 years and older. Poverty is one of the main developmental challenges which Swaziland is facing. Sixty-three percent of Swaziland's population is reported to be living in poverty, 88% of which reside in rural areas and 67% of this impoverished community are women (GOS, 2014a). Poverty levels also vary between across Swaziland's administrative regions where the Shiselweni and Lubombo regions reported higher levels of poverty than the Manzini and Hhohho regions (GOS, 2012a). Unemployment, reported at 28.5% in 2013 is another developmental challenge for Swaziland, particularly for youth (UNCT, 2014).

Swaziland's development agenda is guided by the National Development Strategy (NDS) which is a long term overarching development strategy with which all policies and programmes for the country are to be aligned with (GOS, 1999; UNCT, 2014). Swaziland has further developed a Poverty Reduction Strategy and Action Program (PRSAP) with a vision to "*attain a level of development akin to that of developed countries while ensuring that all citizens are able to sustainably pursue their life goals, enjoy lives of value and dignity in a safe and secure environment in line with the objectives of sustainable Development by 2022*" (GOS, 2007a; UNCT, 2011). Swaziland aims to realise this vision through concentrated efforts on the following areas: governance; improved economic and environmental management; human capital development; research and development, agricultural development; industrialization and diversification; strategic infrastructure and youth (Dlamini *et al.*, 2014).

2.3 STUDY AREA

This research was centred around the Lower Usuthu Sustainable Land Management (LUSLM) Project, which aimed to introduce improved cookstoves as an intervention towards the introduction of sustainable land management initiatives in the project area (SWADE, 2013).The Lower Usuthu Sustainable Land Management (LUSLM) Project is a project funded by the International Fund for Agricultural Development (IFAD), the Global Environment Facility (GEF) and the Swaziland Government. The aim of the project, which is still ongoing, is to promote the use of sustainable land management practices in the Lower Usuthu area. The LUSLM project is located in the Lubombo region, in the Siphofaneni area (Figures 2.2) (SWADE, 2013). Siphofaneni is one of 55 administrative constituencies (also known as *Tinkhundla*) which are centres for social and economic development and also used for election of members of parliament, local administration and provision of basic government services (GOS, 2007b). Each constituency has several chiefdoms which are predominantly rural communities governed under traditional authorities. In total, there are 180 chiefdoms in Swaziland, administered through Swazi Law and Custom (Stringer *et al.*, 2007). The Chiefdoms and Sections in the LUSLM project area are shown in Figure 2.2, however, the areas targeted for this research are:

i. **Mphumakudze:** Sidlangatsi and Mphumakudze
ii. **Gamedze 1:** Ntfondvo and Lanjane
iii. **Mkhweli:** Mkhaya, Phuzumoya, Mfigini/Siphofaneni
iv. **Nceka**: Magojela, Sankolweni and Sikhunyana
v. **Luhlanyeni:** Mgambeni, Luhlanyeni and Vovovo
vi. **Mamisa:** Gucuka, Mamisa and Malayinini

The LUSLM Project was initiated for the benefit of communities which, based on their geographic location, did not benefit from the use of irrigation water from the Lower Usuthu Irrigation Project (LUSIP) dam for the irrigation of sugar plantations, but could potentially be affected by the negative impacts of the LUSIP project on land resources (SWADE, 2013). The LUSLM Project had the following objectives:

i. To promote development and mainstreaming of a harmonized, cross-sectoral approach to sustainable land management (SLM) at the national level;

ii. To reduce land degradation, biodiversity loss and mitigate climate change;
iii. To improve the livelihood opportunities, resilience and food security.

The LUSLM project plan identified afforestation - planting of new trees in an area where there were previously no trees; reforestation – replanting of trees where they have been harvested and forest conservation – protection of already existing trees (SWADE, 2012). Trees are an important source of woodfuel in rural communities as categories. Trees and other forms of biomass are also important for soil nutrition and the prevention of soil erosion, all of which are forms of land degradation (SWADE, 2012). The promotion of the use of clean cookstoves was therefore an intervention which was found suitable to reduce the rate at which trees are harvested for woodfuel. However, prior to the promotion of clean cookstoves, it was important for the LUSLM project to develop a baseline on awareness, acceptability and penetration of clean cookstoves in the project area as a result of the Government led Programme on Basic Energy Conservation (ProBEC), which has an ongoing programme on the promotion of clean cookstoves (GOS, 2013a).

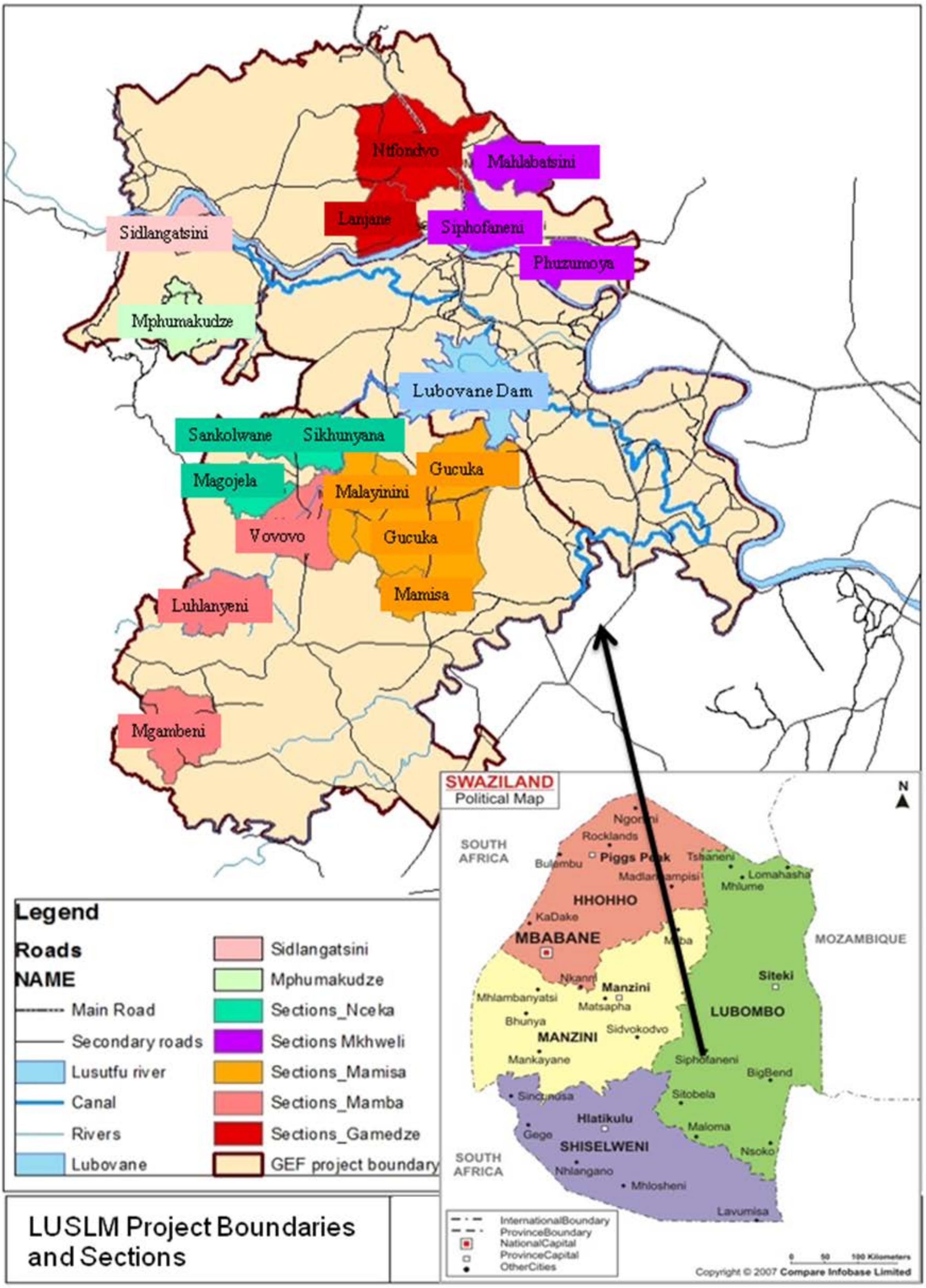

Figure 2.2: Map showing the location of the sampled area (after SWADE, 2013; Compare InfoBase, 2015).

3 CHAPTER 3: RESEARCH METHODOLOGY

This chapter describes the methods and tools used to conduct this study which assessed the acceptability of clean cookstoves in the Siphofaneni area. It first describes the theory behind the qualitative and quantitative approaches to research followed by the research approach. This includes the primary and secondary collection of data, data requirements and sources, data analysis and report writing. The ethical considerations observed are also described in this chapter.

3.1 RESEARCH APPROACH

The process of creating a theory, measuring variables and the collection of data for the purposes of testing a hypothesis is what constitutes social research (May, 2001). Social research explores and describes the relationship between variables where researchers draw conclusions from these relationships (Flowerdew and Martin, 2013). Various approaches can be used to carry out social research such as qualitative and quantitative approaches (Burns, 2000). The approach taken and tools used ultimately depend on the aim and objective of the research (Mouton, 2001). Other types of research combine approaches through a process called triangulation which is a mixed methods approach (Toloie-Eshlaghy *et al.*, 2011; Wisdom *et al.*, 2012).

Qualitative analysis has the ability to improve the understanding of the context in which the literature being assessed was developed (Mouton, 2001). It was used to interpret and reveal concepts and meanings of social phenomena through approaches such as direct observation, analysis of text and discussion with participants (Miles and Huberman, 1994; Hay, 2010). Quantitative analyses on the other hand deal with evidence which can be quantified and subjected to statistical analyses to substantiate claims (Clifford *et al.*, 2010). The quantitative approach was therefore found to be relevant in answering the research questions and objectives presented in Chapter 1. This research followed a quantitative approached as it sought to quantify variables such as: i) behaviour, which describe trends in of energy sources and cooking technologies used ii) attitudes, opinions and beliefs with regards to clean cooking technologies. In addition, the quantitative approach sought to classify the population in the survey area according to various demographic variables such as family size and level of education of breadwinner.

3.2 Research Design

A preliminary literature review was first undertaken to give insight into the research and to identify the research gap where authors such as Marufu (1997), Heltberg (2004), Brew-Hammond (2010) and Bazilian *et al.* (2012) highlight the challenge of low energy access and the high dependence on woodfuel in the developing world. Research into energy use patterns also revealed the introduction of clean cookstove programmes around the world which have had varying success while also highlighting critical success factors such as stakeholder involvement. The review of work by Authors such as Chartrand and Bargh (1999), Assefa and Frostell (2007), Trancoso *et al*., (2007) Ruiz-Mercado *et al. (*2011) and Lui, Wang and Mol (2013) enhanced the understanding of role and importance of social perception in decision making for the roll out of new technologies.

Swaziland’s energy balance revealed a high dependence on biomass as an energy source. Swaziland was chosen as an area of focus as the literature review also revealed that Swaziland has a rural electrification programme as well as a clean cookstove programme however when contrasting electricity access rates, level of woodfuel use and the uptake of clean cookstoves nationally, it was revealed that the is a gap in these policy interventions, particularly where it pertains to the rural population.

In preparation for Primary data collection, the Lower Usuthu Sustainable Land Management Project was identified as a project seeking to introduce clean cookstoves as part of sustainable land management solutions which therefore provided an opportunity to conduct a baseline assessment on the perception of clean cookstoves in that area as it was envisaged that the findings of this research will be beneficial in shaping the clean cookstoves programme for the project area. The primary data were collected using a questionnaire. Detailed literature review was then conducted through the use of journals to obtain more information on what informs energy choices, the linkage of energy with other development issues to place energy in a wider context, and critical success factors for cookstove programmes. Additional secondary data were obtained from published statistics, national reports and surveys. The national reports used which include the National Housing and Population Census, the Swaziland Household Income and Expenditure Surveys, the Swaziland Energy Access Report, were important secondary data which defined the national context as it pertained to energy use patterns, socioeconomic conditions and clean cookstoves. The next step entailed reviewing and sorting of data collected, which was then analysed and interpreted for purposes of presenting findings, drawing conclusions and making recommendations. The final stage entailed report writing and editing.

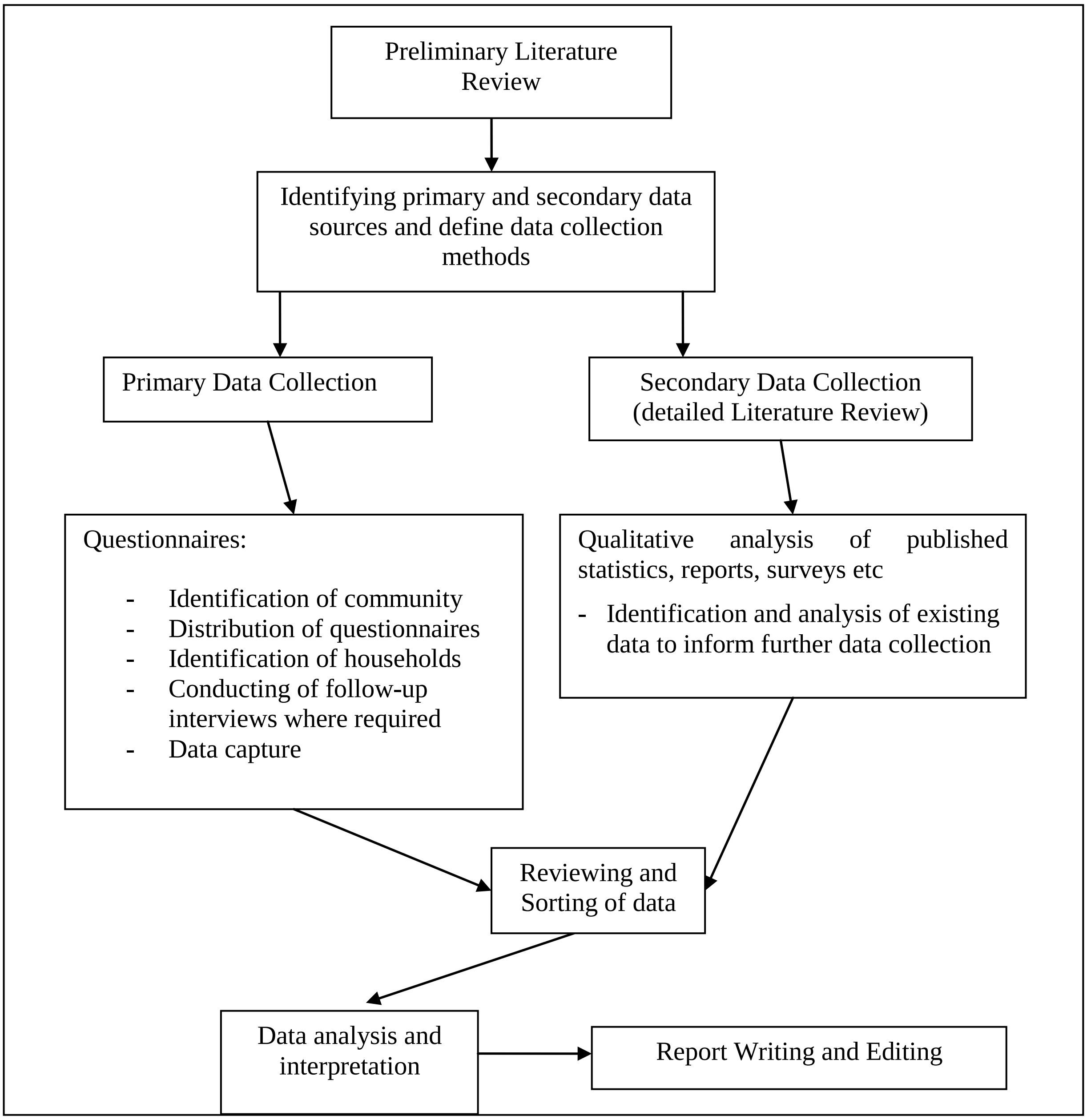

Figure 2.3: Flow chart of research design and methodology to be followed.

3.3 SAMPLE SELECTION

The study aimed to obtain views on cookstoves and the attitude of rural households towards them. This therefore necessitated the need to target the stove users in the family, which is mostly women and female children (Agenbroad *et al.*, 2011; Burwen and Levine, 2012). The unit of study in this survey was therefore primarily women, as they are responsible for cooking in the household. However, single men and heads of households were not excluded in cases where women could not be interviewed.

The identification of the units of study and the target population are important in the planning phase of a survey (Neuman, 2013). The target population can be defined either by geographic boundary, temporal boundary or a boundary defined by population characteristics (Clark, 1997). The survey targeted 18 sections under six chiefdoms in the Siphofaneni area in Swaziland. The LUSLM database estimated the total number of households in the targeted area at approximately 1383. This research targeted 1217 households across the survey area. Using the assumption that one homestead has at least one household, the overall sample rate for the survey was approximately 88%.

The chiefdoms and sections surveyed which made up the sampling frame were pre-defined by the LUSLM Project Manager. The systematic sampling approach was used based on accessibility of each Chiefdom and distance from Siphofaneni town. The distance between each household, terrain and time were factors determining the number of samples in section. The LUSLM project, through previous surveys, developed a database of all households in the project area. All households have household numbers and household information is documented on the LUSLM information management system through the use of Geographic Information System (GIS) for ease of location and identification.

Table 3.1 shows the number of homesteads in each section and the number of households which were sampled. A homestead is defined as a collection of households where each household is nucleus made up of family members who eat from the same kitchen (GOS, 2007b).

Table 3.1: Table Showing the Number of Households Sampled in each Section.

Chiefdom	Section	# Homesteads	# Households Sampled
Mphumakudze	Sidlangatsini	33	31
	Mphumakudze	71	76
Gamedze 1	Ntfondvo	46	46
	Lanjane	56	56
Mkhweli	Mkhaya/Mahlabatsini	59	72
	Phuzumoya	59	63
	Mfigini/Siphofaneni	118	79
Nceka	Magojela	75	72
	Sankolwane	70	66
	Sikhunyana	62	46
Luhlanyeni	Mgambeni	160	113
	Luhlanyeni	100	98
	Vovovo	230	181
Mamisa	Gucuka	71	60
	Mamisa	73	69
	Malayinini	100	89

3.4 Primary Data Collection Method

Various data collection techniques include focus groups, participant observation, interviews and surveys (May, 2001; Flowerdew and Martin, 2013). The ultimate method chosen is depended on the aims and objectives of the study as well as the variables being investigated (Clifford *et al.*, 2010). The methods used to collect data in this research are further described.

The primary data collection entailed the dissemination of a questionnaire (Appendix A) which contained both structured and semi structured questions to permit answering of core questions as well as elaboration where questions required more explanation (Clark, 1997; May, 2001). Questionnaires disseminated during a survey are data collecting tools which help to obtain information about certain aspects and characteristics of people's lives which cannot be found in published sources (Gomez and Jones, 2010). Perception surveys using a questionnaire as a data collection tool were also used by Tukana and Lloyd (1993) and Burwen and Levine (2012) to assess attitudes and cooking practices in Fiji and Ghana respectively.

The questionnaire was administered through face-to-face interviews with the respondents. Enumerators were provided with questionnaires, stationery and maps, identifying households by their numbers. Mixed responses were received, where some households had no respondents, some were not eager to be part of the survey and some respondents were reluctant to answer personal questions such as income levels. Sections with low response rates were therefore prioritised for revisits.

The questionnaire sought to measure the following key variables demographic characteristics of respondents which were control variables control variables that partly reflect perceived behavioral control such as age, gender, education and income, (Liu Wang and Mol, 2013). Variables associated with household energy consumption were household energy types, perceptions on current energy and cookstove technology usage. Although it may very often be overlooked, social acceptance is one of the most important requirements for the successful adoption of any technology, such as energy infrastructure technologies (Heras-Saizarbitoria *et al.*, 2011). Variables associated with attitude/towards environmental conservation and clean cooking technologies were attitudes towards energy efficiency and alternative energy, as well as knowledge of and attitude towards cleaner cookstoves. This level of detail was not been covered in the national surveys. The questionnaire (Appendix A) divided into five sections. Section A focused on demographic related questions. Section B focused on questions related to source of energy while section C dealt with cooking technologies and cooking patterns. The knowledge and perception of clean cookstoves was established in section D. Knowledge in this survey referred to whether or not the respondents were aware of clean cookstoves and how they became aware of them. Questions related to household income and expenditure were placed in section E due to the sensitivity of these questions and the anticipation of some respondents not being comfortable responding to them.

In line with LUSLM policies, the fifteen (15) enumerators used to administer the questionnaires for this research were recruited from within the LUSLM project area. A training manual was developed and provided to enumerators (Appendix B). Training was conducted on the project objectives, enumeration techniques, code of conduct, map reading and interpretation of questionnaire. The questionnaire was tested for suitability and appropriateness prior to dissemination (Babbie, 2010). Pre-testing a questionnaire ensures that the questionnaire is tested for appropriateness in length while also establishing whether the topic is engaging and questions are understood by the respondent (Clark, 1997). Furthermore, it enables the researcher to check whether the data it produces is of appropriate quality as well as enabling questions which found to be sensitive or least desirable to be placed last or eliminated if necessary (Wisdom *et al.,* 2012). The testing phase took place over two days, in the Phuzumoya and Mfigini/Siphofaneni Sections. Feedback from the pre-testing phase was discussed in a feedback session with enumerators, which resulted in improvements being made to the questionnaire.

Further information on the ProBEC which could not be found in published sources was obtained through an unstructured interview with the Programme Officer, N. Dlamini.

3.5 Secondary Data Collection Methods

Secondary research is research based on data that already exist (Mouton, 2001; Babbie, 2010). This section described the literature which was consulted, as well as additional data which were sourced to substantiate the primary data (Mouton, 2001). Sources of this kind of data, according to Singleton *et al*.(1993) may be placed in five broad categories: (1) public documents and official records (2) private documents; (3) mass media; (4) physical, nonverbal materials; and (5) social science data archives. The first and fifth categories were used in the study for secondary data collection.

3.5.1 Government Publications

This study used and makes reference to the Swaziland Housing and Population census of 2007, the Swaziland Household Income and Expenditure Surveys from years 2000 - 2001 and 2010 – 2011 as well as the Swaziland Energy Access Survey of 2013. These surveys provide information on settlement patterns, population size and density, income levels, family size, as well as basic services available to communities including energy services. Census data also provides information on fuel sources utilised in different communities in Swaziland. These national surveys were important to this study as they assisted in demonstrating local relevance and importance of the topic of research and therefore are useful for purposes of observing temporal changes in energy use and for making comparisons (Clifford *et al.*, 2010).

Other national documents consulted include the National Development Plan, the Poverty Reduction Strategy and Action Plan, the Swaziland MDG Report for 2012 and the United Nations Development Action Framework report for the period 2011 – 2015. These documents provided key socio-economic statistics for Swaziland and are public documents therefore freely available from Government Departments and the UNDP.

3.5.2 Online Publications

Additional reports and journals were obtained from Wits online portals. Other freely available published documentation was sourced from organisations such as the International Energy Agency (IEA), International Panel on Climate Change (IPCC). These documents provided information on energy use trends, challenges, programmes and other relevant statistics, theories and case studies.

3.6 DATA ANALYSIS

The survey data were captured into a Microsoft Excel spreadsheet and analysed. Main themes were identified and the response data were organised into categories to identify patterns of similarity and dissimilarities (Babbie and Mouton, 2001). The analysis focused on the following key themes: i) household profiles; ii) fuel use and preferences; iii) current cookstoves being used; and iv) knowledge and acceptability of clean cookstoves. The data analysis also sought to determine if there are any beliefs shared by participants as well as the identification of idiosyncratic beliefs, which are beliefs mentioned by only a single participant (Francis *et al.*, 2010). The use of tables and graphs was used to portray energy use trends, to aid in the classification of households (Mouton, 2001). Main themes were also identified from secondary data contained in journals and reports in line with the research objectives (Babbie and Mouton, 2001).

3.7 Ethical Considerations For The Questionnaire And Interviews

Ethical considerations are important as they ensure that the researcher takes responsibility for his or her actions (Proctor and Smith, 2003). It is important to exercise sensitivity when conducting research to ensure that people are treated with respect and integrity (Clifford *et al.*, 2010). Ethical behaviour therefore protects the rights if the individuals, communities and the environment which forms part of the research (Gomez and Jones, 2010). The research survey officially introduced the survey through local authorities by the LUSLM Officials, as part of the ongoing larger surveys being conducted under the LUSLM project. This initial introduction assisted in obtaining authority, buy-in and raising awareness on this survey, at household level. This research was also conducted in line with the principles laid out by the Ethics Committee of the University of Witwatersrand. All relevant consent was obtained from the respondents who needed to clearly understand the aim and objectives of this research, as well as any risks and benefits that may arise. Household names and numbers were known, due to the survey being part of an ongoing development project; however, such details have been kept confidential and were not used in the report. Information sheets contained in appendix C were presented to respondents in the questionnaire, to inform participants of their right to withdraw from participating in the questionnaire and interview at any time, as well as the right to refrain from answering any question they wished not to answer.

4 CHAPTER 4: LITERATURE REVIEW

This chapter examines important concepts related to this research. It describes global energy access, with a focus on developing countries. It presents a review on energy access trends and household energy choices through the energy assessing the ladder model, multiple fuel use and fuel switching concepts. The literature also focuses on cooking fuels, reviewing global biomass use and cookstove technologies and cooking patterns. Research on clean cookstove programmes was also investigated, focusing on benefits, adoption methods as well as successes and challenges of clean cookstove initiatives around the world.

4.1 GLOBAL ENERGY ACCESS

Energy access tends to be associated mostly with access to electricity. However, in the context of developing countries, the rural energy mix comprises energy sources such as wood fuel, charcoal, waste, dung, agricultural residues, candles, coal and paraffin (Marufu 1997; Heltberg, 2004). Various studies have shown the link between energy access, economic, social development and ultimately the attainment of Millennium Development Goals (Modi *et al.*, 2005; Brew-Hammond, 2010; Bazilian *et al.*, 2012; Kahsai *et al.*, 2012; Groh, 2014). Ajayi (2013) and Mandelli *et al.* (2014) highlight the rich fossil resources base Africa has in coal, oil and gas, as well as hydropower and other renewable energy sources, however, the lower installed capacity per capita is still very low. This confirms the poor access to electricity by households, which is due to factors such as poor infrastructure and high electricity tariffs in sub-Saharan Africa (Balachandra, 2011; Kahsai *et al.*, 2012).

North Africa and Mauritius have high electricity access rates which are 97% in Libya, 98% in Algeria and Egypt, 99% in Tunisia, and 100% Mauritius (Brew-Hammond, 2010). These access rates compare well with China, the Middle East and Latin America, where the average access range is 80% – 90% (Szabó *et al.*, 2013) (Table 4.1). Data vary depending on the institution they were sourced from. Although Asia has the largest number of people living without access to modern energy, this number only makes up 17% of developing Asia while in sub-Saharan Africa 68% are without access to modern energy and 79% rely on woodfuel for cooking (Bazilian *et al.*, 2012). In East African countries such as Tanzania, Burundi and

Uganda, woodfuel consumption has contributed to over 90% of total energy consumption (Karekezi and Turyareeba, 1995; IEA, 2012). This comparison shows that Sub-Saharan Africa is therefore lagging behind in terms of access.

Table 4.1: Share of Population without Access to Modern Energy Services by Region in 2010.

Developing Countries	**Population without access to electricity**	**Population using woodfuel for cooking**
Africa	**57%**	**68%**
Democratic Republic of Congo	*85%*	*93%*
Ethiopia	*77%*	*96%*
Kenya	*82%*	*80%*
Nigeria	*50%*	*74%*
Tanzania	*85%*	*94%*
Uganda	*92%*	*96%*
Other Sub-Saharan Africa	*56%*	*75%*
North Africa	*1%*	*1%*
Developing Asia	**18%**	**51%**
Bangladesh	*54%*	*91%*
China	*0%*	*29%*
India	*25%*	*66%*
Rest of Developing Asia	*34%*	*54%*
Latin America	**6%**	**14%**
Middle East	**9%**	**5%**
World	**19%**	**38%**

Source: IEA, 2012.

Some of the least electrified countries in Sub-Saharan Africa include Chad, Somalia, Uganda, Sierra Leone and Rwanda (Brew-Hammon, 2010; IEA, 2012). Table 4.1 contrasts electricity access rates with population using woodfuel for cooking. The data also show that despite high electrification rates in China and India, there is still a significant proportion of the population which uses woodfuel. These countries have large populations which require various sources of energy other than electricity such as woodfuel, biogas, LPG and kerosene to meet the demand (Balachandra, 2011; Niu *et al.*, 2014). Charcoal is also a frequently used fuel in rural households, primarily for cooking purposes, although used more predominantly in urban areas (Johnson and Bryden, 2012). The burning characteristics of charcoal result in lower emissions and a higher energy output (Troncoso *et al.*, 2007; Mazimpaka, 2014). Although it has been promoted as more appropriate than woodfuel, its production process is inefficient and it is still less ideal than modern forms of energy (Zulu and Richardson, 2013).

Swaziland's electricity access rate was reported at 61%, which is higher than the average rate for sub-Saharan Africa (GOS, 2013b). The dependence on woodfuel was reported to be 47.4% (nationally), with the majority of these households being in rural areas. Other primary energy sources for cooking are LPG, paraffin (GOS, 2013b). Findings from the electricity access survey conducted in 2013 compliment the findings depicted in Figure 4.1, which demonstrate the link between energy use and socio-economic status.

2000/01

	Lowest	Second	Third	Fourth	Highest	Total
Wood	94.8	86.0	76.9	56.4	21.1	58.8
Coal	0.0	0.5	1.5	3.5	3.1	2.1
Electricity	0.0	2.1	3.1	10.8	43.1	16.7
Paraffin	3.5	7.4	10.6	14.5	8.3	9.3
Gas	1.7	4.1	7.9	14.8	24.4	13.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Computed from the Swaziland Household Income and Expenditure Survey, 2000/01.

2009/10

	Lowest	Second	Third	Fourth	Highest	Total
Wood	95.4	85.3	67.6	43.9	14.2	51.6
Coal	0.8	2.6	2.3	2.4	0.5	1.6
Electricity	0.8	3.7	13.1	26.6	61.0	28.4
Paraffin	2.8	5.1	5.9	8.9	4.5	5.6
Gas	0.1	3.3	11.0	18.3	19.8	12.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Computed from the Swaziland Household Income and Expenditure Survey, 2009/10.

Figure 4.1: Percentage of households using different types of energy for used for cooking from the lowest to the highest income quintile, (GOS, 2001; 2010).

Figure 4.1 shows that households with the lowest income use woodfuel for cooking while those with the highest levels of income use electricity and LPG, which is linked to affordability. Statistics show that households with a higher income can afford to purchase their energy, opting for modern convenience and cleaner forms of fuel such as electricity and

LPG. Electrification programmes are being undertaken in many African countries (Howells *et al.*, 2005; Bhattacharyya, 2006). The governments of Zimbabwe, Kenya, South Africa and Swaziland have also invested in electrification programmes (Marufa *et al.*, 1996; Kituyi *et al.*, 2001; Howells *et al.,* 2005; Madubansi and Shackleton 2006; GOS, 2013b). As a result, Swaziland's electrification rate has increased from 26% in 2007 to 61% in 2013 (GOS, 2007b; GOS, 2013b). The main barrier to households accessing electricity is affordability, a combination of high energy prices and low household incomes, particularly in rural areas (Shackleton *et al.,* 2006; GOS, 2013b). To promote increased access, the South African Government introduced incentives such as the Free Basic Allowance which however has not significantly reduced the dominance in the use of woodfuel (Shackleton *et al.,* 2007). Household energy use, particularly energy for cooking, accounts for a large share of energy use in comparison with other demand sectors (Sesan, 2012).

These findings, when contrasted with those on electricity access and biomass use, indicate that there is still a challenge with regards to biomass, and justifies efforts to introduce biomass related interventions in countries. Despite being electrified, rural households still use woodfuel for cooking and water heating due to their large thermal demands (Vermeulen *et al.*, 2000). The majority of biomass used for fuel is obtained by individual gathering as opposed to being marketed; therefore inadequate data records are kept and household biomass statistics is largely estimated (Ludwig *et al.*, 2003). The World Energy Outlook (2012) reports that over 1.8 billion people in developing Asia and approximately 700 million people in sub-Saharan Africa lack clean cooking facilities (IEA, 2012). India and China are the top two in developing Asia and account for more than half of the global total (Pachauri and Jiang, 2008). In Sub Saharan Africa, Nigeria, Ethiopia and the Democratic Republic of Congo had the highest populations relying on biomass for cooking (IEA, 2012).

The developed world in contrast has modern energy sources such as electricity and gas as primary sources of energy for cooking however also have coal and woodfuel forming part of their energy mix (Sander *et al.*, 2011). Although woodfuel consumed in developed countries contributes a significant share of the global woodfuel consumption, it is a form of energy that is not of high significance in their energy budgets.

4.2 THE ROLE OF SUSTAINABLE ENERGY IN THE DEVELOPMENT AGENDA

Energy is important in a household as it is used for activities such as cooking, water heating, space heating, water pumping, refrigeration, lighting and powering appliances (Vermeulen *et al.*, 2000; Birol, 2007). The ability for woodstoves to serve multiple purposed can explain the reason why woodstoves cannot be easily replaced by electric stoves, which makes fuel switching difficult (Howells *et al.*, 2005). Cooking with electricity and gas, however, is relatively cleaner and more efficient than coal and biomass (Heltberg, 2004). In addition to cooking, modern energy services also play an important role in the provision of water and sanitation services, powering of machinery and equipment, transportation and communication (Kebede *et al.,* 2010). Electrification also drives economic processes while its sustainable production and use reduce environmental degradation (Kanagawa and Nakata, 2007). Health, education and environmental protection are the overarching themes to the MDGs (Clarke and Feeny, 2011). The role that sustainable energy plays in the development agenda has been re-emphasised with sustainable energy being proposed as one of the post-2015 Agenda sustainable development goals (Shyu, 2014). Sustainable access to energy, defined as the provision of energy that is accessible, cleaner and more efficient, has an important role in improving quality of life (Bazilian *et al.*, 2012; Bhattacharyya, 2012; IEA, 2013). Sustainable energy supply is therefore crucial for economic and human development (Shackleton *et al.*, 2007). It ensures that while energy is being provided to meet the current energy needs, there is limited harm to the environment and energy sources are exploited in such a manner that ensure availability of energy resources in the future (Pachauri and Spreng 2011; Bhattacharyya, 2012).

The developing world is plagued by many challenges which include climate change, poverty, lack of access to sustainable energy, energy security, land degradation and HIV/AIDS (Mushala, 2003; IPCC, 2007; Thomas *et al.*, 2008). Energy poverty is still a growing concern despite Africa being rich in natural resources. Mozambique, Zimbabwe, Botswana, Swaziland and South Africa are rich in coal resources while countries such as Angola, Nigeria, Mozambique and Ghana are rich in natural resources such as oil and gas (Saha, 2003; Musango and Brent, 2011). Southern Africa also has substantial hydropower potential in the Democratic Republic of Congo, Mozambique and Zambia (Mandelli *et al.*, 2014).

4.2.1 Energy Poverty

Poverty is commonly addressed from an economic perspective, resulting in the inability to purchase food items which enable households to prepare daily meals (Pachauri and Spreng, 2004; 2011). The lack of food is exacerbated by the inability to cook due to energy sources being inaccessible. This inaccessibility may be related to depleting biomass resources or high energy prices (Sagar, 2005). The concept of energy poverty came about through the identification of the linkage between the lack of energy and poverty (Kees and Feldmann, 2011). Energy poverty is one of the barriers to achieving sustainable development. However, energy poverty remains a neglected topic in development initiatives (Shyu, 2014). Energy impoverished communities lack access to modern energy, resulting in the reliance on biomass, particularly for cooking (Bazilian *et al.*, 2012). The heavy reliance on traditional biomass for household energy needs, particularly in developing countries, also has a significant bearing on energy poverty (Birol, 2007). It is estimated that 1.6 billion people in developing countries do not have household access to electricity, the majority of which are located in South Asia and Sub-Saharan Africa (IEA, 2012; Szabó *et al.*, 2013).

Links between poverty to environmental degradation through the unsustainable use of woodfuel have also been identified (Geist and Lambin, 2002; Mataya *et al.*, 2002). In addition, issues of energy poverty cannot be addressed without addressing energy governance, which looks into the actors, institutions and processes involved in decision making on energy service provision (Bazilian *et al.*, 2012). Energy governance therefore goes beyond just addressing energy access needs but also takes into account affordability of energy services as well as the quality of the energy services being provided (Bazilian, *et al.*, 2012).

4.2.2 Linking Sustainable Energy and Climate Change

The link between climate change and sustainable development arises from the urgent need to mitigate greenhouse gases as well as the need to adapt to the projected impacts of climate change (Winkler *et al.*, 2006). Climate change impacts manifest themselves through the rise in sea level and changes in precipitation (frequency, timing, intensity), while also contributing towards frequent storms and floods in some areas whilst other regions experience droughts (IPCC, 2007). In its first assessment report the IPCC projected average temperature increases of between 0.15 ºC and 0.3ºC per decade (Nkondze *et al.*, 2014). The warming rate experienced in the African continent in the twentieth century was about 0.5ºC per century with the warmest years occurring between 1987 and 1998 (Hulme *et al*., 2001). Climate scenarios indicated that global temperatures could increase by 3% by 2050 (IPCC, 2007). Rainy seasons are projected to have increased precipitation while the dry seasons are projected to become drier (Lacombe *et al*., 2012). Temperature projections for southern Africa indicate likely increases in temperature and evapo-transpiration (Matondo *et al.*, 2004a; Lumsden *et al.,* 2009; Nkondze *et al.,* 2014). The implications for southern Africa are that it will experience a late onset and shorter rainy season (de Wit and Stankiewicz, 2006; New *et al*., 2006). Water availability is likely to decrease by up to 50% in semi-arid regions of southern Africa (Srinivasan, 2010). These forecasts are a concern for southern African due to its dependence on its natural environment and its ecosystems to support livelihoods through subsistence farming and provision of firewood, making it highly vulnerable to the impacts of climate change (Shackleton *et al*., 2006; Kepe, 2008; Manyatsi and Masarirambi, 2010). The high levels of poverty in developing and least developed countries reduced the capacity to adapt to climate change (Tor *et al*., 2004). A temperature rise exceeding 3.5ºC could result in extinction of 40 – 70% of plant and animal species (IPCC, 2007; Srinivasan, 2010).

4.2.3 The Energy and Water Nexus

Changes in temperature, precipitation and evapo-transpiration have a direct impact on power generation (IPCC, 2007). Focusing on Egypt, where power installations require freshwater for cooling, the impacts of climate change coupled with rapid economic growth will have serious consequences for both water and energy demands (Siddiqi and Anadon, 2005). Similar challenges are foreseen in catchment areas such as the Congo and Zambezi where projected increases in average annual rainfall as well as increases in temperature and decreases in precipitation due to climate change will lead to decreased run-off and river flows (Mukheibir, 2007). This in turn will negatively affect hydropower production (Harrison and Whittington, 2002). Kenya and Tanzania in east Africa have in the past decade experienced shortages in electricity which were linked to seasons of drought (Mwema and Gheewala, 2012; Achieng Ogola, 2012). The Inga in the Congo Basin and Cahora Bassa Dam in

Mozambique have large potential for increased hydropower generation to supply the southern African Power Pool, however, these schemes are also threatened by the impacts of climate change (Beck and Bernauer, 2011; Cole *et al.*, 2014). Any shortages in power not only affect Mozambique and the Democratic Republic of Congo, but also countries which form part of the power pool (e.g. South Africa), which is highly dependent on coal for its power production and is under pressure to reduce its high GHG emissions through incorporating renewable energy into its energy mix (Winkler, 2006).

While achieving universal energy access is important, it will inevitably result in an increase in the global energy demand (Bazilian *et al.*, 2012). In order to meet that meeting the goal of universal access by 2030, electricity demand is predicted to rise by 13%, while a threefold increase in installed generation capacity is expected and ultimately a tenfold increase would is required to achieve access for all in sub-Saharan Africa (Bazilian *et al.*, 2012). It is further estimated that Africa will need to increase its installed capacity for power generation from 79 GW to 500 GW to achieve 100% electricity access (Gertler *et al.*, 2011; Wolfram *et al.*, 2012). The future energy mix to be adopted to meet Africa's future energy demand in will ultimately determine the increase in GHG emissions therefore a low carbon path in which renewable energy will play a key role, is necessary (Khennas, 2012). Although there are different assumptions quantifying the resultant emission of the future energy demand, an additional 44 –183 Gt of CO_2 is anticipated (Chakravarty and Tavoni, 2013). The link between energy and economic development has been demonstrated.

4.3 BIOMASS USE IN DEVELOPING COUNTRIES

The combustion of biomass into energy from sources such as woodfuel, charcoal, and non-woody biomass takes place daily all over the world, predominantly in developing countries for multiple purposes such as cooking, heating and lighting (ESMAP, 2003). Bioenergy is also an important energy source in rural communities but is to a lesser extent also used in urban areas of developing countries (Soussan, 1990; Yevich and Logan, 2003). The use of biomass in the form of woodfuel and charcoal is on the decline in Asia but still on the rise in Africa and South America (Arnold *et al.*, 2006). A large share of biomass consumed in sub-Saharan Africa is consumed in the household sector (Musango and Brent, 2011). The different types of biomass used vary within a particular region, depending on resource availability in a particular community. In addition to woodfuel, Swaziland also uses dried grass, cow dung, agricultural waste such as maize stalks and cobs, dried aloe, and dried leaves (GOS, 2013b). Rwanda uses charcoal, woodfuel and briquettes, whilst Zambia, Mozambique and Kenya use charcoal (Mazimpaka, 2014).

In sub-Saharan African, wood-based biomass energy (fuel wood and charcoal) is most dominantly used for cooking purposes (Prasad, 2011; Sander *et al.*, 2011; Iiyama *et al.*, 2014; van der Plas and Abdel-Hamid, 2014). The advantage of using biomass as a fuel, particularly wood based biomass, is owing to its ability to burn directly, to produce heat on open fires, also known as three stove fires and traditional cookstoves, in the developing world (Kees and Feldmann, 2011). Woodfuel in the form of charcoal has a significant market in sub-Sharana Africa, which provides employment opportunities and other benefits for including collectors, harvesters, producers, transporters, wholesalers and retailers (Openshaw, 2010; Iiyama *et al.*, 2014). Woodfuel is sourced from indigenous and private forests, as well as within homesteads, and is often collected free of charge. Where it is bought, it is purchased at relatively cheap prices (Williams and Shackleton, 2002). The harvesting and use of biomass also has its disadvantages which include indoor air pollution, contributing towards global warming as well as contributing towards deforestation. Some of these disadvantages are discussed in the following sub-sections.

4.3.1 Indoor Air Pollution and Global Warming

Statistics reveal that each year there are between 0.8 and 2.4 million deaths which occur as a result of the inhalation of smoke from indoor air pollution, resulting from inefficient burning of biomass when cooking. These deaths occur particularly in women and children under the age of five (Jiang and Bell, 2008; Kees and Feldmann, 2011; Thurber *et al.*, 2014). Indoor air pollution is made worse by poor ventilation in kitchens, and leads to severe respiratory illnesses. The exposure of women and children to these pollutants is high, due to the amount of time they spend around the stove while cooking (WHO, 2006; Agenbroad *et al.*, 2011; Burwen and Levine, 2012). Other factors which determine the levels of indoor air pollution are the type and condition of fuel used, type of stove used for cooking, family size, cooking duration and structural attributes of the kitchen such as ventilation, roofing, floor doors and walls (Singh *et al.*, 2012).

The incomplete combustion of biomass results in the emission of carbon monoxide (CO), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and polycyclic aromatic hydrocarbons (PAHs) amongst others (Torres-Duque, 2008; Hasanudin *et al.,* 2011). Other emissions that occur include black carbon, which is also reported to be a significant contributor to global warming (Ramanathan and Carmichael, 2008; Burwen and Levine, 2012). The burning of biomass for cooking purposes is estimated to contribute between 1–3% towards anthropogenic global warming (Ludwig *et al.,* 2003). Exposure to carbon monoxide reduces the oxygen-carrying capacity of the blood and can lead to unconsciousness and death. Carbon dioxide is an irritant to the respiratory system while nitrogen dioxide causes inflammation of the airway and decreases immune defence in the body, making it susceptible to infection (Torres-Duque, 2008). The burning of woodfuel in the cooking area also gives rise to soot, which settles on the kitchen walls, making them dark and dirty (Jerneck and Olsson, 2013).

4.3.2 Contribution towards Deforestation

When collecting woodfuel, households would initially collect dead, dry braches. As the demand for woodfuel increases though, live woody stems and branches are cut. As these trees are not replaced, this activity over time leads to degradation of the woodland (Aron *et al.,* 1991, Grainger, 1999). Deforestation is on the increase, particularly in Africa, where woodfuel is unsustainably harvested for direct burning for cooking and for the production of charcoal (Brouwer *et al.*, 1997). However, some researchers have argued it is not only energy uses that result in deforestation, however activities such as the timber industry, large scale agricultural production and settlement are bigger contributors towards woodfuel scarcity than woodfuel harvesting for household purposes (Hurst and Barnett, 1990; Masera, 1994; Twine and Siphugu, 2002).

Mechanisms for the regulation of access and use of biomass resources tends not to be effective due to weak enforcement (Manyatsi and Hlophe, 2010; Schure *et al.,* 2014). Informal, socially embedded institutions generally govern access, and the trade is open to less privileged and rural actors. Mwampamba (2007) discussed the challenge of having a fuel mix in which charcoal and firewood are both major sources of woodfuel in Tanzania. The author suggests that the impact of charcoal trade has been underestimated and together with the growing demand for woodfuel, the long term availability of the resource is at risk. In Mozambique, charcoal production has been identified as one of the main causes of deforestation (Cuvilas *et al.*, 2010). Malawi acknowledged the socio-economic importance of woodfuel and is introducing progressive forest policies in an attempt to lift the charcoal ban and introduce commercialising woodfuel production and introducing licensing to enable revenue generation while also ensuring ecological sustainability (Zulu, 2010).

Women and children spend hours gathering firewood and cooking. This practice is not only time consuming but also has safety risks and physical strain from carrying heavy bundles of wood from distant forests (Ruiz-Mercado *et al.*, 2011; Burwen and Levine, 2012). Access to modern energy addresses gender equity and women empowerment issues through reducing the need for women and children to spend considerable amounts of time collecting firewood therefore allowing children to focus on education and women to engage in income generating activities (Kanagawa and Nakata, 2007).

4.4 Factors which Influence the Choice in Energy Sources and Cooking Technology Choices

The previous sections described the energy use situation, narrowing in on biomass as a dominant fuel used in developing countries, particularly rural households. This section aims to explain the reasons behind the choices in energy use through three different models. These are the energy ladder model, the fuel switching model and the multiple stove use model.

4.4.1 Energy ladder model

The household energy transition process assumes the move of energy users from traditional forms of energy such as biomass to more modern forms of energy such as electricity. This transition is influenced by characteristics such as occupation, level of education of the household head, the price of fuel, and ease of access to improved technologies (Foell *et al.*, 2011; Gebreegziabher *et al.*, 2012). This transition can also be defined using the energy ladder concept which assumes a direct relationship between income and the type of energy source (Figure 4.2). The energy ladder is also defined as a hierarchy of fuel sources depicted by increasing prosperity and results in increased cleanliness of the energy source, its efficiency in use, increased cost and improved convenience in its use (Masera *et al.*, 2000).

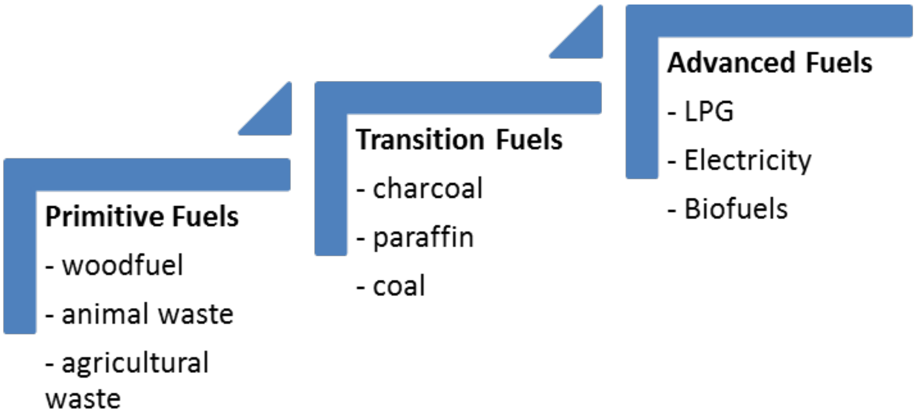

Figure 4.2: Energy Ladder Model (Heltberg, 2004).

Fuel sources such as crop waste, wood and charcoal are found at the bottom of the hierarchy; paraffin (also known as kerosene) further up in the hierarchy and at the top are fuels such as LPG, solar energy and electricity (Heltberg, 2004). Energy ladders are therefore typically characterized by the most affordable energy sources at the bottom, which are preferred by the low-income households, and more expensive fuels at the top. These are higher quality energy carriers, more convenient in use, cleaner in terms of emissions, safer to use, and have a variety of end-uses (Masera *et al.*, 2000). An analysis of the energy ladder model by Arthur *et al.* (2012) revealed flaws in the assumption of choice of energy source being determined mainly by income, as well as the assumption that the price of energy per unit increases as a household moves up the ladder. In their analysis of energy use in Mozambique, they identified cases where biomass proved to be more costly per unit of energy than paraffin or electricity. Cases where paraffin is relatively affordable due to its high efficiency of use and presence of subsidies in certain countries, were also identified, which consequently justified it having a lower ranking on the energy ladder, as it is classified as an energy source for low income households (Arthur *et al.*, 2012).

The case of Tigrai in Ethiopia is one of many cases which demonstrate that there are more considerations other than income which determine the types of fuel used in households (Jan, 2012). Lessons learnt from the Indian National Program on Improved Cookstoves highlight the importance of considering socio-cultural parameters such as traditional cooking habits, type of food, quantity, type of fuel and duration of cooking (Raman *et al.*, 2014). Kowsari and Zerriffi (2011) also proposed the incorporation of human and contextual variables into the household energy transition process. Coupled with income and socio-cultural parameters is the lack of incentives for households to switch from wood based biomass to electricity or other modern forms of energy (Sander *et al.*, 2011). Communities with challenges to access modern fuel due to affordability and availability of modern energy services in the short and medium term will struggle to switch to modern energy sources (Foell *et al.*, 2011).

4.4.2 Fuel Switching Model

The fuel switching model further assumes that households are able to perceive certain fuels and cooking technologies as more preferable than the traditional ones, for all cooking purposes, and this contributes towards the decision to completely substitute the traditional cooking technology once income and access barriers are removed (Ruiz-Mercado *et al.*, 2011). A literature review on energy use and cookstoves has demonstrated that total substitution of cooking fuels and cooking technologies rarely takes place instantaneously. Most households do not completely switch technologies, but adopt a multiple use strategy, in which both new and traditional cooking technologies are used.

A study conducted in Mexico revealed that 31% of households which originally used woodfuel also use LPG (Masera *et al.*, 2005; Troncoso *et al.*, 2007). The use of multiple fuels and cooking technologies in households is therefore documented as common practice in developing countries (Heltberg, 2004, 2005; Ruiz-Mercado *et al.*, 2011). An analysis conducted by Heltberg (2004), comparing findings from Brazil, Ghana, Guatemala, India, Nepal, Nicaragua and Vietnam, revealed that there was a positive relationship between economic development and fuel switching in urban areas, triggered by increased income. Furthermore, the assessment revealed that larger families were more inclined to a multiple fuel use, mixing both solid and non-solid fuels to meet their energy demands. In addition, the findings showed a link between higher levels of education in enticing the use of modern fuels. In Indonesia, an effort was made to substitute the use of kerosene with LPG. The success of the programme was also attributed to the increase in kerosene prices, which acted as a deterrent. Fuel stacking, however, was also observed as the prices of woodfuel and kerosene increased. In line with the findings by Heltberg (2004), levels of education, income and household size were also seen as determinants of the increased uptake of LPG (Andadari *et al.*, 2014). Other factors include convenience and safety (Gupta and Kohlin, 2006).

4.4.3 Fuel Stacking and Multiple stove use

Households in Mozambique satisfy their energy demand for cooking and lighting using a mix of energy sources. Each household will determine its energy mix depending on availability of energy sources and the ability to afford both the fuel and the appliance (Arthur *et al.*, 2012). In Mpumalanga, South Africa, a dominance of the use of woodfuel was observed. A mix of electricity and woodfuel was also observed in some households. Despite the availability of LPG and paraffin as alternate fuels to supplement either woodfuel or electricity, none of the households surveyed reported complete switching and exclusive use of these alternatives (Matsika *et al.*, 2013). The conclusion by Ruiz-Mercado *et al. (*2011) that traditional stoves are not completely abandoned can therefore be validated. This is one of the reasons why the programme on the introduction of solar cookers in South Africa emphasised the solar cookers being promoted as an add-on cooking device to enhance the flexibility in cooking in the targeted households (Wentzel and Pouris, 2007). A similar trend is observed in India, where over 60 % of the households used multiple sources of fuel through a combination of biomass and kerosene or biomass, kerosene and electricity (Dhingra *et al.*, 2008). Although no literature was found on similar assessments for Swaziland, fuel use statistics which show that 50% of rural households are electrified while 71.9% of the same rural population use woodfuel for cooking (GOS, 2013b). This shows that there is a section of the rural population which is electrified, yet still use certain types of wood stove. Further investigations would need to be conducted to confirm this assumption.

This use of multiple fuel cooking technologies by a single household at a given time is termed stacking (Masera *et al.*, 2000). Considering the persistent challenge of poverty and low income in Africa, it is no surprise that there is an increasing trend in the consumption of woodfuel. Domestic fuel mixes therefore need additional input such as subsidies, in order for there to be a significant shift from using primary fuels to more modern fuels such as LPG and electricity (Gundimeda and Köhlin, 2008). Davis (1998) concluded that the use of electricity is likely to displace other fuel and be used as a single fuel in high-income electrified households while low-income electrified households are more likely to be using four or more different types of fuels. It is therefore important for countries to have a comprehensive approach in developing policies aimed at tackling the biomass reliance issues in Africa. Such an approach would need to have multiple solutions to investigations on the barriers to the transition to modern energy in that particular country (Gebreegziabher *et al.,* 2012). Unless these barriers are removed, clean cookstoves will continue to be used as additional cooking technologies as opposed to being replacements of the traditional cooking methods (Johnson and Bryden, 2012). The various cookstove initiatives and the different approaches taken are discussed in the next section. This assessment aims to assist in assessing the applicability of the energy use models that have been discussed in this section.

4.5 SOCIAL PERCEPTIONS TOWARDS RENEWABLE ENERGY TECHNOLOGIES

Rural dwellers are major consumers of energy in rural residential areas however their preferences tend not to be given much consideration in the design and development of public projects (Liu, Wan and Mol, 2013). Social acceptance is an important requirement which determines the uptake and adoption of a new technology such as renewable energy technologies (Heras-Saizarbitoria *et al*., 2011). The importance of social acceptance of new renewable energy technologies has been emphasized in literature by researchers such as Walker (1995), Sauter and Watson (2007) and Diez-Mediavilla et *al*. (2010) where the focus of their research has been on social acceptance of technologies such as wind and solar plants for specific projects.

The advantage of obtaining social acceptance for a particular technological solution is that it increases chances of long term sustainability of a particular solution while also decreasing the time required for project implementation through addressing perception, which can be a major barrier (Assefa and Frostel, 2007). According to Vanclay in Assefa and Frostel (2007), social impacts can be linked to the different level of needs and can also be described as changes to people's way of life, culture, community, political systems, environment, health and wellbeing, personal and property rights as well as fears and aspirations. A Social Impact Assessments is therefore very important decision making tool which enables the analysis, monitoring and managing of social consequences and is increasingly being used to enhance the Environmental Impact Assessment process (Assefa and Frostel, 2007).

Liu, Wan and Mol (2013) centered their research around the theory of reasoned action also known as the theory of planned behavior which suggests that people consider the consequences of behaviors before engaging in them, and that they choose to perform behaviors that may lead to desirable outcomes. Their research tested this theory in Shondong, China where the results showed that with given sufficient information to promote understanding about the benefits of the technology, residents were supportive. Furthermore, positive intention, which was demonstrated through willingness to pay, was higher where households had increased levels of knowledge on renewable, increased income however decreased as age (Liu, Wan and Mol, 2013). These findings therefore highlight the need to design appropriate awareness strategies to inform and educate the communities targeted for a particular technology.

The theory of reasoned action complements the diffusion of innovations theory. The diffusion of innovations theory states that diffusion takes place over time, allowing members of a social system to learn about the innovation evaluate it and assess its usefulness and benefits, before making a decision (Ruiz-Mercado *et. al.,* 2011). Adoption of a new technology is not instantaneous, as the attitudes towards new technologies vary amongst users in different communities and can be classified into four categories: i) those who easily accept a new technology and influence others, ii) those that are quickly influenced by the first group, iii) Those who are sceptical and take caution and iv) those who adopt the new technology when under extreme economic or social pressure (Troncoso *et. al.,* 2007). The definition of the first two groups can also be explained by chameleon effect which suggests that individuals unintentionally mimic the behaviour of others in their social circles (Chartrand and Bargh, 1999). It can therefore be deduced from these theories that providing information on a new technology is important however it such information is processed differently by different people depending on their social settings. It would therefore not be advisable for project developers to implement a one-size-fits-all approach where introducing a new technology.

4.6 CLEAN COOKSTOVE INITIATIVES IN DEVELOPING COUNTRIES

The daily meals in most households are cooked, baked, or processed using thermal energy from a cookstove. In a rural setting, particularly in Sub-Saharan Africa, the daily provision of a balanced meal is very important as this region has high poverty levels (Maxwell, 1999). Also important is the use of a cookstove which will provide the most benefits to the user while minimising the unwanted effects of indoor air pollution and the need to engage in laborious activities for the collection of firewood (Jiang and Bell, 2008; Kabir and Kim 2011; Abeliotis and Pakula, 2013).

Clean cookstove initiatives began in the 1970s, which were designed and implemented by governments and environmental organisations which address a variety of goals, some of which are to improve fuel efficiency and reduce emissions through the inclusion of a combustion chamber and a chimney to extract smoke outdoors (Barnes, 1994; Troncoso *et al.,* 2007). Solid fuels are increasingly being replaced by liquid or gaseous hydrocarbons such as paraffin and liquid petroleum gas (LPG) which have better conversion efficiencies, and therefore produce less emissions at the point of use (Bhattacharyya, 2012). Some global initiatives which aim to harness the benefits of modern and improved cooking technologies include the Sustainable Energy for All initiative which has a goal of achieving universal energy access by 2030 (IEA, 2013). The International Energy Agency (IEA) has developed a global energy scenario entitled ‘‘Universal Modern Energy Access Case”, with a target year of 2030, and which envisions 100% access to clean cooking technologies which will include LPG stoves, biogas stoves as well as advanced biomass cookstoves. This target was based on the assumption that a mix of technology solutions will be explored, depending on cost, resource availability and government policies in a particular region (IRENA, 2013). There is also the Global Alliance for Clean Cookstoves (GACC) which is an alliance which brings together United Nations Agencies, Governments and local NGOs in an effort to merge diplomacy, technology, research, advocacy, and economic opportunity, with the aim of having 100 million households using clean and efficient stoves and fuels by year 2020 (GACC, 2011; 2014).

Various cookstove initiatives have been implemented around the world with using different approaches and attaining varied levels of success (Barnes, 1994). Some large scale initiatives include the Uganda cookstove programme, the National Improved Cookstove Programme in China and National Programme on Improved Chulhas (NPIC). The National Improved Cookstove Programme (NICP) in China was Government driven and disseminated 130 million improved stoves in the early 1990's through the use of low cost strategies and high subsidies (Smith *et. al,* 1993). This was not a sustainable approach which led China to improve on its strategy to include the establishment of stove performance testing standards, continuous monitoring and support for stove manufacturers and energy service companies through the provision of extension services and certification systems for purposes of standardising stoves (Sinton *et al.*, 2004). This was done to create an enabling environment which reduced Government's role to a more oversight role, while the development and dissemination of improved stoves was left in the hands of the private sector. As the cookstove programme was improved, government financing of the initiative eroded and the programme is now private sector driven (Smith and Deng, 2010).

In India, the National Programme on Improved Cookstoves (NPIC) was also Government initiated through the Ministry of Non-conventional Energy Sources (MNES). It began in 1985 with the aim of enhancing conservation of woodfuel and reducing smoke in kitchens (Kishore and Ramana, 2002). The programme also aimed at reducing cooking time and deforestation. Some of the cookstoves which were promoted were the Nada chulha (stove) and the Astra stoves. The Nada chulha was designed with the involvement of local women while the Astra was a product of the Bangalore Centre for Application of Science and Technology to Rural Areas under the Institute of Science. One of the important lessons learnt from this programme was the importance of research, development and demonstration (R, D and D) in ensuring longevity of the improved chulhas (stoves) for the success of the NPIC (Kishore and Ramana, 2002). By the year 2001, the programme which was driven by the Government of India in collaboration with NGOs, had distributed over 34 million improved cookstoves (Agarwal, 1983; 1986). After 2001, the Government of India decentralised the programme implementation. One of the key lessons learnt in India was that of subsidizing the stoves without investing in after sale services such as maintenance of the stoves. The heavy subsidies also suppressed the early development of a market for the stoves, which would have improved efficiencies in manufacturing and maintenance of the stoves (Barnes *et al.*, 1993).

Uganda started its cookstove programme in 2005 and disseminated energy saving rocket stoves to approximately 500,000 households (Kees and Feldmann, 2011). The factors which led to the success of the programme were suitable design of the rocket stove to household needs, the convenience in the use of the technology, and the stove was affordable (Kees and Feldmann, 2011). There are different types of rocket stoves, differing in size, material use and function (Adkins *et al.*, 2010b). Some are brick lined institutional stoves while others are more portable household stoves. One of the main features of a rocket stove is the inclusion of a vertically elongated combustion chamber which was designed to control airflow, combustion and mixing (Habermehl, 2008). The rocket stove design also uses insulating material and is designed to channel hot air and gases towards the pot to enhance heat transfer and reduce heat losses (Habermehl, 2008). The rocket stove design was also used in Kenya under the Millennium Village Projects (MVP), a multi sectoral programme aimed at strengthening the capacity of the 10 sub-Saharan countries it is being implemented in, to achieve the MDGs (Adkins *et al.*, 2010a). The project has a midday meal programme for primary school children who adopted the use of the rocket stove in Kenya in an effort to reduce indoor air pollution and reduce woodfuel requirements (Sanchez *et al.*, 2007). Some of the stoves used in the programme were designed in Uganda with assistance from GTZ, and local contractors were used to build the stoves (Adkins *et al.*, 2010a). The efficiency tests conducted on these stoves in the Sauri village showed woodfuel savings of approximately 236 tonnes per year when compared with the three – stone fire (Adkins *et al.*, 2010a). The approach taken by Mozambique was to reduce woodfuel consumption as well as increase the efficiency of charcoal production through the introduction of the Nikahluleli and Xigandlambeto, which are woodstoves, and the Xitiko, which is a charcoal stove used in Maputo and Sofala. The results of this initiative show that uptake of these clean cookstoves will take time and is dependent upon effective involvement of stove users (Cuvilas *et al.*, 2010).

GTZ has supported various cookstove initiatives around the world. The Southern African Development Community (SADC) initiated a regional Programme for Biomass Energy Conservation in Southern Africa (ProBEC) and commissioned the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH for its implementation (Lerner and Schubert, 2009). ProBEC is being implemented in Lesotho, Malawi, Mozambique, Tanzania, South Africa, Zambia, Botswana, Democratic Republic of Congo, Angola, Madagascar, Namibia and Swaziland (Gifford, 2010). The approach of the programme is concept development, product development, capacity development and market development of efficient wood burning cooking technologies. The target groups for ProBEC are low-income households, social institutions and small and medium-size enterprises (SMEs) (Habermehl, 2008). Various types of cookstoves were promoted under ProBEC, which differed from country to country. Tanzania disseminated over 15,000 stoves, Mozambique over 13,000 stoves, and Malawi over 27,000 stoves. Swaziland, which was one of the last countries to join ProBEC, disseminated only 203 stoves (Gifford, 2010). The Kenya Ceramic Jiko (KCJ) is a very popular household stove in Kenya, east and central Africa. It is a one-pot stove which uses charcoal which is made up of a ceramic liner fitted inside a metal case (Allen, 1991). The Tsotso stove is manufactured in Namibia, which is a modification of the original Tsotso stove from Zimbabwe (Kuhnhenn, 2003).

In contrast, South Africa’s focus is a movement away from traditional fuel sources through promoting the use of LPG and solar cookers (Wentzel and Pouris, 2007). There were limited published reviews on ProBEC or the ongoing clean cookstoves project in Swaziland. A summary of the programme was obtained from an interview with the National Project Coordinator. The programme has a steering committee which is called the National Advisory Group, and which is made up of Officials from Ministries responsible for energy, forestry and environment, officials responsible for food security and nutrition, agricultural extension officers, stove producers, stove distributors, stove users and the Renewable Energy Association of Swaziland. Clean cookstoves in Swaziland are promoted through the use of local media and live demonstrations in various communities around the country. Local retailers are also being engaged and motivated to stock and sell the stoves. Stove trials were also conducted in selected households, as a means of generating interest and obtaining feedback from users of the technology (Dlamini, 2013). Figures 4.4 to 4.7 show the types of fuel efficient wood stoves promoted under the ProBEC in Swaziland.

The Basinthuthu stove (Figure 4.4) is a two plate wood stove manufactured in Swaziland, consisting of an oven for baking or roasting. A geyser can also be attached at the customer’s request. The Basinthuthu stove produced on demand and its price varies depending on demand and cost of material (Dlamini, 2013). The Vesto Stove (Figure 4.5) is a one pot stove which cooks and also roasts meat. This stove also uses cow dung or dried grass in the absence of wood. Vesto stoves are manufactured locally in Swaziland. The Vesto stove is ideal as a quick alternative stove and can be used indoors and outdoors. The Modified Welcome Dover (Figure 4.6) is a bigger two plate woodstove which caters for baking and the use of three-legged pots. This stove was designed to be a cheaper alternative to commercially produced clean cookstoves such as the Basinthuthu. It is an indoor stove made out of brick with a chimney attached to reduce the accumulation of smoke in the kitchen (Dlamini, 2013). The Lion stove (Figure 4.7) is an institutional stove, used in institutions such as schools, orphanages and prisons, as these are large consumers of woodfuel (GOS, 2014). It is a two pot stove which accommodates three-legged pots. These brick stoves are constructed using trained stove builders through support from GTZ. The trained stove builders are thereafter responsible for training others and maintaining quality control and training of more trainers (GOS, 2012).

The household stoves are currently sold at four outlets in the major towns around the country. The outlets are responsible procuring the stoves based on the demand. Currently, the Ministry of Natural Resources and Energy is the only entity actively promoting clean cookstoves in the country. Awareness raising activities include the use of print and electronic media as well as through live demonstrations. This limits its effectiveness as the programme only hires one officer to carry out all the work (Dlamini, 2013).

Figure 4.3: Basithuthu Stove (GOS, 2014).

Figure 4.4: Vesto Stove (GOS, 2014).

Figure 4.5: Modified Welcome Dover Stove (GOS, 2014).

Figure 4.6: Lion (Institutional) Stove (GOS, 2014).

4.7 Critical Success Factors for the Successful Implementation of Clean Cookstove Initiatives

The lessons learnt from the various cookstove programmes around the world highlight critical factors for successful cookstove programmes. A summary of the key lessons from various countries and cookstove initiatives is presented in this section.

4.7.1 Investing in Research, Technology and Skills Development

Key lesson 1: Continuous research and development is important in ensuring quality and that functional cookstoves are produced and disseminated.

The shape of the combustion chamber, the material with which the stove was constructed, the height and diameter of the chimney and the positioning of the cookpiece, have an influence on the emissions produced and the efficiency of a stove (Agenbroad *et al.*, 2011). Improvements in cookstove designs over the years have moved beyond simply focusing on fuel and combustion efficiency, but have also focused on improving overall stove designs, up-scaling stove manufacturing for economies of scale and improving marketing and distribution of stoves (Barnes *et al.*, 1993; Grieshop *et al.*, 2011). Economies of scale are an added advantage which resulted in the lowering of supply costs and making biogas stoves more affordable (Bond and Templeton, 2011). It is also important to take into consideration how best to deal with intellectual property rights with regards to stove designs (Bond and Templeton, 2011).

Key lesson 2: Capacity building through training develops skills and employment opportunities for locals.

Lessons can be learnt from countries such as Burundi, which incorporated capacity building for stove builders, although there was need for supervision and quality control (Karekezi and Turyareeba, 1995). In Uganda, a community based approached was adopted where local artisans were trained as stove builders, making use of local material and service providers (Kees and Feldmann, 2011). Capacity building initiatives develop new skills which enable new employment generating opportunities for those who have been training (Simon *et al.*, 2012). Swaziland used the trainer of trainers approach to train institutional stove builders in all four regions of the country. This not only developed skills but enables stove builders to form companies and further market their skills (Dlamini, 2013).

Key lesson 3: quality control is very important in ensuring long term sustainability of cookstove programmes.

In India, the fixed mud chulhas with a chimney and the portable metal chulhas without chimney were not durable stoves. The mud stove had to be rebuilt every year while the metal stoves did not last more than 2 years. This compromised the functionality of the stove and drastically reduced its thermal efficiency (Kishore and Ramana, 2002). Quality control can be maintained through the establishment of a testing and certification programme which will incorporate laboratory and field testing to enhance quality control and maintain standards (Adkins *et al.*, 2010a).

4.7.2 Stakeholder Consultation

Key lesson 4: Poor information flow between producers, consumers and intermediary organisations hinders the roll out of clean cookstoves. It is important to take into consideration socio-cultural, economic, political, and institutional considerations of the targeted communities in the design of cookstove programmes.

Stove users are aware of the social and environmental costs of the sources of energy which they use (Howells *et al.*, 2005). The diffusion of cookstove innovations needs to follow a decentralised mode which ensures that both the innovation promoters and potential users share information to enable a mutual understanding of the innovation as well as active participation by all stakeholders in the design and implementation of the innovation (Troncoso *et al.*, 2011). Clean cookstove adoption should extend beyond acceptance and initial use to ensuring sustained use over time (Ruiz-Mercado *et al.*, 2011). The introduction of clean cookstoves, however, should take into consideration changes in cultural practices and habitual factors such as changing the size of woodfuel used by cutting it into smaller pieces, changing the cooking location and position, exercising different controls over the fire, and losing benefits such as space heating (Foell *et al.*, 2011).

Challenges were encountered in Tanzania where a lack of understanding of rural household needs and priorities hindered progress of the programme (Karekezi and Turyareeba, 1995). In Fiji, the programme did not take into account socio-cultural, economic, political, and institutional barriers, and thus the benefits of the stoves were not realised (Jan, 2012). The assessment of the adoption of the electric mitad cookstove in Ethiopia revealed that in urban households, different cooking technologies are used when preparing different meals. This finding reveals the reason why continued interdependencies between electricity and traditional energy sources will exist despite improved cookstove interventions, and therefore needs to be considered when designing future cookstove interventions in Ethiopia (Gebreegziabher, 2007). Some of the factors to be considered are the existing types of pots, types of meals cooked, cultural preferences, aesthetics and safety (Pachauri and Spreng, 2008; Burwen and Levine, 2012; Sesan, 2012).

4.7.3 Cost of Clean Cookstoves

Key lesson 5: Improved cookstoves must be affordable to the target market.

One of the challenges reported in the implementation of the cookstove programme in Burundi was that introducing a new cookstove meant rural impoverished households had to incur additional costs to replacing their traditional cooking methods (Karekezi and Turyareeba, 1995). Findings in Fiji also revealed that the cost of an improved smokeless stove was high compared to disposable income (Tukana and Lloyd, 1993). Affordability of improved cookstoves should be maintained at all times for the benefit of the target market (Simon *et al.*, 2012). Besides mass production of cookstoves, other solutions that have worked are the introduction of end-user finance mechanisms such as credit facilities and tailor-made micro-finance options (Wentzel and Pouris, 2007; Rao *et al.*, 2009). Lessons from India and China reveal that subsidies can be introduced; however they need to be well structured to ensure all relevant stakeholders benefit from them and they must be sustainable (Barnes *et al.*, 1993). On the other hand, giving out the stoves at no cost would not have guaranteed success of the clean cookstove programme as free items tend to have a perception of being of little or no value at all (Karekezi and Turyareeba, 1995).

4.7.4 Distribution Networks and Marketing

Key lesson 6: Modern fuels and improved cookstoves being promoted must be accessible to rural communities to avoid increasing costs, which result in poor communities paying more for household energy than urban dwellers.

Sub Saharan Africa has significant challenges with regards to energy infrastructure; particularly in rural areas due to distribution networks which are not fully developed. As a result, distributors of energy services mark up the prices, making them unaffordable (Saha, 2003; Wentzel and Pouris, 2007). Supply chains must be established with the aim of maximising the number of households which can access the technologies (Simon *et al.*, 2012). To enhance sales, marketing campaigns and stove demonstration are important to raise awareness of the technologies being promoted, whilst also highlighting the health and environmental improvements of cookstoves (Bailis *et al.*, 2009).

4.7.5 Institutional Setup

Key lesson 7: Development of public-private partnerships, to foster further investment for the improvement of the cookstove technologies

Cookstove initiatives over the years have been implemented through international co-operation, Non-Governmental Organisation (NGO) support, and government involvement (Kees and Feldmann, 2011). In Africa, a number of cookstove programmes have been supported by organisations such as GTZ, including those in Uganda and Southern African Development Community (SADC) (Gifford, 2010). Fiji also received support from GTZ to conduct assessments of the cookstove programme (Tukana and Lloyd, 1993). The Chinese National Improved Stove Program was initially a government imitative which grew to incorporate other players such as the stove manufacturing private sector (Zhang and Groenendaal, 2001; Sinton *et al.*, 2004). Stakeholders such as government, non-governmental organisations, multilateral institutions, and the private sector are important in energy poverty alleviation (Spagnoletti and O'Callaghan, 2013). There is need for the engagement of local agencies as well as civil society and non-profit organisations which have the ability to reach and influence communities and political figures (Simon, 2010). Collaboration with research institutions is also important to ensure that research is used to continuously improve cookstove designs (Berrueta *et al.*, 2008).

Key lesson 8: Encouraging programmatic approaches which focus on health and the environment in addition to the promotion of clean cookstoves to achieve a wider impact and overall reduction in programme costs.

In 2007, the Safe Water and AIDS Project (SWAP) and the Nyando Integrated Child Health and Education (NICHE) projects in Kenya entered into a partnership which aimed at improving child survival in Western Kenya (Silk *et al.*, 2012). This partnership improves the effectiveness of interventions to improve air quality, water quality and health through sharing of programmatic resources, while using multiple interventions including efficient cookstoves for the target community (Silk *et al.*, 2012). Swaziland can leverage on the multi-stakeholder National Advisory Group and projects such as the LUSLM project to ensure that cookstove initiatives are incorporated into wider development programmes.

4.7.6 Measurement and Monitoring

Key lesson 9: To be able to ascertain progress in implementation, monitoring and measuring needs.

Monitoring and evaluation of improved cookstove programs is essential for indoor air quality and stove performance (Smith *et al.,* 2007; Simon *et al.*, 2012). In Mexico's Central Highlands, non-profit organisations and University Centres provided technical support to the clean cookstove programme through organizing laboratory testing, field validation and awareness and education (Bailis *et al.*, 2009). Qualitative and quantitative testing of cookstove performance is also important for assessment and comparison of different stoves and cooking processes (Abeliotis and Pakula, 2013). Cookstove adoption rates also need to be assessed, taking into account demographic and socio-economic factors (Troncoso *et al.*, 2011). Studies on stove adoption rates must put emphasis on understanding the dynamic interaction between the users, the cooking technology and the fuels used (Ruiz-Mercado *et al.,* 2011). It is important to know how often the stoves are used and the different purposes the stove serves in the household (Burwen and Levine, 2012).

4.8 CONCLUSION

The literature review has highlighted the dominance of woodfuel as a cooking fuel in developing countries. The role of sustainable energy was emphasised in global efforts towards poverty alleviation. Cookstove programmes have been implemented for over four decades and there is a wealth of experience from which countries like Swaziland can learn. They offer the benefits of improved health, reduced woodfuel consumption and less time spent on collecting firewood and cooking.

Studies by authors such as Assefa and Frostel, (2007) and Bargh and Chartrand (1999) have demonstrated that perceptions influence actions and therefore the perception of rural women in the project area would have an impact on whether they adopt and use clean cookstoves or not.

In summary, it can be see that while promoting the environmental and technical benefits of clean cookstoves which improve rural livelihoods, issues related to social capital, resilience and self-reliance also need to be taken into consideration (Wickramasinghe, 2011). The following Chapter presents the findings of this research, which will further be evaluated in Chapter 6 in the context of existing literature.

5 CHAPTER 5: SURVEY RESULTS

This chapter presents the findings of the survey conducted in the LUSLM programme area. The demographics of the households in the area are presented, depicting a typical rural household profile. Findings on fuel use and cooking patterns are then presented to determine the most dominant types of fuel used, reasons for this use as well as household preferences with regards to fuel used for cooking. Finally, the findings on the knowledge of and perceptions on clean cookstoves are presented.

The survey targeted 18 sections under six chiefdoms. The LUSLM database estimates the total number of households in the targeted area at approximately 1383. This research targeted 1217 households across the survey area. Using the assumption that one homestead has at least one household, the overall sample rate for the survey can be estimated at 88%.

5.1 LUSLM PROJECT AREA HOUSEHOLD DEMOGRAPHIC PROFILE

The breadwinners in the survey area were educated up to Primary School level or have no formal education, with the exception of two sections, Phuzumoya and Sankolwane. In these two sections, more than 50% of the breadwinners were educated up to Secondary School level. In most sections, the average household size has between six and ten family members. Only Lanjane, Sankolwane and Luhlanyeni have a dominant household size of three to five family members.

Determining the level of income of households was a challenge as respondents were either uncertain about income levels or were reluctant to reveal income related information. Worth noting, however, were regular comments from respondents about the lack of employment and income streams for their households. Those households with family members which are engaged in some form of income generating activity earned an income from a salary which is spent mostly on grocery items.

5.2 HOUSEHOLD ENERGY PROFILES: FUEL AND TECHNOLOGY USED IN COOKING

The research findings show that overall; the surveyed chiefdoms use woodfuel, electricity, coal, paraffin, LPG, and to a small extent solar energy for cooking. Other forms of energy include agricultural waste such as cow dung and crop harvest waste. Table 5.1 depicts overall proportions of the different types of fuel used as the primary source of fuel for cooking in the project area. It can be seen that 92% of the households in the survey area cook mainly with woodfuel. Although electricity, coal and LPG are also used, these sources of fuel are only used by 3% of the surveyed households.

Table 5.1: Primary Cooking Fuels in the Survey Area.

FUEL USED	NUMBER OF HOUSEHOLDS	PERCENTAGE OF HOUSEHOLDS
Woodfuel	1115	93.2%
Electricity	44	2.5%
Coal	9	1.1%
Paraffin	3	0.3%
LPG (LPG)	34	2.6%
Solar	0	0%
Other	3	0.3%

The analysis of the fuel mix in each of the surveyed chiefdoms, shown in Figure 5.1, also shows a preference in the use of woodfuel as the primary cooking fuel. The majority of households which use electricity as the main fuel for cooking are in Mkhweli and Luhlanyeni. Only nine of the 1217 households surveyed, cooked mainly with coal, and these are in Nceka, Mamisa and Luhlanyeni. Three households cooked mainly with paraffin in Gamedze 1 and Nceka. These results show that the use of paraffin, coal and solar energy for cooking is insignificant in the project area.

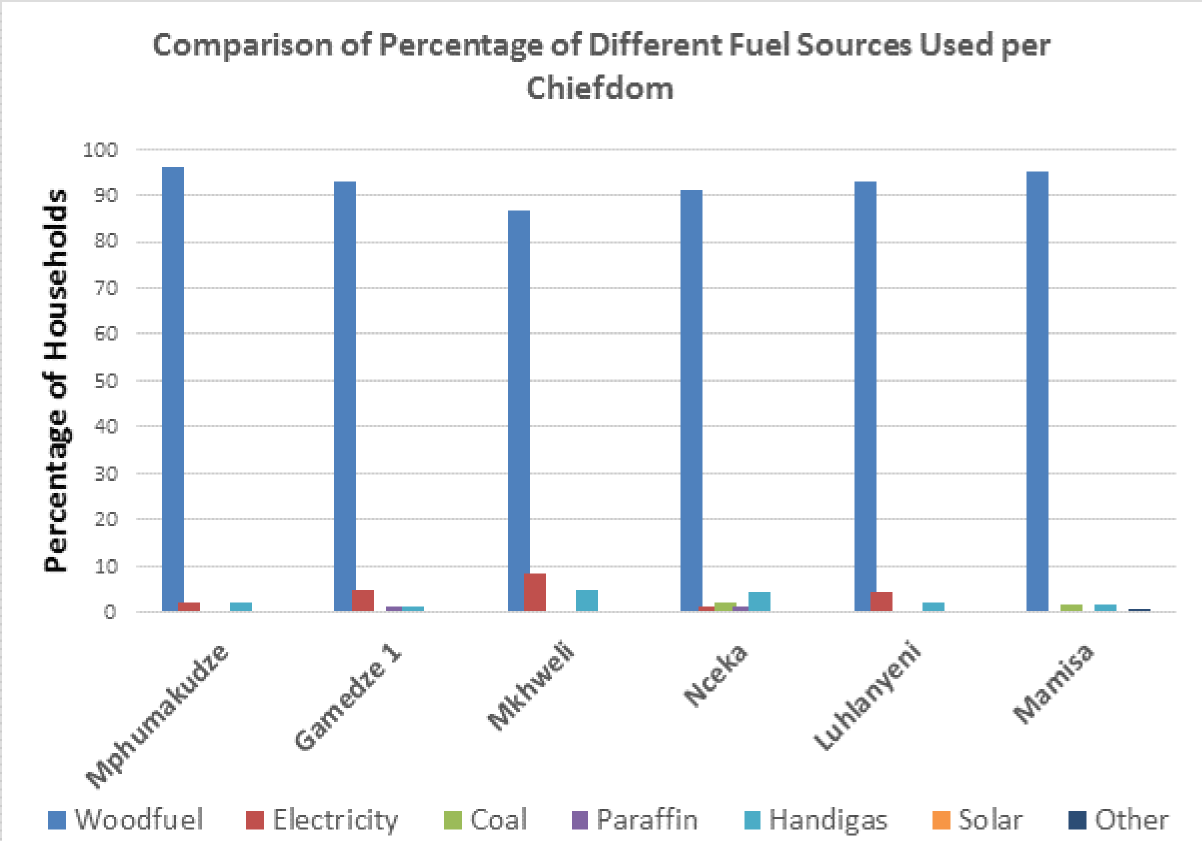

Figure 5.1: The fuel mix for cooking in the survey area.

The most common reason for the use of woodfuel as the main source of fuel for cooking is its relative affordability. Mixed responses were obtained with regards to availability of woodfuel in the different sections. The responses indicate that woodfuel is available in Sidlangatsini, Mphumakudze, Magojela, Mgambeni, Luhlanyeni and Mamisa. In Lanjane, 50% of the households feel that woodfuel is still readily available, while the remaining sections are of the opinion that woodfuel is no longer sufficient. Furthermore, the survey findings reveal that woodfuel is collected by mainly women and girl children. The estimated average distance travelled to collect woodfuel in Sidlangatsini, Mphumakudze, Ntfondvo and Lanjane is between three and five kilometres, while the remaining sections are estimated to travel further than 5 km to collect woodfuel. Woodfuel is collected on average twice per week, depending on the household size.

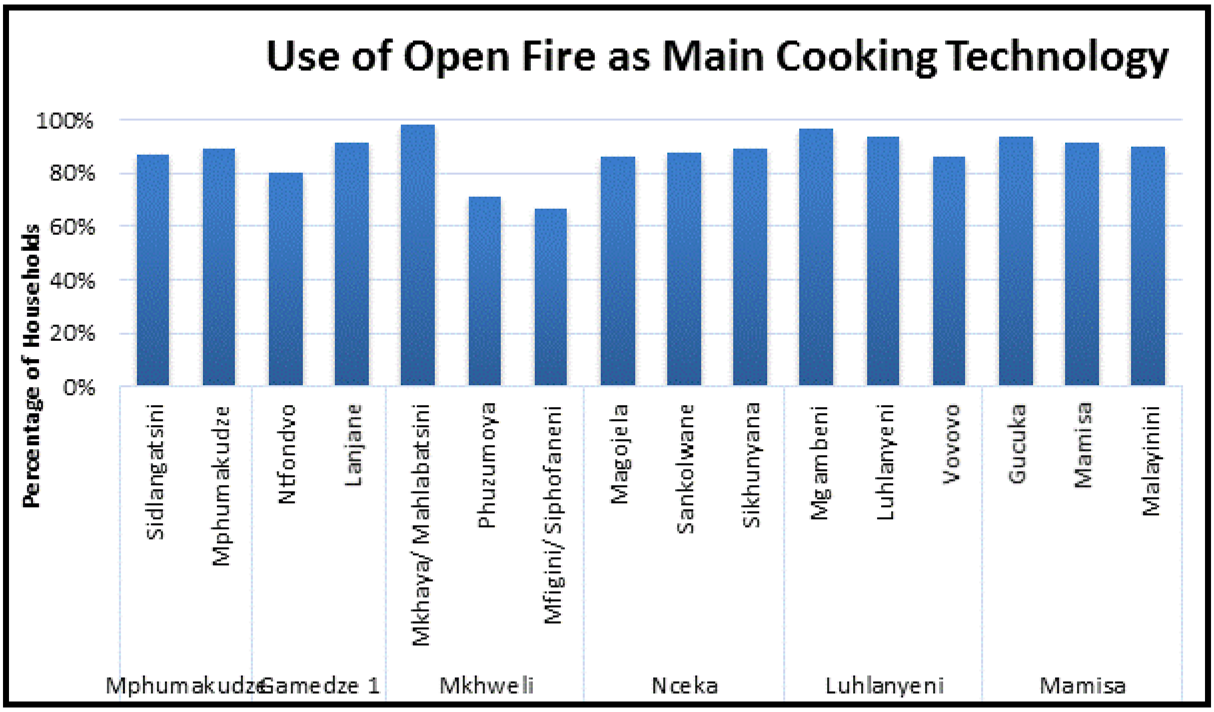

Figure 5.2: Percentage of Households which use Open Fires as Main Cooking Technologies.

Results portrayed in Figure 5.2 show that over 60% of households in all sections in the surveyed area cook with woodfuel using on an open fire, also known as the three-stone fire. The main reason stated for this cooking method is that there is no direct cost related to the purchase of a woodfuel and a cookstove. The survey also reveals the use of multiple technologies for cooking in some households. Respondents feel that LPG followed by electric stoves and to a much lesser extent woodstoves and paraffin stoves, are the most preferred alternative types of cookstoves (Table 5.2). LPG and electric stoves are used because they are quick to use, while the woodstove is an indoor stove and is suitable when the weather does not permit outdoor cooking. Data on alternative cookstoves is not available for Phuzumoya and Mfigini/Siphofaneni, as these were the areas where the questionnaire was tested and the question was not included in the questionnaire at the time.

On average, two meals are cooked per day in the survey area. Typical meals consist of maize porridge, vegetables, and a source of protein which is either meat or legumes. Other uses of cookstoves are boiling of water, baking, space heating, heating of pressing irons and grilling meat and maize. Users who are satisfied with their primary cooking technologies are those cooking with electric stoves, LPG stoves and woodstoves. The open fire method of cooking is the least desired.

Table 5.2: Most Preferred Alternative Cookstove Used in the Survey Area.

Chiefdom	Section	Most Preferred Alternative Cookstove Used			
		Electric Stove	LPG Stove	Woodstove	Paraffin
Mphumakudze	Sidlangatsini		X		
	Mphumakudze		X		
Gamedze 1	Ntfondvo	X			
	Lanjane		X		
Mkhweli	Mkhaya/ Mahlabatsini		X		
	Phuzumoya		not asked		
	Mfigini/ Siphofaneni		not asked		
Nceka	Magojela	X	X		
	Sankolwane		X		
	Sikhunyana	X	X		
Luhlanyeni	Mgambeni	X			
	Luhlanyeni	X	X	X	
	Vovovo				
Mamisa	Gucuka		X		
	Mamisa	X			X
	Malayinini	X			

The survey proceeded to investigate the uptake of clean cookstoves in the survey area. The level of uptake was measured by the household ownership of a clean cookstove. The linkages between the challenges associated with the use of biomass and with the uptake of clean cookstoves were also explored, considering the ongoing programme by the Government of Swaziland promoting clean cookstoves.

5.3 UPTAKE OF CLEAN COOKSTOVES

The uptake of clean cookstoves in the survey area was investigated to establish the extent to which knowledge of these stoves has penetrated the survey area, and consequently the impact that the cookstove programme has had in convincing households in the survey area to purchase and use clean cookstoves. Another important indicator which was being measured was the perception of clean cookstoves as it was also assumed to have an impact on the uptake of the stoves.

5.3.1 Level of Knowledge of Clean Cookstoves

To assess the level of knowledge, the respondents were asked if they had any knowledge of clean cookstoves, the advantages and disadvantages of the use of these cookstoves and how they obtained information on these stoves. The level of knowledge therefore refers to the number of respondents who confirmed having knowledge of clean cookstoves. This assessment is important as a means of assessing the effectiveness of the ongoing clean cookstove awareness campaign being implemented by the Ministry of Natural Resources and Energy.

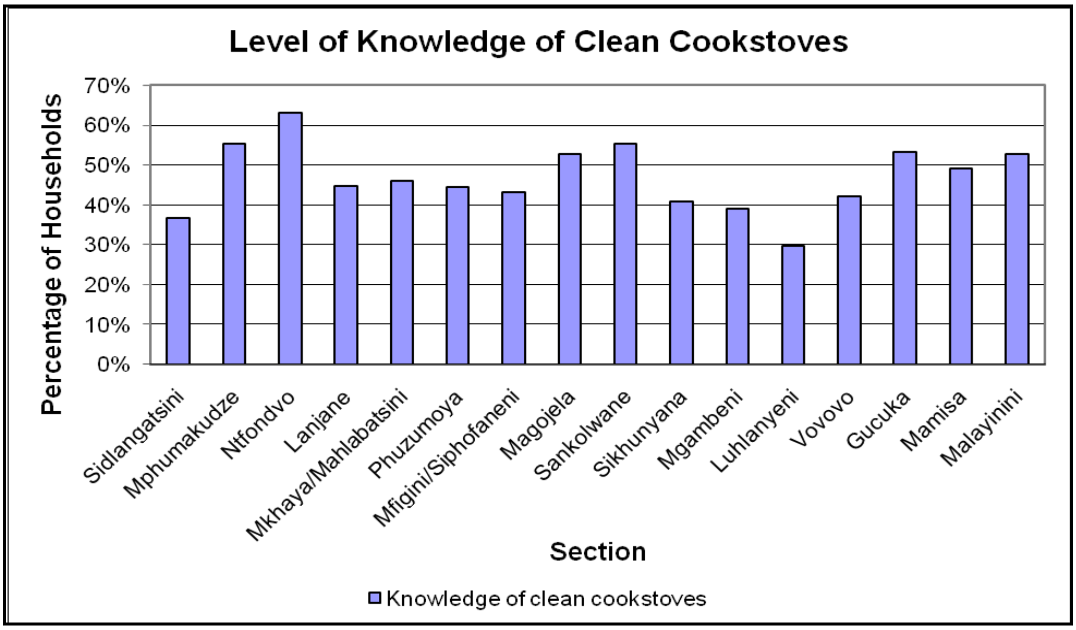

Figure 5.3: Level of Knowledge of Clean Cookstoves in the Survey Area.

The results indicate that only six out of the 16 sections in the survey area have a majority (<50%) of households with some form on knowledge on cookstoves. These Sections are: Mphumakudze, Ntfondvo, Magojela, Sankolwane, Gucuka and Malayinini (Figure 5.3). Ntfondvo, with 63% of the households is the Section with the highest number of respondents who know what a clean cookstoves is. Luhlanyeni on the lower extreme has only 30% of its households with knowledge of clean cookstoves.

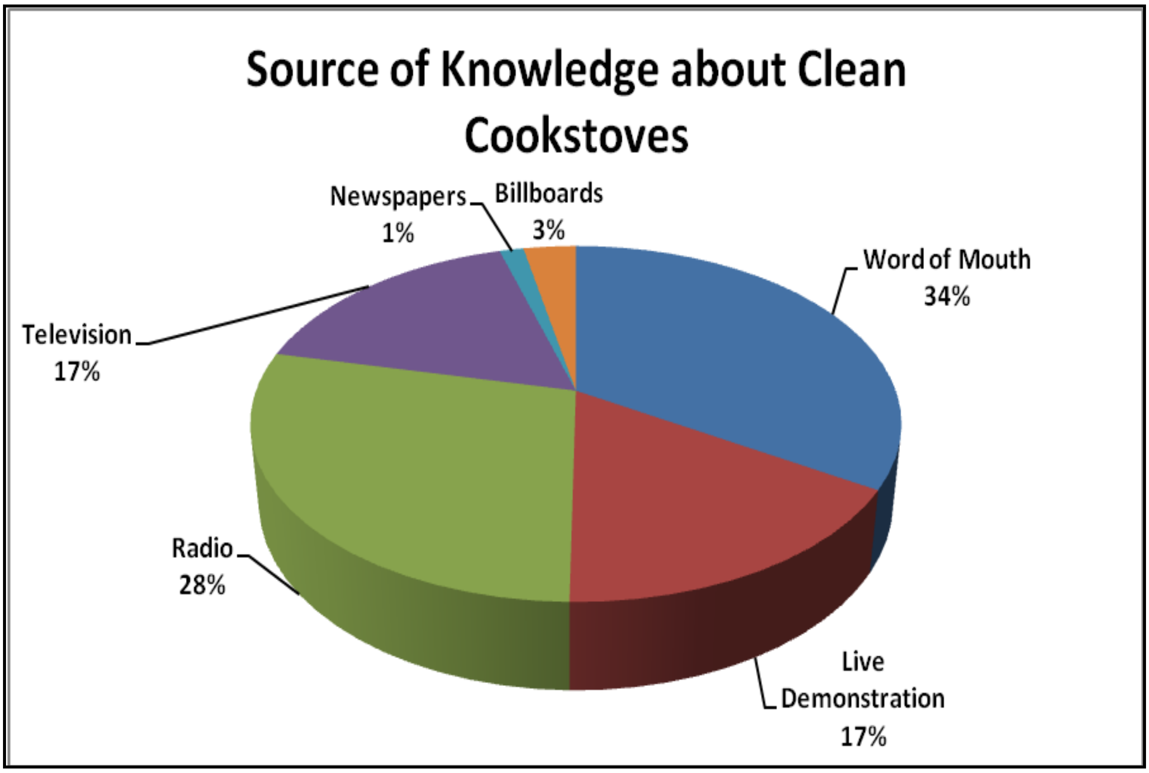

Figure 5.4: Source of Knowledge on Clean Cookstoves in the Survey Area.

Figure 5.4 shows that word of mouth is the most common source of knowledge on clean cookstoves in the survey area. The second most significant source of information is radio (28%). Households which confirmed having knowledge of what clean cookstoves are, obtained their knowledge from radio programmes which promoted these cookstoves. The least popular medium of awareness is newspapers, through which only 1% of households in the total survey area are informed on clean cookstoves. Other forms of information dissemination through which information on clean cookstoves is made available include television (17%), live demonstrations (17%) and billboards (3%).

5.3.2 Ownership of Clean Cookstoves

Out of a total of 1217 households in the survey area, only 2% of households (22 households) own clean cookstoves. The types of cookstoves owned by households in the survey area are the Masheshisas stove, Vesto stove, Basinthuthu stove, Lion stove and one household indicated the use of another type of stove, which was not specified (Figure 5.5).

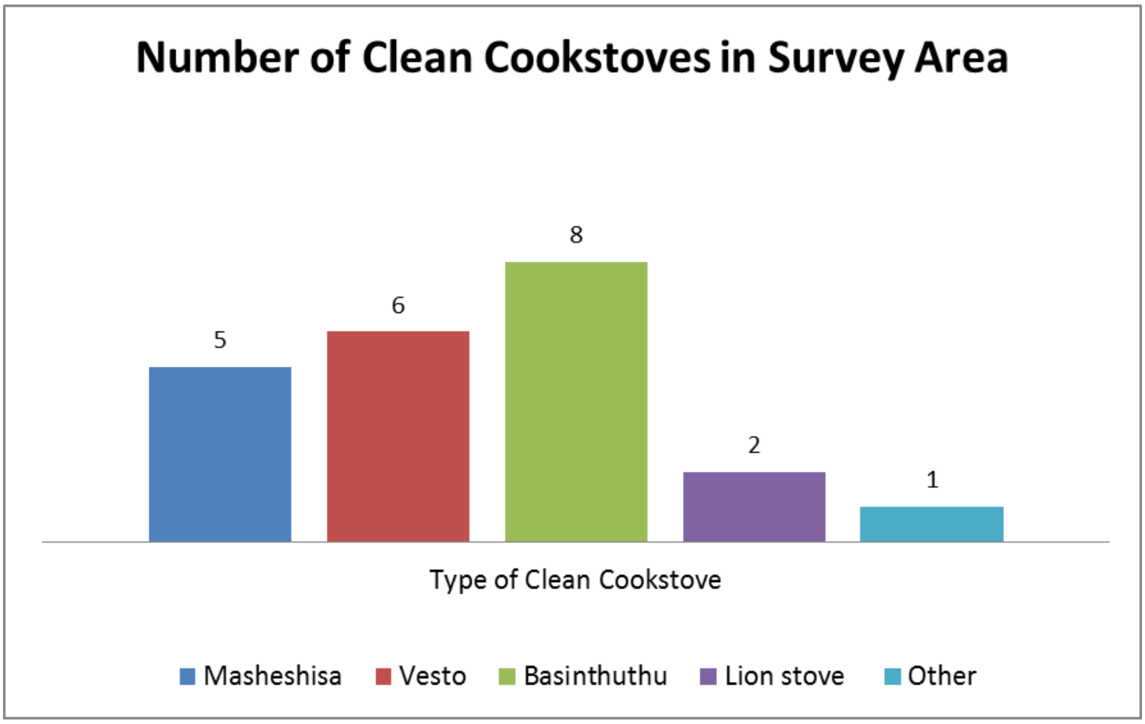

Figure 5.5: Ownership of Clean Cookstoves in the Survey Area.

5.3.3 Perception of Clean Cookstoves in the Survey Area

The perception of clean cookstoves was measured through obtaining opinions of advantages or disadvantages of clean cookstoves, the desire to own a clean cookstove and the willingness to pay for a clean cookstove to replace currently used cooking technologies. These questions were posed to respondents who had initially indicated having knowledge of clean cookstoves. Most of the respondents with knowledge of clean cookstoves feel that they are good stoves to cook with. Based on their perception or experience using the stoves, the respondents gave their opinion of the advantages and disadvantages of using clean cookstoves. These perceptions are listed in Table 5.3 in descending order, starting with the most commonly mentioned advantage or disadvantage.

The results in Table 5.3 indicate that clean cookstoves are easy to use and the time taken to cook food is shortened. Clean cookstoves also have the ability to be used indoors and outdoors, using less woodfuel than an open fire. The reduced requirement of woodfuel shortens the number of trips and distance travelled by women and children to travel to collect woodfuel. Other advantages mentioned relate to specific stoves such as Basinthuthu, which is a multi-functional clean cookstove with the ability to cook more than one pot at a time, while also having a baking oven and the option of fitting a geyser. The respondents are also aware of the health benefits associated with the use of clean cookstoves, such as reduced smoke while cooking. Clean cookstoves also keep the kitchen clean and free of soot. Aesthetics are also important to stove users and some respondents mentioned that the stoves look good.

Table 5.3: Advantages and Disadvantages of Clean Cookstoves.

Advantages		**Disadvantages**	
Saves Wood	67%	Uncertain	78%
Saves time	17%	Not Safe	10%
Uncertain	10%	Not durable	6%
Produces less smoke	7%	Less functionality	4%
Easy to use	6%	Not affordable	3%
Multiple functions	5%	Limited availability	0%
Affordable	3%		
Safe	2%		

The disadvantages on the other hand refer to safety issues, particularly for children. The portable nature of some of the stoves means it is accessible to children, who may injure themselves from playing with it. Some respondents mentioned the potential danger during lighting of the stove, citing their suspicion that the ignition process could be explosive. The one pot clean cookstoves are seen as an inconvenience because only one pot can be used for cooking at a time, therefore when cooking more than one pot for a large family, the cooking process takes long. Another important concern with switching from the use of open fires to clean cookstoves is that households will need to purchase a new set of pots which will suit the new technology because the three-legged pots currently being used are designed for open fires. Respondents felt that the clean cookstoves were made from light material and are therefore not durable, while also difficult to maintain. Given that space heating is important in Swazi homes, the inability for the clean cookstoves to radiate heat is seen as a disadvantage, more than this characteristic depicting combustion efficiency. The clean cookstoves are also perceived to be unaffordable and unavailable in rural areas. A comparison with field testing surveys conducted by Adkins *et al.* (2010b) in Uganda and Tanzania, show a preference for the Stovetech, which is a one pot stove, is simple to use and cooks food quickly. The findings show that other considerations in choosing a cookstove are the types of meals prepared and preparation methods, usability, safety and the size of the stove.

In order to make recommendations for improvement of the clean cookstove technologies in Swaziland, respondents were asked to describe specific features they would prefer in a clean cookstove and these are listed in Table 5.4.

Table 5.4: Preferred Material Attributes for Clean Cookstoves.

Minimum Number of Plates	At least three plates to enable cooking of more than one meal at a time. This would speed up the cooking process.
Preferred Material	brick, metal
Ability to Cook Indoors	yes
Additional attributes	Multifunctional: with oven and geyser
	Durable and easy to maintain
	Aesthetically pleasing
	Allow for space heating

One of the attributes listed is the desire for the stove to be appealing in its design. The most preferred material of construction is iron; however there is also a preference for a brick stove. Emphasis was made on the stove being durable and being a good conductor of heat to enable space heating. A multifunctional stove was also found to be desirable as it enables cooking of more than one pot of food at the same time while also boiling water and in some cases allowing the stove user to bake. Following these recommendations, the preferences of clean cookstoves and willingness to pay were then analysed and the results presented graphically in Figures 5.6, 5.7 and Table 5.5.

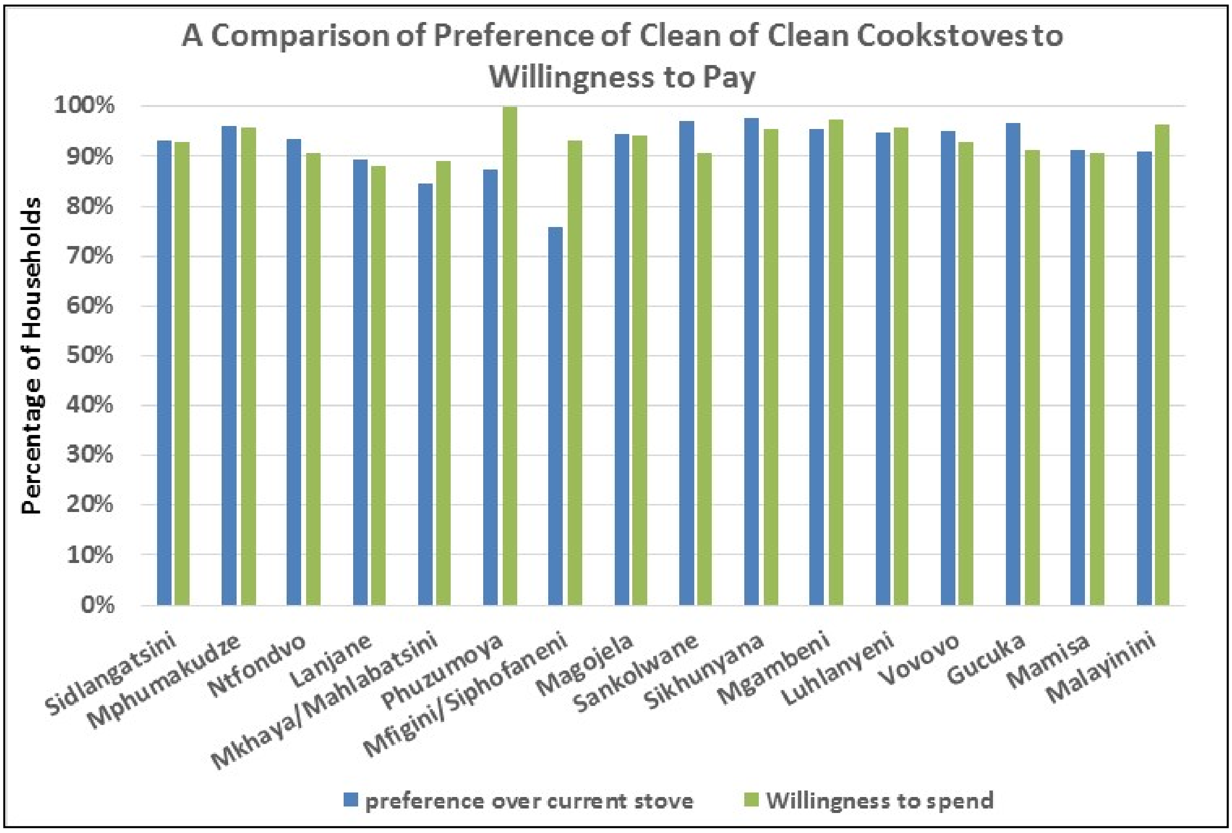

__Figure 5.6: Graph of Household Preference of Clean Cookstoves and Willingness to Pay.__

The preference of clean cookstoves over the current cookstove being used in households was contrasted with the willingness to spend on a clean cookstove (Figure 5.6). The results show that over 80% of households in most communities, with the exemption of Mfigini/Sphofaneni, prefer clean cookstoves over their current cookstoves. An anomaly was seen in Phuzumoya where all households are willing to spend money to purchase a clean cookstove, although less than 90% of the same households preferred the clean cookstoves. This trend portraying that more households are willing to spend on the cookstoves than those preferring clean cookstoves is also observed in Mfigini/Sphofaneni and Malayinini.

The results portrayed in Figure 5.7 depict the prices which households are willing of pay for a clean cookstove. The results indicate that a total of 409 households (34%) desire to obtain the stove for free (Figure 5.7). On the extreme side of the price scale, the findings show that 234 households are willing to pay more than E1000 (approximately US$94) for a clean cookstove.

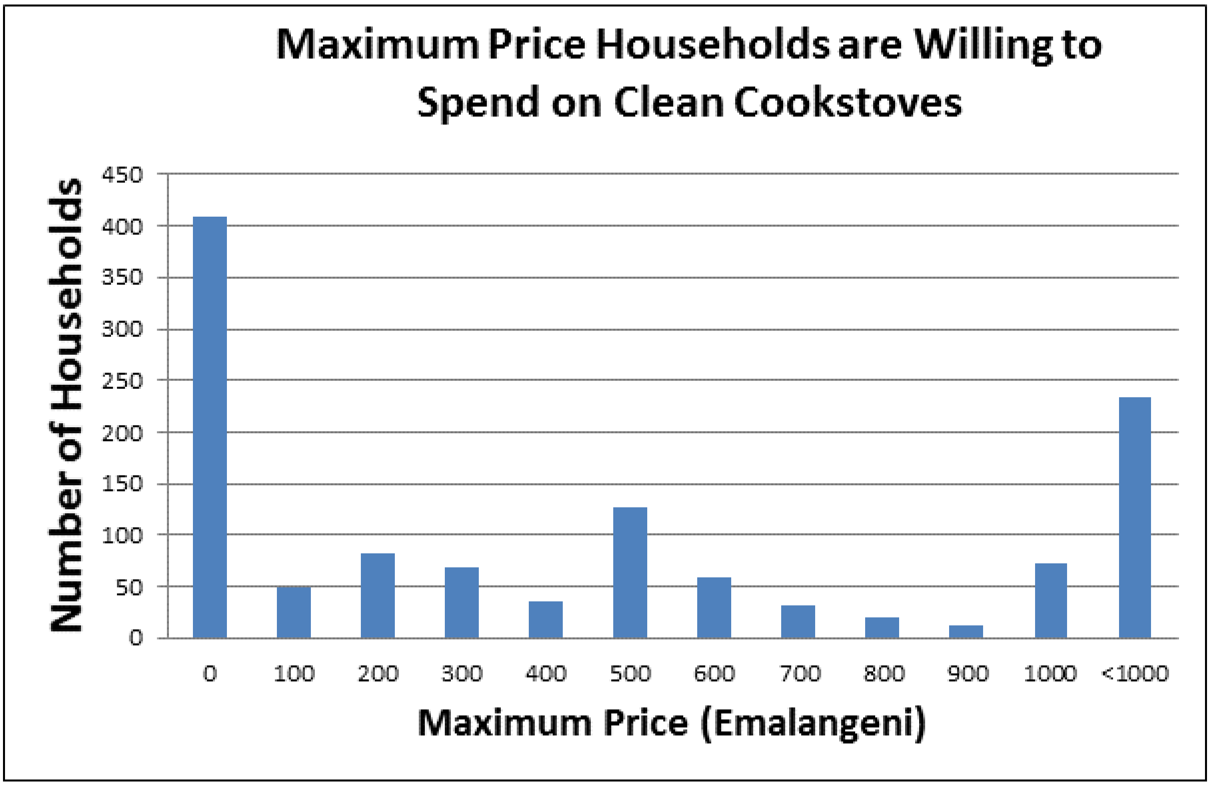

Figure 5.7: Graph of Maximum Price Ranges in Emalangeni which Households are willing to Spend on Purchasing a Clean Cookstove. (1 Emalangeni = 1 Rand).

Table 5.3 shows the preferred prince ranges for clean cookstove for the majority of households in the different sections surveyed. The most notable preference is for obtaining free clean cookstoves. Sections with the majority of households which are not willing to spend money for a clean cookstove are Mkhaya/Mahlabatsini, Phuzumoya, Mfigini/Siphofaneni and Ntfondvo. Mphumakudze, Luhlanyeni, Vovovo, Gucuka, Malayinini; these prefer price ranges between E 401 – E 500 (approximately $38 - $48), while the majority of households in Mgambeni are willing to spend between E 500 ($48 and E 600 ($58). The anomaly seen in Mfigini/Sphofaneni and Malayinini indicates that there are more households willing to pay for clean cookstoves than there are households which desire the cookstoves. This could be attributed to sampling error.

Table 5.5: Clean Cookstove Price Range Preferences.

	Maximum Price Majority (<50%) Households were Willing to Pay for Clean Cookstoves (Emalangeni)						
	Free	**100**	**200**	**300**	**400**	**500**	**600**
Ntfondvo, Phuzumoya, Mkhaya/ Mahlabatsini, Mfigini/ Siphofaneni							
Malayinini							
Sidlangatsini Sankolwane							
Lanjane, Magojela, Mamisa Sikhunyana							
Mphumakudze, Luhlanyeni, Vovovo Gucuka Malayinini							
Mgambeni							

5.4 CONCLUSION

The results profile households according to household demographics; the type of fuel and cooking technology used as well as the knowledge and perception of clean cookstoves. The main findings show a dominance of the use of woodfuel on an open fire for cooking. Almost all households are not satisfied with the open fire method of cooking and prefer modern fuels and cooking technologies such as LPG and electricity. With regards to clean cookstoves, the results show that despite there being an ongoing programme in Swaziland promoting clean cookstoves, the level of knowledge and uptake of clean cookstoves is still very low.

The following chapter will provide more depth in the analysis of these results, comparing them to relevant theories and other literature and secondary data reviewed to substantiate the research findings.

6 CHAPTER 6: ANALYSIS OF RESULTS

This chapter presents a more in-depth analysis of the research results. The analysis, presented in four themes, covers a) fuels and cooking technologies used; b) approaches to clean cookstoves in Swaziland with the level of uptake of clean cookstove technologies; c) perceptions of clean cookstoves and d) a discussion on the barriers to the uptake of clean cookstove technologies in the survey area.

6.1 FUEL USE IN THE SIPHOFANENI AREA

Ninety-two percent of the households surveyed use woodfuel on an open fire for cooking their daily meals. Woodfuel is still a commonly used fuel due to its affordability and availability. These results confirm the findings of previous studies on fuel use trends in sub-Saharan Africa and Swaziland by authors such as Marufu (1997), Heltberg (2004); Bazilian *et al.*(2012) and GOS (2013b) through the Swaziland Energy Access Survey. Ntfondvo differed slightly from this trend in that although its dominant fuel use is woodfuel, the most commonly used cookstove is the woodstove as opposed to an open fire. Other fuel types used for cooking to a lesser extent are electricity (3.6% of households) and LPG (2.8% of households). This trend also aligns with results of the Swaziland Households Income and Expenditure Survey conducted in 2000/2001 and 2009/2010, which showed that the most commonly used cooking fuel in Swaziland is woodfuel, predominantly in the lower income groups in the country while the highest income groups use electricity and LPG (GOS, 2001; 2010).

National statistics obtained through the Swaziland Energy Access Survey aimed to assess the progress in the electrification of rural households in Swaziland through the Rural Electrification Programme. It showed a national electricity access rate of 61%, with the rural access rate at 50% in 2013 (GOS, 2013b). In addition, this study revealed that in terms of electricity infrastructure coverage, the electricity distribution network covers 95% of the country (GOS, 2013b). However, the electricity access results reported in the Swaziland Energy Access Survey, when contrasted with woodfuel usage rates of 92% in the survey area, show that despite the good electricity network coverage, and growth in the number of households connected to the grid, there is a low level of electricity use for cooking in rural areas. These findings show that some households which can afford to connect to the grid still cook with woodfuel. A growing concern is that of availability of woodfuel resources in future, with some household participants having to walk distances exceeding 5 km in some instances, to collect woodfuel. A similar concern was reported by authors Aron *et al.* (1991) for rural South African communities which have been experiencing localised woodfuel shortages due to overharvesting. A survey conducted in Maun, Botswana revealed that harvesting sites are chosen by some households based on quantity of woodfuel available and a significant portion of the surveyed communities travel between 15 km and 150 km, to areas known to be abundant in woodfuel (Hiemstra-van der Horst and Hovorka, 2009).

The Swaziland Energy Access Survey conducted in 2013 gave a more recent picture of the rural energy use scenario and its results also portray dominance in the use of woodfuel as the main source of fuel for cooking, followed by electricity and paraffin (GOS, 2013b). This trend shows similarities between Swaziland and other developing countries, as research has revealed that approximately 40% of the world's population rely on biomass for basic energy needs: cooking and heating (IEA, 2013; Bhattacharyya, 2012). China and India have relatively high electrification rates, yet there is still a significant proportion of the population which uses woodfuel for cooking (Balachandra, 2011; Niu *et al.*, 2014). A similar situation is seen in South African rural communities where households use predominantly woodfuel for cooking (Matsika *et al.*, 2013). South African has an abundance of coal resources; therefore coal also features dominantly in the household energy mix (Eleri, 1996; Kimemia *et al.*, 2014). Access to modern energy sources, as shown in Table 4.1, continues to be a challenge for the developing world, including Swaziland, despite the implementation of electrification programmes (Kituyi *et al.*, 2001; Howells *et al.*, 2005; Madubansi and Shackleton 2006). The reasons behind this stacking would need to be verified in further studies. However, the findings validate conclusions by Matsika *et al.* (2013), which state that complete switching rarely takes place in the rural context. A study in Ethiopia showed that stacking of traditional cookstoves with electric stoves was not only an issue of affordability but also socio-cultural, linked to cooking preferences (Gebreegziabher, 2007). Fuel switching in Mozambique takes place and is influenced by availability of fuel resources and affordability (Arthur *et al.*, 2012). Literature has also revealed that even in urban areas with high electricity access rates, the use of electricity for cooking is not feasible due to the high cost of using electricity.

Cooking with electricity is therefore most common in high income household (Karekezi and Majoro, 2002; Sander *et al.*, 2011).

6.2 CURRENT COOKING TECHNOLOGIES IN THE SIPHOFANENI AREA

Households which cook with electric or gas stoves (Table 5.2) are the most satisfied with their current cooking technologies. In contrast, respondents in Luhlanyeni and Malayinini expressed satisfaction with using woodstoves. Overall, the most preferred form of energy is electricity, followed by LPG. These findings are consistent with national references (GOS, 2013b). The survey results confirm the importance of global initiatives aimed at improving access to modern energy based on the role that sustainable energy access plays in the development agenda (Ketlogetswe *et al.,* 2007; Pachauri and Spreng, 2011). Households desire modern energy sources to enable transition out of energy poverty to improved quality of life (Abdalla, 1994; Sagar, 2005; Sesan, 2012).

Although the results cannot prove whether there were cases of complete switching from woodfuel to electricity, findings in Mexico suggest possible reasons for using more than one form of energy for cooking. Berrueta *et al.* (2008) found that the use of woodfuel does not significantly drop with the increase in the use of LPG and it was also noted that LPG is used in conjunction with traditional sources of energy, making LPG a secondary fuel for cooking food items that require less energy. Households in informal settlements have increased due to urbanisation, increasing the need to access modern energy services (Madlener and Sunak, 2011). The households, however, are limited by the need to split their low incomes between food and high energy costs, leading in some cases to illegal electricity connections (Karekezi and Majoro, 2002). To further substantiate the results of this survey, comparisons were made with theories emanating from the energy use models which are the energy ladder, energy stack and multiple stove use models, described in Chapter 4. This research, coupled with the Energy Access Survey and the Household Income and Expenditure Surveys confirms the relationship between the sources of energy used in rural households in Swaziland to socio-economic status of rural households. The research findings further confirmed the argument by Masera *et al.* (2000) which improved on the energy ladder model to suggest that other factors such as resource availability, technical practices and health impacts also influence fuel choice.

6.3 COOKING PRACTICES IN THE SIPHOFANENI AREA

The stove users in the survey area cooked for families with an average family size ranging between three to five members, requiring on average two meals per day. These meals consisted of maize porridge, vegetables and as a source of protein either meat or legumes. Cooking times vary depending on the meals being cooked. Maize porridge takes less than an hour while beans can take up to four hours. The type of cookstove used therefore varies depending on the meal being cooked. Households with more than one cooking device tend to cook faster meals on stoves such as LPG and paraffin stoves while the foods that require more heat and longer cooking times are cooked over open fires. Traditional cookstoves were also used for boiling water, baking, space heating, heating irons and grilling. In simpler terms, this meant that food was cooked in large quantities where the open fire allowed for the placement of more than one pot at a time, reducing the cooking time.

The knowledge of what cookstoves are used for and the significance of the types and quality of fuel and cooking technologies is very important in the design of a cookstove (Johnson and Bryden, 2012). In Botswana, woodfuel is used for cooking samp and siswaa (boiled meat) which require longer cooking times, while LPG is used for boiling water for tea and cooking rice (Hiemstra-van der Horst and Hovorka, 2008). In Mexico, nixmatal (mixture of maize and lime which is cooked and grinded for making tortillas) is typically cooked on an open fire as it requires high temperatures while making the tortillas requires lower temperatures (Troncoso *et al.*, 2007). This is important because clean cookstoves not only change cooking technologies, but also cooking practices (Ruiz-Mercado *et al.*, 2011).

6.4 SWAZILAND'S CLEAN COOKSTOVE PROGRAMME

The introduction of clean cookstoves in Swaziland began in the 1990s through a donor funded programme by GTZ (GOS, 2009; Dlamini, 2013). The Swaziland cookstove programme formed part of the ProBEC initiative which was being implemented throughout the SADC region (Gifford, 2010). The programme entails awareness raising, training and policy development (GOS, 2012). Awareness was on clean cookstoves using print and electronic media, as well as community based live demonstrations around the country (Dlamini, 2013). In addition, local artisans were trained to construct the institutional stoves and were assisted to form a company to enable the stove builders to generate income out of building these institutional stoves, such as the lion stove. Due to the late inclusion of Swaziland in the SADC ProBEC initiative, Swaziland had limited donor funded support as compared to the other SADC countries (Gifford, 2010). The programme is now wholly funded by the Swaziland Government (Dlamini, 2013). India and China also implemented government initiated cookstove programmes involving local business and organisations in the implementation (Barnes, 1994).

Only 22 (2%) of households in the Swaziland survey area own clean cookstoves. Nationally, the level of clean cookstove uptake is 4% (GOS, 2013b). Less than half the population of most of the sections surveyed have any form of knowledge on cookstoves. The low level of clean cookstoves uptake is therefore expected. Pakistan also had low level of uptake of clean cookstoves (20%) due to socio-cultural, economic, political, and institutional barriers which were not well considered in the design of the programme (Jan, 2012). The cookstove programme in rural Mexico also did not achieve desired results due to differing preferences among individual stove users as well as the gender dimension which failed to incorporate men, who are main woodfuel harvesters, in the design of the programme (Troncoso *et al.*, 2007). The most popular cookstove was the Basinthuthu cookstove (Figure 5.4), which is a multifunctional cookstove, with the ability to cook more than one pot, boil water as well as bake. The Masheshisa and Vesto stoves are one pot stoves and popular mainly as an alternative that is quick, when the user has limited time to cook. However, the Jiko stove, which is a one pot stove is most popular in Kenya and east Africa (Allen, 1991). In Malawi, it is the rocket stove, which similar to the Basinthuthu, is a multifunctional stove (Habermehl, 2008). The preference of different stove types varies depending on the community and country.

Studies by Jan (2012) and Lewis and Pattanayak (2012) identified a positive relationship between level of education and uptake of clean cookstoves. This survey shows that the majority of breadwinners in the households surveyed have not been educated beyond the

Primary School level. The limited level of education could possibly explain the low level of awareness about these cookstoves as well as the low incomes being earned by families in the survey area. The limited level of education could also be a barrier to understanding and appreciating the technology. When applied to the approach used in Swaziland's clean cookstove programme, it was concluded that Swaziland's programme followed a centralised model where communication about the clean cookstoves generally flowed one way from the promoter (Government) to the users of the technology (Troncoso *et al.*, 2011). This approach limits information sharing and the active participation of stove users in the design and manufacture of clean cookstoves in Swaziland. This implies a need to re-evaluate the marketing and awareness strategies being implemented under the cookstove programme.

6.5 PERCEPTIONS OF CLEAN COOKSTOVES IN THE SIPHOFANENI AREA

Most respondents who know about clean cookstoves feel it is a good stove to cook with. Fifteen out of the sixteen sections surveyed had over 80% of their households preferring clean cookstoves. The survey results list woodfuel savings, time savings and reduced smoke as three of the main advantages when using clean cookstoves. These responses demonstrate the appreciation of the impacts that the use of woodfuel has by a selection of the respondents. Households are concerned about the high levels of smoke produced from the burning of woodfuel, which results in indoor and outdoor air pollution which is undesirable for health purposes. To further assess the perception of clean cookstoves, various aspects were looked into which included overall preference for the stove, willingness to pay, price ranges which were affordable to respondents, as well as the preferred attributes of the stove. The households in the survey area already have an existing technology such as woodstoves or the use of an open fire which they currently use to cook their meals. Households expressed a strong desire to own a clean cookstove, however, certain barriers such a price and availability made it difficult for them to purchase the stoves. It could not be ascertained from the survey findings whether households in the survey area are inclined to a certain type of source of fuel based on taste preferences. In fact, a study conducted in India on the Oorja biomass gasifying stove indicated that taste considerations were not a factor in the decision to purchase the Oorja over the traditional cookstove (chulha) (Thurber *et al.*, 2014).

The most affordable clean cookstoves are the Masheshisa stove and the Vesto stoves, which are one pot stoves. These stoves are used more where a quick meal is being prepared, or in the case of bachelor owned households. The most functional multi-use stoves are the Basinthuthu and Modified Welcome Dover, which both cost over three thousand Emalangeni (E3, 000.00 ~ $292). This stove is relatively expensive when compared to the price (E400 ~ $38) which the majority of the population in the survey area are willing to spend on a clean cookstove. Another notable finding is that only 34% of households in the survey area prefer being given a clean cookstove stove for free. Although respondents were uncomfortable revealing their levels of income, the SWADE (2013) socio-economic survey of this area indicates that households in the survey area had low levels of income. Almost a fifth of the households in the survey area are willing to spend an amount exceeding E1000.00 ($94) for a clean cookstove. This willingness to pay, however, has not translated into a meaningful uptake in clean cookstoves in the area. This therefore confirms findings by Karekezi and Turyareeba (1995), Pachauri and Spreng (2008), Foell *et al.* (2011); Burwen and Levine (2012), Jan (2012), and Sesan (2012), that a wide scope of factors other than income and affordability influence the choice in fuel use and cookstove technologies.

The work covered by authors such as Chartrand and Bargh (1999), Assefa and Frostell (2007), Trancoso *et al*., (2007) Ruiz-Mercado *et al. (*2011) and Lui, Wang and Mol (2013) amongst others gave insight into the role and importance of social perception in decision making and taking action thereafter. Social perception therefore plays a critical role in the design and implementation of clean cookstove programme as the challenges faced would be similar to those faced by other renewable energy technologies (Walker, 1995; Krohn S, Damborg, 1999; Díez-Mediavilla *et al*., 2010). In line with the above mentioned theories, the results of this research imply that the limited knowledge on clean cookstoves makes it difficult for respondents to confidently respond to basic discussions about cookstove technologies. The limited knowledge not only hindered active engagement on the advantages, disadvantages and design of cookstoves but also translates into the decisions made by respondents on whether or not to spend their money on a clean cookstove. It can be deduced from results on desire for the stoves indicate that respondents were positive towards the idea of a cooking technology that would improve their cooking experience. This research however was limited in that it did not allow for detailed assessment of the socio-economic issues which shape and inform rural perceptions of households in this survey area and further research is therefore necessary in this area.

6.6 BARRIERS TO IMPLEMENTATION OF CLEAN COOKSTOVE INITIATIVES IN SWAZILAND

Following the review of literature to identify the critical factors for the successful implementation of clean cookstove initiatives and the analysis of the survey results, a reflection on the possible barriers to the roll out of the clean cookstove initiative in Swaziland is given below, including recommendations adopted from lessons learnt in cookstove initiatives around the world.

i) Research, Technology and Skills Development

No scientific research or stove testing has been conducted on the clean cookstoves being promoted in Swaziland, to test the level of efficiency leading to improved stove designs and the development of new innovative solutions. Continuous research on how the cookstove designs can be carried out is not being conducted in Swaziland. There is also no consultation with stove users for the provision of feedback on the use of the clean cookstoves, to inform designers. There is potential to form partnerships with Technical Institutes or Universities to develop programmes on clean cookstoves which will focus on improving the technical designs of the stoves. These research findings must feed into industry, for mass production of these cookstoves. Quality control and protection of intellectual property rights are important to consider. Local design and manufacturing of clean cookstoves will create the need for skills development in the construction and maintenance of these stoves.

ii) Stakeholder Consultation

The Multi-stakeholder National Advisory Group is made up of an appropriate mix of stakeholders. It however does not meet on a regular basis (Dlamini, 2013). This group needs to be engaged more and have clear deliverables which inform research programmes and marketing strategies. The most crucial aspect which needs to be focused on is that of the perception of rural households on clean cookstoves and such information can only be obtained through active engagement of communities in the design of cookstove programmes. Stove users and existing clean cookstove users also need to be engages and consulted on a regular basis to check whether the clean cookstoves are still being used and whether they are producing the desired results. Stove users, manufacturers and stove builders could provide meaningful input into the design, material and functionality of the stoves.

iii) Cost

The socio-economic status of rural households is not suitable for selling clean cookstoves to rural households at cost. Swaziland is a small country with a small population, therefore it does not benefit from economies of scale. No price subsidies have been availed to rural households for this programme, since its inception. In addition to the purchase of new cookstoves, households would also need to purchase new pots, an additional cost to the already impoverished households. This factor was not taken into consideration in the cookstove programme. The Ministry of Natural Resources and Energy in consultation with key stakeholders could introduce sustainable incentives or financing solutions for rural households to be able to purchase these stoves.

iv) Distribution and Marketing

The clean cookstoves are only available in selected shops around the country, making them inaccessible to remote communities. There is also limited skills and capacity to maintain the stoves (Dlamini, 2013). The Ministry of Natural Resources and Energy, in conjunction with retailers, will need to review the marketing strategies to increase clean cookstove availability.

v) Institutional Setup

The Ministry of Natural Resources and Energy through the Clean Cookstove Programme is currently the only entity which is actively promoting clean cookstoves (Dlamini, 2013). This function needs to be decentralized and the Ministry can leverage on existing food security, nutrition and health related programmes, to integrate clean cookstoves as part of a holistic approach to poverty eradication efforts in Swaziland. There is potential to leverage on existing development programme such as the LUSLM project to promote the benefits and use of clean cookstoves as such programmes have established relationships with the rural communities in which they are working and this provides a platform for active engagement on rural energy solutions.

vi) Measurement and Monitoring

The performance of clean cookstoves needs to be monitored over time to ensure effectiveness and continuous improvement. The variables which can be monitored include efficiency, woodfuel consumption, emission levels and cooking times. It is important to know who the clean cookstove users are, where they are located, how many there are and how long they have been using the clean cookstoves for. This information will be useful in feeding into further research as well as development of strategies for enhancing the clean cookstove programme.

6.7 CONCLUSION

This chapter provided an analysis of the results presented in Chapter 5. The results were contrasted with local and regional trends as well as with theoretical principles formulated to model the factors determining household energy choices. Commonalities were found in fuel use, factors determining fuel use, particularly cost of stoves, as well as typical barriers that limit the successful implementation of clean cookstove programmes. The following chapter concludes the main findings of the research and further provides recommendations for future research.

7 CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The literature reviewed in this study centred on global, regional and local energy access and energy poverty. The energy sector cannot be viewed in isolation and this therefore necessitated the views of other developmental issues such as climate change and water. The use of biomass as a primary source of cooking energy in a large population of homes in rural areas was explained through various energy use models such as the energy ladder. A review was conducted of the various approaches to the implementation of clean cookstove programmes around the world, which have had varying successes. The case of Swaziland sought to analyse perceptions and the impact of rural perceptions on the uptake of clean cookstoves.

The research findings show that Swaziland, like many other developing countries, still has a strong reliance on woodfuel as a source of household energy. The results further indicate that 92% of households in the survey area rely on biomass for cooking. The open fire is the most commonly used method of cooking. This dominance is significant in policy development and decision making, as there is still a high percentage of the Swazi population living in rural areas.

The low uptake of clean cookstoves (2%) in the survey area, demonstrates significant challenges in the approach Swaziland is using in the implementation of the clean cookstove programme. Respondents cited affordability, accessibility of stoves and lack of awareness of what clean cookstoves are and how they work, as the main reasons for not owning clean cookstoves. This is despite there being an ongoing countrywide marketing campaign for clean cookstoves. Lessons learnt from literature shows that stove users in rural communities need to provide active input into the design and implementation of the clean cookstove programmes, to ensure appropriateness, ownership of designs and ultimately increase the use of clean cookstove technologies in Swaziland. The survey results indicate a low level of awareness of what clean cookstoves are and a 2% ownership of clean cookstoves in the survey area. These results are comparable with a nationwide assessment conducted by the Government of Swaziland, which reported a 4% uptake in 2013. The respondents are not satisfied with the use of open fires for cooking and are receptive to the use of clean cookstoves. More than 90% of households prefer clean cookstoves and demonstrated willingness to pay for them. The important aspects which need to be considered in design of clean cookstoves are that the stoves must be multifunctional, require small amounts of wood, reduce cooking time, reduce smoke, and must be safe and easy to use. Multifunctional cookstoves enable cooking of multiple meals, as well as performing other functions such as boiling water and baking. The price of clean cookstoves is an important factor in decision making as these households are located in a rural area and 34% of the respondents prefer free stoves. There is also evidence of some households using more than one type of fuel for meeting their daily household needs which indicates that one type of energy source does not always satisfy all households' needs.

In conclusion, this research demonstrates the importance of perception in the introduction of energy innovations, particularly in rural settings. It is important for rural energy programmes to understand the socio-economic setting of communities and population being targeted for the roll out of energy technologies. Furthermore, active engagement of the targeted population allows for better understanding of the technology and removal of misconceptions which in this case translate into a higher uptake of clean cookstove technologies. The implication of these results is that Government policies and strategies for addressing rural energy needs such as the clean cookstoves programme need to be informed by the needs and lifestyles of the potential users of these cookstoves. Stove users need to be engaged in the design of the cookstove programmes, prior to implementation. Furthermore, issues of quality of the stoves, local production, marketing of the stoves and ensuring affordability are also very important and need to be prioritised. Government interventions on clean cookstoves also need well defined targets which are informed by comprehensive biomass resource assessments, behaviour assessments as well as assessments of the demand for clean cookstove technologies (Wickramasinghe, 2011).

7.2 RECOMMENDATIONS

It is recommended that further qualitative research should focus on behavioural aspects to establish a deeper understanding of household dynamics, including decision making, gender roles, culture, income and affordability aspects of rural households. This will then better inform programme design, cookstove research, the development of testing programmes, capacity development, needs, supply chain options and the type and level of awareness raising that is required.

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ANNEXES

APPENDIX A: Survey Questionnaire

THE PERCEPTION OF CLEAN COOKSTOVE TECHNOLOGIES IN THE LUSIP GEF PROJECT AREA

Name of Enumerator: ______________________________Date:____________________

Start Time: ______________________________Completion time: ____________________
Chiefdom: ______________________________ Section______________________________

Homestead Number [ ] *Please insert the last three digits of the homestead front door. It should correspond with the homestead number on the list provided.*

Household No [ ]

For the following questions, please tick one option unless stated otherwise.

SECTION A: Basic Demographic information

1. How many members are there in your household? *Here you are trying to establish how many people eat from the same pot (labadla ndzawonye, kulinye lidladla)*

1	< 3	
2	3 – 5	
3	6 – 10	
4	11+	

2. Who is the breadwinner of the household? *Here you are trying to find out who is the main person supporting the family financially*

1	Father	
2	Mother	
3	Elder Children	
4	Grandparents	
5	Child headed household (<18)	
6	Other (please specify)	

3. What is the level of education of the <u>breadwinner</u>? *What is the highest certificate obtained by the breadwinner?*

1	Primary School *(grades 1 – 7)*	
2	Secondary School *(forms 1- 3)*	
3	High School *(form 4-5)*	
4	University/College/	
5	Did not attend any form of schooling	
6	Did not attend school but has other training e.g. welding, driving etc	

SECTION B: Fuel Used for Cooking

Ask about the type of fuel used for cooking in the household and tick the appropriate box. It is possible that a household may use more than one type of fuel at any one time but it is the fuel that is used most often that should be recorded

4. What is **<u>the main</u>** form of energy used for cooking in your household? *Bapheka ngani?*

1	Wood fuel	
2	Electricity	
3	Coal	
4	Paraffin	
5	Handigas	
6	Solar (lilanga)	
8	Other (please elaborate)	

5. Why do you cook with the above fuel? *Yini sizatfu sekupheka ngako*?

1	Cheap	
2	Readily available	
3	Clean	
4	Cooks quicker	
5	Other (provide detail)	

6. Do you use the same fuel throughout the year (summer/winter/morning/evening)? *Kuyashintja yini lolobasa ngako?*

1	Yes	
2	No	

7. If no, what other form of energy do you use for cooking? *Nangabe bayashintja, baphindzse basebentise ini lenye?*

1	Wood fuel	
2	Electricity	
3	Coal	
4	Paraffin	
5	Handigas	
8	Other (please specify)	

8. Ideally, what forms of energy would you prefer to use for cooking? *Ebe konkhe bekubahambela kahle, ngabe babasa ngani/ yini labafisa kubasa ngako?*

1	Wood fuel	
2	Electricity	
3	Coal	
4	Paraffin	
5	Handigas	
8	Other(please specify)	

9. Why would you prefer to use the above fuel for cooking? *Leni? Yini leyenta bafise kubasa ngaloku labakushito ngenhla(question 8)?*

1	Cheap	
2	Readily available	
3	Less smoke	
4	Cooks quicker	
5	Other (elaborate)	

The following questions are to be answered by those households who use <u>woodfuel</u> for cooking. <u>If the household does not cook using wood, please skip to question 16.</u>

10. Where do you source your woodfuel for cooking? *Utfota kuphi/ Utitfolaphi tinkhuni?*

1	Communal Forests	
2	Purchase (please detail where)	
3	Household Yard	
4	Other (please specify)	

11. If your woodfuel is sourced in communal forests, how far do you travel to collect it? *Training centre to Lusip Office = 2km*

1	< 1km	
2	1 – 2 km	
3	3 – 5 km	
4	Further than 5km	

12. Is the woodfuel still sufficient in the communal forest? *Tinkhuni tisekhona yini lapho nitfota khona?*

1	Yes	
2	No	

13. Who collects woodfuel in your household? *Kutfota bani*

1	Men	
2	Women	
3	Children	
4	Women and Children	

14. How often is it collected? *Batfota kangaki*

1	Number of times per day	
2	Number of times per week	
3	Number of times per month	

15. How much woodfuel do you use a week (under normal conditions)? *Nisebentisa tinkhuni letinganani ngeliviki?*

1	1 wheelbarrow	
2	2 wheelbarrows	
3	3 wheelbarrows	
4	4 wheelbarrows	
5	Other (please specify e.g. van load, truck load. Please specify size where possible e.g. budze/bubanti)	

SECTION C: Cooking technology

16. How many meals do you cook per day?

1	One meal	
2	Two meals	
3	Three meals	
4	More than three meals	

17. What types of meals do you typically cook and how long does it take to cook that particular meal? *Ask them to give examples of the food they cook in a typical meal e.g. porridge, beans, meat*

17a. Breakfast_________________________________ 17.a.1 time taken: [________] mins

17b. Lunch____________________________________17.b.1 time taken: [________] mins

17c. Supper___________________________________ 17.c.1 time taken: [________] mins

18. What is the **main** type of cookstove you use?

1	Open fire	
2	Wood Stove	
3	Coal Stove	
4	Hand Made Stove	
5	Paraffin Stove	
6	Handigas Stove	
7	Electric Stove	
8	Other (please specify)	

18a. What made you choose this type of stove? *Usikhetseleni lesitofu lesi*

1	Cheap	
2	Readily available	
3	Less smoke	
4	Cooks quicker	
5	Durable (lasts long)	
6	Other (please specify)	

19. What is the **other** type of cookstove you use?

1	Open fire	
2	Wood Stove	
3	Coal Stove	
4	Hand Made Stove	
5	Paraffin Stove	
6	Handigas Stove	
7	Electric Stove	
8	Other (please specify)	

19a. What made you choose this type of stove? *Usikhetseleni lesitofu lesi*

1	Cheap	
2	Readily available	
3	Less smoke	
4	Cooks quicker	
5	Durable (lasts long)	
6	Other (please specify)	

20. What else is the stove used for? *Siphindze sisebente ini lesitofu?*

1	Baking	
2	Boiling Water	
3	Space Heating	
4	Heating up pressing irons	
5	Other (please specify)	

21. Are you happy with the current stove you are using?

1	Very happy	
2	Satisfied	
3	Somewhat satisfied	
4	Unsatisfied	

SECTION D: Clean and wood saving cookstoves and perceptions towards their use

22. Have you heard about cleaner and wood saving cookstoves? *Uke weva yini ngaletitofu letikhona nyalo lokutsiwa tonga tinkhuni tinciphise intfutfu?*

1	Yes	
2	No	

23. If yes, where did you hear about them? *Uvephi ngato?*

1	Radio	
2	Television	
3	Newspapers	
4	Live demonstrations	
5	Word of mouth	
6	Billboard	
7	Other (please specify)	

24. Do you own a clean and wood saving cookstove?

1	Yes	
2	No	

25. If yes to 24, which one do you own? *Unasiphi saletitofu letonga tinkhuni?*

1	Masheshisa	
2	Vesto	
3	Basinthuthu	
4	Modified welcome dover	
5	Lion stove (libhubesi)	
6	Rocket baking oven	
7	Other (please specify)	

26. What do you think are advantages of clean and wood saving cookstoves? *Nawucabanga letitofu timcoka ngani, tisitaphi?*

____

____

____

27. Do you feel it's a good stove to cook with? *Ubona kutsi sitofu lesikahle yini?*

1	Yes	
2	No	
3	Not sure	

28. What do you think are disadvantages of clean and wood saving cookstoves? *Yini lokukabi ngaso lesitofu?*

____

____

____

29. Would you prefer clean and wood saving cookstoves to the current stove you are using? *Uyasinconota yini kulesi losisebentisa nyalo sitofu?*

1	Yes	
2	No	

30. If yes, would you be willing to <u>spend money</u> to purchase a clean and wood saving cookstoves? *Nangabe usinconota, ungavuma yini kukhokha imali usitsenge?*

1	Yes	
2	No	

31. What are specific features you would want a clean and wood saving cookstove to have? *Ungatsandza sakhiwe njani lesitofu lesongako? Yini lemcoka kuwe longafisa umuntfu lowakha titofu akwati* ***<u>(please read out the options to them)</u>***

a	No. of plates	
b	Material	
c	Cooks indoors	
d	Cooks outdoors	
e	Price	

SECTION E: Income and Expenditure

32. What are the sources of income for your household? (you can tick more than one)

1	Monthly salary	
2	Business/farming/casual	
3	Pension/elderly grant	
4	Multiple sources	
5	None	

33. What is your household income per month? *Tick below each option*
If the respondent is not comfortable with this question, please skip it

1. E0 - E 500	2. E500 - 1000	3. E1,001 – E2,000	4. E2,001 – E3,000
5. E3,001 – 5,000	6. E 5,001 – 7,500	7. E7,501 – 10,000	8. >E10,000
9. Not sure			

34. What does your household spend on **<u>the most</u>** on each month? *Imali yalakhaya isebenta kuphi kakhulu? Tick below each option*

1	**2**	**3**	**4**	**5**
Electricity	Paraffin	Handigas	Wood	Groceries
6	**7**	**8**	**9**	**10**
Water	Petrol	Bus Fare	School Fees	Other

35. Do you have any other comments? *Kukhona yini lokunye lofisa kukungeta?(questions, comments, suggestions, complaints)*

____

____

____

______

Thank you for your time.

Enumerator Notes:

The notes area should be used to record:

• If the householder states that they are usually in only at certain times;

• Anything out of the ordinary e.g. a threat from a householder;

• Reasons why forms issued and completed forms collected do not tally;

• Anything which assists you in your enumeration.

____

____

____

____

____

APPENDIX B
ENUMERATOR MANUAL

THE PERCEPTION OF CLEAN COOKSTOVE TECHNOLOGIES IN THE LUSIP GEF PROJECT AREA

1 OBJECTIVES OF SURVEY

The objectives of this survey are to:

a) Identify current cooking fuels and technologies being used in the Siphofaneni area;
b) Assess knowledge of clean cookstove technologies and cooking fuels in the Siphofaneni area;
c) Undertake an analysis of the acceptance of the available clean cookstove designs in the Siphofaneni area;

2 PROJECT AREA

This research project will focus on rural households in under the LUSLM project in the Lubombo region. The specific Chiefdoms and Sections to be targeted are:

- **Mphumakudze:** Sidlangatsi and Mphumakudze
- **Gamedze 1:** Ntfondvo and Lanjane
- **Mkhweli:** Mkhaya, Phuzumoya, Mfigini/Siphofaneni
- **Nceka:** Magojela, Sankolweni and Sikhunyana
- **Luhlanyeni:** Mgambeni, Luhlanyeni and Vovovo
- **Mamisa:** Gucuka, Mamisa and Malayinini

3 DEFINITIONS

- Family: A family is a group of related persons who share living quarters and their principal meal
- Homestead: Refers to a house or a collection of houses found in a common yard of home (UMUTI).
- Household: refers to a person of group of persons who may be related (family) or unrelated or both who live together and share meals (eat from the same pot). They should share at least one meal per day. There can be more than one household in a homestead. Special cases to be included in defining number of members of the household include lodgers, servants and adopted children
- Enumerator: Person asking questions
- Respondent: person being asked questions
- Enumeration Area (EA): The LUSLM project area is divided into segments or portions called enumeration areas.

4 ENUMERATION PROCESS

4.1 Code of Conduct

- All information obtained by an Enumerator relating to individuals or households in the course of the Census enumeration must be treated as strictly confidential.
- An Identity Card (ID) attached to a chain is issued to each Enumerator. It must be worn at all times and produced whenever you are introducing yourself to the householder or any other person.
- Information relating to any individual should not be passed on to any other person or body. If necessary, the information may be passed on to LUSLM Supervisors.
- No attempt must be made to obtain information other than that required by the census.
- Remarks, even of a casual nature, regarding your enumeration work in one household must not be made to another household.
- Each enumerator completes their own questionnaire.

4.2 During enumeration the main activities are

a) Asking questions
b) Recording answers
c) Checking completed questionnaires, e.g. for consistency and completeness
d) Scheduling call-backs, e.g. visiting at different times
e) map-spotting dwelling units on the EA map

This is the most important job in the census and every effort must be made to obtain complete and accurate responses and to record them correctly. The after-enumeration activities include returning completed questionnaires and other equipment to the Supervisor. Any relevant issues or observations that are not reported in writing must be conveyed to the Supervisor.

4.3 Establishing Rapport with the Respondent

1 The Enumerator and respondent are strangers to each other, and one of the main tasks is to establish rapport (relationship/understanding). First impressions count and will influence willingness to co-operate.
2 Always be neat and friendly
3 Use a direction that appears to be well used as an entrance. Do not jump over fences or any other property boundaries. Ask the locals your way to the next dwelling unit when in doubt
4 The questionnaire for the Census is in English and will have to be translated into Siswati however the meaning should not be changed.

5 Make a good first impression: smile, be polite, introduce yourself and the organisation, state the objectives of the survey

6 Always have a positive approach: Avoid apologetic mannerisms such as saying "Are you too busy?", "Would you mind answering some questions?" Such statements could make the respondent think that your mission is unimportant and may invite refusals.

Suggestion:

"Sawubona, libito lami ngu___________________ ngisuka ka SWADE. Sifise kwati kabanti ngekupheka kwenu lakhaya. Inhloso yeproject________________________ Timphendvulo tenu titosita SWADE kutsi ati kancono kutsi sitofu lesilungele lendzawo, lesonga imvelo, ngusiphi. Siyanetsembisa kutsi timphendvulo tenu angeke sititjele lamanye emakhaya".

7 Stress the confidentiality of responses when necessary, be neutral throughout the interview. Never allow the respondent to think that s(he) has given the right or wrong answer by expression on your face or tone of your voice and never appear to approve or disapprove of any of the respondent's answer. Failing to read the complete question may destroy that neutrality.

8 If an unclear answer is given try to probe in a neutral way by asking: "Can you explain a little more"; "I did not quite hear you, could you please tell me again".

9 Never suggest answers to the respondents. Probe in such a way that the respondent comes with a relevant answer. You should never read out the list of coded responses.

10 The wording and sequence of the questions must be maintained. If the question has been misunderstood, repeat it slowly and clearly.

11 If the respondent is giving irrelevant answers, do not stop him or her abruptly or rudely. Listen and try to steer back to the original question. Maintain a good atmosphere throughout the interview

12 Do not form expectation (do not judge households)

13 Do not hurry the interview. Ask questions clearly to ensure understanding by the respondent, pause after each question.

4.4 Field procedures

Each Enumerator will be provided with the following documents and equipment:

- Questionnaire
- Blue pens
- Clip-board
- Enumerator Manual
- Official ID/letter and census badge.
- Map and boundary description of EA
- List of names of persons to contact in the EA

5. MAPS

Maps detailing the enumeration area will be provided. Please make sure you understand the map of your EA and contact a supervisor when in doubt**.**

5.1 Households to be enumerated

A list of households in each EA will be provided, detailing the household number as well as the household name

Appendix C: Information Sheet

Dear Sir/Madam

The person conducting this questionnaire is a Masters Student in the School of Geography and Environmental Studies at the University of Witwatersrand. The student, Lindiwe Dlamini, is completing her dissertation entitled *“The perception of clean cookstove technologies in rural Swaziland”*. The questionnaire should not take more than forty five minutes to be completed. You are free to withdraw at any stage if you wish to do so. Please be advised that any personal information divulged in the interview will be kept confidential and will not be published without obtaining your prior consent.

Your participation in this questionnaire is valuable and highly appreciated.

Thank You

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STUDENT

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Information Sheet for Interviews

Dear Sir/Madam

The person conducting this interview is a Masters Student in the School of Geography and Environmental Studies at the University of Witwatersrand. The student, Lindiwe Dlamini, is completing her dissertation entitled *"The perception of clean cookstove technologies in rural Swaziland"*. The interview should not take more than thirty minutes to be completed. You are free to withdraw at any stage if you wish to do so. Please be advised that any personal information divulged in the interview will be kept confidential and will not be published without obtaining your prior consent.

Your participation in this interview is valuable and highly appreciated.

Thank You

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