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Assessing the awareness, adoptability and sustainability of improved pellet cook stoves of low income households in Lusaka, Zambia.

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Abstract

In order to attain sustainable development, there is need for clean and reliable energy. Woodfuel (charcoal and firewood) make up over 70 percent of the national energy consumption in Zambia as only about 25 percent of the population has access to electricity. It is among the most important domestic fuels for low income households in Zambia. The country's low income are continuously affected by the low availability of sustainable, clean and reliable energy. Cooking with solid fuels and inefficient cook stoves has adverse effects for human wellbeing, health and the environment. One initiative for sustainable energy provision in urban Zambia has been the introduction of improved cook stoves (ICS) based on sawdust pellets to replace traditional cooking on charcoal braziers that have dominated usage in homes since the 1930s.

One of the main motivations for improved cook stove interventions has been to reduce household demand for woodfuel thus to reduce pressures on deforestation. However, adoption of improved cook stoves designed to reduce these impacts remain relatively low while the demand for woodfuel remains predominantly high. Using a user centred approach, the study investigated the awareness, adoptability and sustainability of improved pellet cook stoves in view of government policies of Matero- George compound, Lusaka low income households. It sought the factors influencing households' preference of traditional or modern cook stoves, the knowledge of available energy options, the challenges households had relating to their current cooking solutions and the options available to them and the appropriateness and effectiveness of government policies promoting the use of improved cooking technologies.

The study employed a qualitative approach using semi structured interview questionnaires. The study involved thirty (30) respondents comprising ten (10) key informants from Departments of Energy (3) and Forestry (2) and the Lusaka City Council (5), and 20 households from Matero-George Compound. The study revealed three main types of energy used by different households,' woodfuel, electricity and the pellet cook stoves and four major determinants of energy choice; in/convenience, economic, health, and risks factors. It also revealed that the expense of the pellet cook stove could be the reason for its slow adoption. Further, the study revealed that the awareness levels of the pellet cook stoves and new technologies was low except for the people involved in the projects. It was clearly pointed out that the government had no policy instruments with regard to dissemination, sensitization and communication strategies on the new cook stoves although they were in the process of developing energy efficient strategies on new cook stoves.

Keywords: Sustainable development, Improved cook stoves, Charcoal, Pellets, Woodfuel, Adoption

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Summary

Most people in developing countries lack access to electricity and clean cooking facilities. The world's poor are continuously affected by the low availability of sustainable, clean and reliable energy. Woodfuel (charcoal and firewood) make up over 70 percent of the national energy consumption in Zambia as only about 25 percent of the population has access to electricity. Charcoal and firewood are on high demand for cooking and heating needs at household level in both urban and rural areas. The dependency on woodfuel has increased with the growth of Zambia's population, urbanisation and the growing demand for woodfuel has consequently increased the pressure on the forest resources. Due to the low income levels of energy consumers and the abundance of wood resources, it is anticipated that the wood fuel will continue to dominate Zambia's energy consumption.

This has resulted in forest degradation and deforestation. Woodfuel use also causes risks such as fires and burns. Further charcoal production for heating and cooking causes human health hazards through smoke inhalation, lung disease, injury and death. Women and children are the most affected because they are highly responsible for cooking. Collecting firewood is also time consuming for women and children because of its scarcity and increasing distance to the wood resource due to escalated deforestation and hence they lose time to engage in income generating activities.

One initiative for sustainable energy provision in urban Zambia and overcoming the impacts mentioned above has been the introduction of improved cook stoves (ICS) based on sawdust pellets to replace traditional cooking on woodfuel that has dominated usage in households since the 1930s. The improved cook stoves can reduce and economise the usage of wood fuel. Despite the promise of improved cook stoves to reduce these impacts, adoption rates are low. The renewable energy technologies such as the pellet cook stoves remain largely unknown and unappreciated and lowly adopted. There is, therefore, need to know more about the local preferences and adoption factors. The study therefore focused on assessing the awareness, adoptability and sustainability of improved pellet cook stoves in view of government policies, using a user centered approach. The findings of the study showed that factors such economic, heath, in/conveniences determined energy choices and that there were low levels of awareness on the improved cook stoves attributed to lack of sensitization, dissemination and communication strategies.

Keywords: Sustainable development, Improved cook stoves, Charcoal, Pellets, Wood fuel, Adoption

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Abbreviations

CDM- Clean Development Mechanism

FAO – Food and Agriculture Organisation

FDG –Focus Group Discussions

GHG- Green House Gases

GRZ- Government of the Republic of Zambia

HFO- Heavy Fuel Oil

HLPE- High Level Panel of Experts

ICS- Improved Cook Stoves

INDC- Intended Nationally Determined Contributions

K- Kwacha

LCC - Lusaka City Council

LPG – Liquefied Petroleum Gas

LuMa- Lusaka-Malmo

NEP- National Energy Policy

SEACAP- Sustainable Energy Access and Climate Action Plan

SDGs- Sustainable Development Goals

SIDA – Swedish International Development Corporation

SMEs- Small Medium Enterprises

UNFCCC – United Nations Framework Convention on Climate Change

ZESCO- Zambia Electricity Supply Corporation

1. INTRODUCTION

Globally, over 1.1 billion people live without access to electricity and almost 3 billion people lack clean cooking facilities. The world's poor are continuously affected by the low availability of sustainable and reliable energy (FAO 2017). Therefore, there is need for modern clean energy crucial to human well-being. The United Nations prioritizes Sustainable Development Goal (SDG) number 7 aimed at ensuring access to affordable, reliable, sustainable and modern energy for all (United Nations, 2015). Clean, affordable and sustainable energy is furthermore crucial to achieving many other Sustainable Development Goals, including poverty eradication (SDG 2), health advancement (SDG 3), quality education (SDG 4), water supply (SDG 6) and climate change mitigation (SDG 13). The UN SDGs posits that by 2030, an upgrade of the energy technology is needed for supplying modern and sustainable clean energy in developing land locked countries (FAO 2017). Zambia, being a developing land locked country, is among the countries implementing this goal.

Most Zambian households rely on woodfuel (firewood and charcoal) for cooking and heating. The dependency on woodfuel has increased with the growth of Zambia's population, urbanisation and the growing demand for woodfuel has consequently increased the pressure on the forest resources. This has resulted in forest degradation and deforestation. The Zambia National Strategy to Reduce Deforestation and Forest Degradation postulates that charcoal and firewood make up over 70 percent of the national energy consumption in Zambia as only about 25 percent of the population has access to electricity. Charcoal and firewood are on high demand for cooking and heating needs at household level in both urban and rural areas. The production of charcoal has a significant landscape level impacts due to the multitudes of tree cuttings at production site level (Liyama et al 2014). In view of the aforementioned, there have been strides by the Zambian government and cooperating partners (private and non-governmental organisations) in promoting policies and initiatives to accessing sustainable and reliable clean energy.

In 2007, Zambia social entrepreneurs in collaboration with the Swedish International Development Agency (SIDA) experimented on pelletizing sawdust waste from the wood processing industry in the Copperbelt. It was discovered that this fuel could replace competing unsustainable charcoal (Pesa 2017). This led to a partnership between The Lusaka City Council (LCC) (Zambia) and the City of Malmo (Sweden) to embark on sustainable energy project known as the Lusaka-Malmo (LuMa) Sustainable Energy Project-2016 to 2018. The partnership promotes sustainable energy solutions through municipal collaborations where both municipalities aim to increase their capacity to deal with negative impacts of unsustainable energy use. Lusaka City Council aims to develop a Sustainable Energy Access and Climate Action Plan (SEACAP) with improved citizen dialogue to monitor adaptation and mitigation achievements from climate change and find alternatives to charcoal in Lusaka. This study centered on the LuMa Sustainable Energy project and was based on the sustainable energy solution partnership between Malmö Municipality and Lusaka City Council.

One initiative for sustainable energy provision in urban Zambia has been the introduction of improved cook stoves (ICS) based on sawdust pellets (figure 3 and 5) to replace traditional cooking on charcoal braziers (figure 2 and 4) that have dominated usage in homes since the 1930s (Pesa 2017). One of the main motivations for improved cook stove interventions has been to reduce household demand for woodfuel thus to reduce pressures on deforestation. Liyama et al. (2014) postulate that improved cooking stoves potentially reduce average daily per capita fuel use by 19–67 percent though the outcomes vary depending on the operating conditions. According to Kulindwa (2018), ICS lead to significant reduction in households' consumption of fuelwood approximately between 420 to 700kg compared to traditional cook stoves. Further, the use of ICS has been acknowledged to reduce the demand for fuelwood by forest dependent households. However, adoption of ICS (designed to reduce pressure on native forests through saving fuelwood) remains low and consistently challenges ICS programmes in developing countries, while the

demand for fuelwood remains predominantly high (Kulidwa et al 2018). Troncoso et al (2011) elaborate that the rate of adoption of ICS by forest-dependent households is low and cites an example of Tanzania where only about 25 percent of rural households use ICS.

There have been 20 years of donor and government funded efforts to grow and popularise improved cook stoves in Zambia (Atteridge 2013). In spite of efforts from Non-Governmental Organisations (NGOs) and universities experimenting with alternative cleaner and more efficient energy sources to reduce charcoal usage, the use of charcoal for domestic cooking is still predominant. Cooking on braziers using charcoal is still being used by 95 percent of urban households in the country. This practice is inefficient since 6 to 10kg of wood is required to produce 1kg of charcoal. This consumption is also expected to rise due to Zambia's high population growth, exacerbated by urban development (Sander et al 2013; Atteridge 2013; Pesa 2017). The improved cook stoves such as the pellet cook stoves have proved useful for only wealthier households for cooking relishes such as beans and dried fish (slow cooking dishes) that take time to cook and in case of load shedding (electricity interruption) (Pesa 2017). Therefore, the improved pellet cook stoves (figure 3) with more efficient combustion than charcoal braziers (figure 2) have remained largely unknown and unappreciated, and hence have delayed in penetrating the market economy and none has gained a permanent market share (Pesa 2017). This is evidenced from a number of projects supported by the United Nations Environment Programme (UNEP) and Japanese and German development funds. A stove manual produced by Project Gaia and Clean Development Mechanism (CDM) project funded by a Germany company failed to penetrate the market (Atteridge 2013).

Though improved cooking technologies and clean fuels designed to reduce air pollution exist, adoption and sustained use in developing countries such as Zambia is a challenge. There is, therefore, need for a systematic review focusing on the state of knowledge of adoption of improved cook stoves. (Jagger et al 2019). Clean cook stove proponents postulate the failure of the market transformation to; **lack of awareness of households of the benefits to switching to clean energy and to the inability to afford the new stoves due to their high price** (Atteridge 2013). Bailis et al (2009) also noted that several countries in Africa have implemented improved cook stove programmes since the 1980s, but few have seen sustained support and success. One of the cited reasons for this slow adoption rate could be that improved cook stoves technologies have generally been more expensive than charcoal braziers (figure 2), requiring a higher up-front investment. Domestic users may have, for this reason found it difficult to switch to a more expensive alternative despite it being more energy efficient. Furthermore, charcoal (figure 4 and 7) is viewed as cheap and as an important source of income for the entire value chain of charcoal production (charcoal burners, transporters, wholesalers, retailers, market women and stove producers). Thus, potential livelihood impacts on groups other than charcoal users should also be considered in the design of future household energy interventions (Atteridge 2013). This could highlight the need to consider economic trade-offs as well as include local perspectives in technologies introduced in order to improve their chances of being adopted by the locals. Kulindwa (2018) confirms that the puzzle of the low ICS adoption rate can be explained by households' budgetary constraints and information asymmetry about the ICS attributes of efficiency, durability, fuel type and types of ICS. A situated approach is, therefore, required to understand the determinants of local preference of charcoal (figure 4 and 7) over improved cook stoves technology (pellet cook stoves) in domestic energy usage (Pesa 2017). The aim of the study was to assess the awareness, adoptability and sustainability of the improved pellet cook stoves in view of government policies, using a user centered approach in Matero, George-Compound, a peri-urban of Lusaka.

1.1. Statement of the problem

According to the Zambia National Energy Policy (NEP) (2008), woodlands and forests cover 66 percent of Zambia's total land of which natural woodlands and forests are the main sources of woodfuel (firewood and charcoal). The NEP further explain that due to the low income levels of energy consumers and the abundance of wood resources, it is anticipated that the wood fuel will continue to dominate Zambia's energy

consumption. Wood fuel accounts for over 70 percent of total national energy consumption, of which 88 percent of wood fuel is consumed by households mainly for cooking and heating (NEP 2008). The current consumption rates exceeding the yield rates of woodland/ forests, due to inefficient production, use and population rise, woodfuel can no longer be considered a renewable resource. This is particularly so, in areas supplying wood fuel to urban centres. Gumbo and Chudumayo (2012) have for, instance, noted that that decline in post-harvest forest management in miombo woodlands in Zambia has contributed to a significant reduction in wood biomass accumulation rendering the current charcoal production system unsustainable. Chidumayo (1990) further observed that 97% of the standing wood biomass was harvested for charcoal production in central Zambia which would be equivalent to clear-cutting around the kiln site. If the current trends of woodland depletion continue, the country will run into desertification which is already threatening some parts of the country. This will affect the future generation and the majority of the people as the country will run into an 'energy crisis' (NEP 2008, p2). Charcoal production has perverse effects on poverty leading to localized deforestation around cities such as Lusaka which is associated with environmental degradation and soil erosion, finally resulting in lower agricultural productivity (Zulu and Richardson 2013). According to the high Level Panel Expert (HLPE) (2017), charcoal production for heating and cooking also causes human health hazards through smoke inhalation, lung disease, injury and death.

The improved cook stoves can reduce and economize the usage of wood fuel. The renewable energy technologies such as the pellet cook stoves remain largely unknown and unappreciated and the adoption rate is slow. There is, therefore, need to know more about the local preferences and adoption factors. The department of energy equally remains highly centralised, adversely impacting on awareness and disseminating information on new technologies such as pellet cook stoves. This is highly attributed to the inadequacy in policy dissemination and implementation of the new technologies and its poor incorporation and integration in development plans. This also calls for more inquiry on the policies that can promote adoption of new cook stoves such as the pellet cook stoves.

1.2. Rationale

This study applied a user centered approach to better understand, analyse and identify factors/ reasons for (non) adoption of improved cook stove technology, that can contribute to a switch to improved pellet cook stoves (figure 3 and 5) from the predominant use of charcoal (figure 2, 4 and 7). By incorporating the local perspectives on the cooking stoves, the prospects of successful transitions to less wasteful technologies would increase. Further, it was envisaged that results of this study would provide much needed data for effective policy design and implementation of user centered approach cooking energy strategies. A realistic solution to deforestation driven by charcoal demand would lie in promoting synergies between forest and energy policies in Zambia (Masinja et al 2012).

According to FAO (2017), a range of charcoal production practices and technologies exist. These differ in resource use efficiencies and implications for sustainability. Charcoal consumed in low income countries is produced using simple technologies with low efficiency and thereby resulting in substantial losses of wood and energy (FAO 2017). Combines with the inefficient, unsustainable charcoal production, the slow adoption of alternative new cook stoves, exacerbate adverse trends such as deforestation, health risks and climate change. This study, adopt a User-Centred Approach, in explored levels of awareness and adoption rate of alternative household clean energy stoves (pellet cook stoves).

1.3. Research questions

The associated research questions of the study are the following:

1. What factors influence households' preference and choice of traditional or modern cook stoves?

2. What challenges do households face in relation to their current cooking solutions and the options available to them?

3. What knowledge do households have about available energy options, their sustainability impacts and their levels of cleanliness?

4. How effective are government policies and strategies in promoting new cooking technologies (improved pellet cook stoves)?

1.4. Scope and De/limitations of study

The study was conducted in Matero, George Compound, a peri-urban (urban poor) of Lusaka (figure 1). Matero is an area of 6.92 km² – Density: 8,033/km² with a total population of 55 629 (Central Statistical Office 2010) that rely on charcoal for cooking and heating with some households not electrified. Matero is a low income township inhabited by residents in informal employment (non-regular wage earners of income). Their many occupancy is blue and pink-collar vocational jobs such as carpentry, welding, sales, cleaning and subsistence farming. Other income generating activities include small scale trade businesses such as charcoal and vegetables. The monthly household average income of Matero residents is between 75 USD and 250 USD (Central Statistical Office 2015). This study was confined to 20 households in Matero Compound. It was limited in that it targeted few urban high density low income households and not the rural households. This is explained by the fact that the urban population is growing faster than the rural population combined with a higher percentage of charcoal user households in the cities and towns. The number of beneficiaries of the pellet cook stoves in Matero-George Compound is a population of people of a particular social standing, economic level and education level which is not representative of the Zambian population (low, medium, high density population) in order to see different reactions from different categories of the population. The study centered on low income households as opposed to people of different economic status including the middle and high income households. The scope of the study was also limited to the few beneficiaries of the pellet cook stoves of 15 households and 5 non-beneficiary households. The study did not target the commercial consumers and business institutions, such as restaurants.

Figure 1 below shows Map of Zambia and the shaded region depicts Lusaka, the capital city of Zambia where the study was conducted.

Figure 1 above shops Map of Zambia and Lusaka is the shaded region.

Source: Steffen Hammer (2017)

1.5. Structure of the thesis

The next chapter outlines the background of the study which has been subdivided into the sustainability, policy and gender and health background. The chapter that follow reviews the literature, which explore studies on charcoal and wood use in Africa in both rural and urban setting. It also highlights on studies based on improved cook stoves and the pellet cook stoves in Africa. The approaches, hypothesis and choice of method chapter illustrates the concepts, theories and methodology through which data was collected, highlighting the research approach used in the field. The theories guided the study. The tools used for data collection were semi structured interviews and the data collection methods included semi structured interviews, focus group discussions and document analysis. The validity and reliability and ethical considerations that the researcher undertook during data collection have also been explained in this chapter. The results chapter focuses on the research findings from the different interviewees including the households in Matero-George Compound, Departments of Energy and Forestry and the Lusaka City Council. The discussion looks into data analysis and interpretation of the results and lastly the conclusion gives an overall study and summary of the study.

2. BACKGROUND

2.1. Sustainability background

Fuel wood and charcoal are important sources of energy for households in developing countries. Gumbo and Chidumayo (2012) postulate that Africa accounts for nearly 80% of the charcoal-based deforestation in the tropical regions of the world. According to the HLPE (2017), globally, wood energy contributes 6 percent of the total primary energy supply. It is important for poor people in developing countries, particularly in Africa accounting for 27 percent of the total primary energy, as it is the only source of energy that is available and accessible (HLPE 2017 p48). More than 2.4 billion people (one third of the world's population) rely on use of wood and charcoal for cooking, particularly in Africa where two-thirds of the households are reported to use woodfuel as their main fuel for cooking. An approximation of 50 percent of wood extracted from forests nationwide is used as fuel wood and charcoal (FAO 2017 p2; HLPE 2017 p49). The use of charcoal as a source of energy has for centuries been instrumental and remains so today. Its production has risen in recent decades and it is projected that its demand will continue to increase, especially in Africa. Its consumption in Africa is expected to increase faster than other regions of the world, doubling by 2030 versus a 24 percent increase for firewood (Arnold et al 2006; Zulu 2013). Gumbo and Chidumayo (2012) posit that due to high levels of poverty, the dependence on biomass energy sources continues in sub-Saharan Africa; a trend comprised with inefficient wood fuel production, consumption practices and inaccessibility by most households to other reliable and affordable commercial energy forms unlikely to change in the near future. In a post-conference of a gathering of 54 African Energy Ministers discussing common approaches to energy access and low carbon economic growth given climate change held in Johannesburg in September 2011 failed to even mention charcoal (Chaix 2011, Zulu 2013). This is notably because charcoal can no longer be ignored as a current and future major energy source, as various authors have also noted.

The wood fuel sector, globally, emits greenhouse gases of about 7 percent of total anthropogenic emissions (FAO 2017, p4). Gumbo and Chidumayo (2012) allude to the fact that emissions of greenhouse gases from charcoal production in tropical ecosystems in 2009 were estimated at 71.2 million t for carbon dioxide and 1.3 million tonne for methane. Additionally, unsustainable wood harvesting and inefficient charcoal production contribute to forest degradation and deforestation. On the other hand, sustainable production of charcoal using well managed resources and improved technologies could lead to low emissions of greenhouse gases with the possibility of reducing emissions by more than 80 percent along the charcoal value chain (FAO 2017, p37). This can help mitigate climate change. A greener charcoal value chain increases access to cleaner energy and reduces health risks associated with rudimentary stoves (FAO 2017).

The High Level Panel Experts (HLPE) (2017) posits that forests deliver ecosystem services essential for food security and nutrition, carbon cycle regulation and protection of biodiversity. However, intensified deforestation due to charcoal production and usage has heightened greenhouse gas emissions and significantly reduced the ability of forests to act as a carbon sink/sequestration, protection of land from soil erosion, regulation of water flow, and provision of habitats for wildlife species (Gumbo and Chidumayo 2012). Furthermore, the forests' ability to provide further ecosystem services, e.g. non-timber forestry products (NTFP) is highly compromised the more the forests are degraded (HLPE 2017). Zulu (2013) alludes to the fact that excessive extraction of forests for fuel threatens the sustainability and integrity of forest ecosystems that underpin the very livelihood opportunities that support poverty alleviation and food security.

Further, the High Level Panel of Experts (HLPE) (2017) postulate that forests and trees contribute to food security and nutrition in multiple ways by providing wood, energy, foods and other products. Cooking plays a pivotal role to food safety and micronutrients provisioning. It can, therefore, be argued that a major contribution of forests to food security and nutrition and health is the provisioning of woodfuel to cook and

sterilize water. Fuel availability has an impact on cooking and dietary decisions, with scarcity leading to omission of meals or exclusion of food that requires longer cooking times. In rural areas of developing countries, where people have no alternative energy sources, the lack of fuelwood can reduce the quality and variety of food consumed (HLPE 2017)

Zambia has the second highest per capita deforestation rate in Africa and the fifth highest in the world, with illegal timber production, charcoal production, agriculture extension and human settlement expansion being the main drivers of deforestation (Masinja et al 2012). Over 66% of the country is covered by forests. These forests are highly threatened by the increased rate of deforestation, which is estimated at 276 000 hectares per annum of the wooded land (Masinja et al 2012). Charcoal production has been one main source of deforestation in many areas. The increase in charcoal usage is also highly attributed to urbanization and its adoption in the urban areas. Zulu (2014 p2) elaborates that "the growing demand for charcoal in Africa driven by high population and urbanization growth rates makes charcoal the major primary source of energy for most urban dwellers for at least another generation." This is because charcoal is more energy dense than firewood. Charcoal is therefore more suitable for distant markets (e.g. cities).

2.2. Policy background

Zambia among other countries has ratified to its Intended Nationally Determined Contribution (INDC) to the 2015 agreement on climate change in response to decisions adopted at the 19th and 20th sessions of the Conference of the Parties to the United Nations Framework on Climate Change (UNFCCC). These include mitigation and adaptation components based on her circumstances and in line with decisions 1/CP.19 and 1/CP.20. Zambia's success in implementing INDC will result in total emission reduction of 38,000GgCO2eq which translates to 47 percent against 2010 as a base year. Climate variability and change is a major threat to Zambia's sustainable development because of the climate induced hazards she continues to experience such as drought and dry spells, floods and extreme temperatures adversely impacting food and water security, water quality, and livelihoods of the people especially in rural communities. This also adversely affects key economic sectors such as agriculture, forestry, wildlife, tourism, mining, infrastructure and health. If this remains unaddressed, the potential climate impacts will undermine efforts to improve livelihoods. These impacts have as estimated GDP loss over a period of 10-20 years. The aggregated estimated total GDP loss by sector was in the range of USD 4,330-5,440 million with the following sector GDP losses: Agriculture (2,200 – 3,130), Energy related (270 – 450), Health (460), and Natural Resources (1,400) (INDC, 2015).

In view of these challenges, Zambia has developed various climate change related policies, strategies, projects and programmes in response to climate change impacts which include: the National Policy on Environment (NPE, 2007); the National Climate Change Response Strategy (NCCRS, 2010); National Forestry Policy of 2014; National Energy Policy of 2008, The National Agriculture Policy of 2014 and Transport Policy of 2002; National Strategy for Reducing Emissions from Deforestation and Forest Degradation (REDD+, 2015); Second National Biodiversity Strategy and Action Plan (NBSAP2); the National Adaptation Plan of Action on Climate Change (NAPA, 2007); Technology Needs Assessment (TNA, 2013); Nationally Appropriate Mitigation Actions (NAMAs, 2014); Second National Communication (SNC, 2015). These are aligned with the Vision 2030 whose mission is promoting "A prosperous middle income country by 2030" and the Revised Sixth National Development Plan (RSNDP) which support low carbon and climate-resilient development pathway. Additionally, Zambia ratified the Kyoto Protocol in 2006 to facilitate the implementation of the Clean Development Mechanism and also the development of the Seventh National Development Plan (SeNDP, 2017-2012) is underway which takes account into climate change issues. Furthermore, Zambia is developing National Adaptation Plan (NAP) for long term adaptation planning and mainstreaming of climate change into national development planning process. The INDC underscored mitigation policies into three programs namely Sustainable Forest Management, Sustainable Agriculture and Renewable Energy and Energy Efficiency (Table 1). These

include forest enhancement (afforestation, reforestation, natural regeneration, sustainable charcoal production (improved kilns), improved cooking devices, switch to electric stove and participatory forest management (INDC, 2015).

Table 1 below shows three main programmes of Zambia's National Mitigation Policies

Name of Programme	Description	Objectives of the programme	Co-benefits
Sustainable Forest Management	Program involves implementing - Forest enhancement including natural regeneration and afforestation/reforestation - Sustainable charcoal production to include improved kilns - Improved cooking devices to include improved biomass stoves, use of ethanol and LPG stoves, and switch to electric stoves - Participatory forest management (CFM, JFM, PFM) - Forest fire management	To promote natural regeneration, afforestation/ reforestation, sustainable charcoal production and utilization practices, and generation of electricity from forest waste and residues.	- Creation of job opportunities and alternative livelihoods contributing to rural poverty reduction - Enhanced information awareness on forest management - Increased biodiversity preservation - Restored hydrological balance in the river basin - Increased resource productivity leading to watershed services, and ecosystem protection restoration of natural habitats - Increased rural household incomes from SMEs - Local community empowerment and capacity building, - Reduced GHG emissions - Improved air quality
Sustainable Agriculture	Program involves implementing - Conservation/ Smart agriculture - Rural biogas plants - Rural biomass electricity generating facilities	To promote conservation/ smart agriculture activities leading to adaptation benefits and enhancing climate resilience, especially in rural areas, and generation of electricity from agriculture waste.	- Reduced indoor air pollution due to cleaner energy use Rural poverty reduction particularly among women and the youth - Creation of job opportunities and alternative livelihoods contributing to reduced rural poverty - Reduced GHG emissions due to reduced fertilizer use and less turning of soil - Biodiversity preservation due to reduced tillage - Improved soil productivity leading to improved crop productivity - Soil carbon sequestration
Renewable Energy and Energy Efficiency	Program involves implementing - Fuel switch (diesel/HFO to biodiesel) - Fuel switch (coal to biomass) - Switch from existing isolated diesel to mini-hydro - Introduce and increase blending of bio-fuels with	To promote the switching from conventional and traditional energy sources to sustainable and renewable energy sources and practices, and use of	- Improved health impacts due to child and maternal mortality and retention of medical personnel - Improved education impacts due to longer hours of study and advanced teaching methods, safety, creation of opportunity for girl child and women's education - Improved

	fossil fuels and where possible substitution with bio-fuels - Off grid RE to non-electrified rural – P.V and Wind - On grid expansion program to support economic growth and grid extension through inter-basin water transfer - Grid extension to non-electrified rural areas	off grid renewable energy technologies for rural electrification as decentralized systems.	food security due to increased agriculture production resulting from use of irrigation especially for women - Increased rural development impacts due to increased economic activities through SMEs - Reduced indoor air pollution and load shedding - Reduced GHG impacts and improved air quality - Reduced energy deficits

Table 1: Zambia's Programmes Contribution to its National Mitigation Goal

Source: INDC (2015)

The Zambian government policies do acknowledge the significance of addressing biomass energy for tackling poverty, development and environmental goals. The 1994 National Energy Policy in its goal included reducing charcoal production by 400 000 tonnes per year by 2010 through efficient production of charcoal and wood fuel use and encouraging alternatives. Similarly, this is also alluded to in the 2002 and the 2006 Poverty Reduction Strategy Papers, while the Vision 2030 posits the decrease of fuel wood usage to 40 percent by 2030 in order to attain a productive and well conserved natural resource for sustainable development (National Energy Policy 2008; Republic of Zambia 2006a; 2006b).

In an effort to deal with climate mitigation and adaptation, it is important to understand various social problems and how different policies affect the social structure and economic patterns of communities. This underscores the need to include local people to make them appreciate the need for change. Hence, it is important to take a user-centred approach to investigate household energy practices in order to identify and determine policy and technical solutions that could lead to large scale change (Pesa 2013). The energy users should be placed at the centre of analysis in the transition process (as agents not passive recipients) in order to establish feasible policy and technical solutions that could induce large behaviour change. There is need to understand the households' needs and requirements and how they make decisions about energy and cooking (Atteridge et al 2013). The value of user-centred approach in assessing and understanding household practices in biomass energy cannot be overemphasized. This calls for policy-makers to realize that energy change interventions must make sense to households on social, cultural, technical, ergonomic and aesthetic levels. Therefore, policies regarding energy access and use must be user centred. Interventions befitting charcoal use reduction need to be socially and financially sustainable. To realise this, they need to be responsive to local communities' problems and to their social, cultural and financial factors that influence their decisions about energy use (Atteridge 2013).

On one hand, electricity price reform is always a complicated political proposal in Zambia. Nevertheless, if it is prioritized, it would be possible to lower prices for low income households while raising the overall tariff income in accordance to with the government's objectives and needs of the electricity utility company, the Zambia Electricity Supply Corporation (ZESCO) (Atteridge 2013). Despite this requiring raising tariffs for other users, most electricity subsidies already benefit the higher income households as opposed to the poor households (Kalumiana 2004). In a survey of Lusaka urban areas, charcoal was the dominant cooking fuel despite the availability and desirability to use electricity in many households (Atteridge 2013). This is because using electric stoves was perceived as too expensive for low and middle income households. This could highlight the need to consider electricity price restructuring to lower tariffs for the poor (Atteridge et al 2013).

Much of the country's electric power is predominantly consumed by the mines while the majority of the citizenry rely on woodfuel and charcoal for their household energy needs. The households use 19 percent of the total Zambia's electricity while 68 percent is used for the mining sector (Central statistical office 2007). This shows that households consume far less electrical power than the mining industry. Hence, it would make sense to reform tariffs to affordable rates for more households to cook with electricity (Atteridge 2013). This would induce more electricity usage than charcoal. However, the price of electricity is perceived as expensive by the average household with the imposed electricity tariffs. Consequently many people resort to charcoal because it is considered to be cheaper than electricity and some parts still have no access to electricity. This fails to meet the plight of the poor with their energy needs.

2.3. Gender and health background

The Zambia Gender and Energy Mainstreaming strategy (2011-2013) highlights a gender perspective on the energy sector where women are predominantly burdened. Zambia, being a patriarchal society, has its energy household responsibilities leaned towards women. They are responsible for collecting firewood comprising 70 percent of wood fuel and charcoal consumed by the nation. This involves walking long distances, carrying heavy loads and being exposed to smoke and fire risks. The women spend about 3 hours daily collecting firewood and another 6 hours per day cooking. FAO (2014) in HLPE (2017) noted that fuel collection is physically demanding, leading to illness from excessive workloads when wood sources are far away from home. This is also time consuming for women and children because of the scarcity and increasing distance to the resource. FAO (2014) further suggests that average time needed to collect one cubic metre of fuelwood varies from 106 hours in Latin America and the Caribbean to 139 hours in Asia and Oceania. Similarly, responsibility for wood fuel collection varies amongst regions, women are responsible for 55.8 percent of fuelwood collection in Latin America, 39 percent in Asia and 77 percent in Africa. Even in countries with moderate fuelwood scarcity, women have been reported to walk up to 10 km to gather wood (HLPE 2017). A research conducted by the Programme for Biomass Energy Conservation (ProBEC) in Chikankata area in Southern Province of Zambia showed that women walked more than 5 km every day. Due to increased deforestation, women and girls now had to walk longer distances and increased time spent in search of wood fuel. Additionally, this had a health impact on the women for instance, firewood is heavy, sometimes weighing as much as 20kg which was dangerous to the spine.

Women, being the primary cooks in most cultures and hence the burden of illness affects them much more significantly than men. A systematic review of 2011 reporting on over 2700 studies showed much higher risks of acute respiratory infection in children and chronic bronchitis in women exposed to solid biomass fuel smoke (HLPE 2017). Charcoal production for heating and cooking causes human health hazards through smoke inhalation, lung disease, injury and death. Biomass fuel pollutants, inclusive of charcoal, have globally been associated with more than 1.6 million deaths each year, with about 400 000 in Sub Saharan Africa (Zulu 2013). According to Gordon et al (2014), in instances of indoor cooking, women are exposed to pollution and smoke which can lead to lung cancer or tuberculosis (TB) and other respiratory infections. Reviewed evidence for the association between household air pollution and respiratory infections, respiratory tract cancers and chronic lung disease have been established. Therefore, the links between the use of woodfuel and respiratory illness (which impacts on nutritional status) in women and children are well established. Chronic lung diseases, obstructive pulmonary disease, obstetrical problems such as stillbirth and low birth weight and bronchitis in women are associated with solid fuel use for cooking. It is therefore arguable that women and girls are particularly susceptible to the toxic effects of pollution and are exposed to the highest concentrations (Gordon et al 2014). According to Zulu (2013) charcoal production has perverse effects on poverty which include negative health impacts at the production and use sites associated with smoke inhalation and carbon monoxide poisoning.

3. LITERATURE REVIEW

3.1. Household urban and rural energy use in Africa

Previous studies have investigated different aspects of household bioenergy use in Africa. These range from urban to rural settings in various parts of Africa. One notable study is the GeoPoll of 2018, January. This comprised a survey on household fuel consumption with 1302 respondents in Nigeria, Kenya and Uganda. The survey determined the most used energy in each of the countries, determinants of switching fuel and the average household expenditure on fuel. 17 percent of the world's population (1.2 billion) of rural and poor urban households depend on solid fuels which include firewood and charcoal to meet their daily cooking needs. Households use a variety of petroleum products such as kerosene and liquefied petroleum gas (LPG) for cooking and heating based on their location, access to different fuel sources and their monthly budget (GeoPoll 2018).

A study conducted by World Bank on household fuel in May 2003 found that modern fuels were mainly used by urban elites who could afford them while they played a modest role in rural areas of main low income countries. Further it was found that if rural households started using modern fuels, they did not always replace solid fuels but often acted as supplement to solid fuel. The survey on this topic, 14 years later showed significant uptake of modern fuels such as LPG, charcoal and paraffin in urban areas, while firewood remained commonly used solid fuel in rural areas. The survey also showed determinants of fuel switching such as availability, price and convenience (GeoPoll 2018).

The survey found that households in rural, urban and peri-urban areas rely on both modern and traditional energy sources for basic cooking needs. Firewood, charcoal and LPG gas were the most commonly used fuels for cooking in Kenya, Uganda and Nigeria respectively. The households in the surveyed countries had not switched completely to modern fuels but used a combination of old and modern fuels with firewood, charcoal, LPG gas and paraffin being the most common (GeoPoll 2018).

GeoPoll's findings posits that evidence from many countries transition from wood based energy to fuels such as LPG does not denote any regularized patterns but decisions on energy consumption and fuel type are influenced by accessibility, availability, affordability, cost and convenience. The criteria also depends on the household's income.

In terms of charcoal usage, Uganda had the highest usage at 41 percent, Kenya at 17 percent and Nigeria at 6 percent. 55 percent of urban users in Uganda used charcoal the most while 23 percent of the rural Ugandans used it primarily as a cooking fuel. In Kenya, 18 and 16 percent of urban and rural respondents used charcoal the most respectively. 6 percent of total respondents in Nigeria cited charcoal as their priority choice with 11 percent of rural respondents and 5 percent of urban respondents indicating that they used charcoal more than any other fuel (GeoPoll 2018).

Firewood was the most frequently used cooking fuel in rural households of Kenya, Uganda and Nigeria. 67 percent of rural respondents used firewood as their most used fuel while 5 percent urban respondents said firewood was their most used fuel. Similarly, 66 percent of rural and 12 percent of urban respondents of Uganda indicated firewood as their most used cooking fuel respectively. In Nigeria, 20 percent of rural households indicated use firewood while only 7 percent of urban households used firewood (GeoPoll 2018.

Electrical energy scarcity is a problem in Sub-Saharan Africa and the use of electricity as a fuel source for cooking was low. The study found Uganda to have the highest consumers of electricity as a cooking fuel source for cooking with 11 percent while Kenya was the least with 3 percent (GeoPoll 2018).

In urban Zambia, Tembo et al. (2015) reported that higher income residential area, lower household size, young household head, those with education levels above secondary school, and male headed households were significantly more likely to use electricity as the sole source of energy.

In another study, results showed almost 99.7 percent of Rwanda's household cooking energy came from solid fuels with firewood dominating the cooking fuel (95.7 percent) in rural areas and charcoal (50.1 percent) and firewood (45.4 percent) the major fuels in urban areas. Rwanda's nonrenewable utilization of biomass consumed by households exceeded 50 percent thereby exerting pressure on the remaining forest resources (Jagger and Das 2018).

Yet another study according to the HLPE (2017) showed that in Central Africa, fuelwood extraction was an important component of human impacts on forests. Citing Kinshasa, the capital of the Democratic Republic of Congo, 90 percent of its 10 million inhabitants relied primarily on charcoal.

3.2. Improved cook stoves and pellets stoves

Other studies based on improved cook technologies in Africa have also been conducted. These involve technologies such as pellet cook stoves and micro gasifying cook stoves among others. In a study conducted in Rwanda on the use and adoption of the pellets and pellet cook stove, 38 percent of households marketed to, adopted the pellet and stove system and approximately 45 percent of those who adopted suspended contracts after signing up. It was found that stove choice, pellet production, pricing structures and customer service strategies influenced implementation, adoption rates and scaling up of the adoption rate and use. Customer satisfaction was attributed to modification of stoves to local specific conditions. The study also showed that pricing pellets competitively with charcoal rendered households' adoption of cleaner fuels and technologies at a cost below or at par with charcoal (Jagger and Das 2018). Information on the barriers and drivers of adoption rate and sustained use of the pellet cook stoves with baseline data from the traditional methods of cooking, showed that, the food was easily burned making it hard for the users to appreciate the technology. One notable factor in the success of the pellet cook stove in Rwanda was communication on design features such as allowing innovations in temperature control. High level training to use pellets efficiently and effectively was also a requirement in order to ensure proper use such as not turning the regulator knob to the maximum as that burned food, pellet loading and temperature control. Furthermore, sustained production levels of pellets to support customers and scaling up production in order to meet demand had been an ongoing issue such that in 2015 and 2016 additional households could not be signed up for the pellet cook stoves due to fear that they would not be able to supply them with adequate pellets (Jagger and Das 2018).

The study also showed that among the adopters of the pellet cook stoves in Rwanda, 65 percent of cooking was still taking place on portable charcoal stoves, fixed charcoal stoves and traditional 3-stone stove. This finding is in accordant to the other findings which showed that 71 percent of improved cook stove using households in Rwanda continued to use charcoal stoves (baseline cooking technologies) (Jagger and Das 2018) .

In another study, Jagger et al (2019) analysed drivers and associations of early adoption of the improved cook stoves marketed by a private firm in Rwanda. They examined the association between adoption of the improved cook stoves and household fuel expenditures and health outcomes. Adopting households had more assets, lower per capita total expenditures and cooking fuel expenditures, and higher per capita hygiene expenditures.

Systemic reviews found that higher education, income, household assets and urban location increased uptake while socially marginalised status, large family size, costs associated with high-quality ICS and processed modern fuels to be used with ICS acted as barriers to adoption (Rehfuess et al 2014). Households that purchased rather than collected fuel were more likely to take up the ICS as money saving was beneficial to households already paying for fuel. The characteristic of the stove and fuel were also other determinants of adoption and sustained used of the ICS.

Gebreegziabher et al. (2012) in urban Ethiopia found that household expenditure, household size, age and education of household head significantly explained household adoption of the electric mitad stove, and Alem et al. (2013) found the price of electricity and firewood and credit access to be significant predictors of electric ICS adoption. Another study from urban Ethiopia found that ICS price, household income, and wealth (home ownership and separate kitchen) were significant determinants of Mirte and Lakech ICS adoption (Beyene and Koch 2013).

In Rwanda, adopters had more durable household goods than non-adopters, higher per capital hygiene expenditures (4.78 USD) than non-adopters (2.0 USD) and more married household heads (83.7 percent) than non-adopters (59.4 percent). On including variables about awareness of health, forest and climate impacts, it was found that household with heads that had knowledge of the health impacts from cooking with biomass on traditional stoves were more likely to adopt the new household energy system (Jagger et al 2019).

Kulindwa (2018) noted that income, age, household size, gender, occupation and education influenced the ICS choice. A study in Uganda showed that constraining the choice to just one stove rather than allowing the households to choose the ICS they preferred, without accommodating the households preference, suppressed ICS adoption. Further, it was found that households were more likely to adopt ICS when they were offered on credit than for payment in cash.

Studies in rural Tanzania showed a strong correlation between payment mechanisms and ICS adoption. Households' favored paying on credit because they did not have a regular cash flow and lacked saving behavior. The results indicated that only 30 percent to 48 percent of ICS were adopted when fuel type choices were randomly offered for sale, while 100% of ICS were adopted when they relaxed the cash payment constraints, and controlled for paying on credit with a longer trial period of 3 months to one year. Household favored buying on credit than cash. Conversely, the results indicated that 80 percent of ICS which used both charcoal and firewood were purchased with cash, despite the liquidity constraints. This suggested that any intervention offering ICS that used both charcoal and firewood encouraged their adoption and thus reduced the demand for forest products. The price of alternative fuel types was also an important determinant of households' adoption of ICS. A high price of the ICS reduced the demand and adoption though the demand increased when supplied on credit. The study also showed that households with heads who were older and female correlated positively with the adoption of ICS. On the other hand, large households with poor housing materials correlated negatively with the adoption of ICS.

Liyama et al (2014) allude to the fact that improved cooking stoves potentially reduce average daily per capita fuel use by 19–67%, but the outcomes vary depending on the operating conditions. In their study it was reported that kitchen performance tests in rural Kenya, where the use of rocket mud stoves in place of traditional three-stone stoves, there was reduced daily fuel uses by 19 percent (from 6.7 kg/day to 5.4 kg/day, a cross-sectional result) and by 29 percent (from 6.5 kg/day to 4.6 kg/day, a longitudinal result).

The figures below show a charcoal brazier (figure 2), improved pellet cook stove (figure 3), charcoal repackaged into smaller quantities for resell (figure 4) and pellets (figure 5).

Figure 2: Traditional charcoal brazier (stove)

Figure 3: Improved pellet cook stove

Figure 2 above shows the traditional cook stove (charcoal brazier-*mbabula*) being used by a beneficiary of the improved pellet cook stove while figure 3 shows the improved pellet cook stove with adjusting knob-heat regulator.

Source: Picture taken by researcher

Source: Emerging Cooking Solutions Facebook page

Figure 4: Charcoal repackaged in smaller packages for resale **Figure 5**: Pellets

Figure 4 above shows charcoal repackaged in smaller sizes for resell, while figure 5 shows pellets. Both charcoal and pellets are used as fuel for cooking on a charcoal brazier and pellet cook stove respectively.

Source: Pictures taken by researcher

4. APPROACHES, HYPOTHESIS AND CHOICE OF METHOD

4.1. Theoretical framework

The conceptual framework for the study draws on theories on sustainable transition (Rogge and Reichardt, 2016; Edmondson 2018), Sustainable Livelihoods (Scoones 1998) and diffusion of innovations (Rogers 2003). These theories were employed as guiding principles to the study in relation to policy instruments and (non) or adoption of new innovations based on the households capacity/ capability befitting their local conditions and economic status.

Policy process on sustainable transition helps explain how policy mixes influence socio-technical change (e.g adoption of pellet cook stoves) and how changes in the socio-technical system also shape the evolution of the policy. It is important to note that policy mixes aiming to foster sustainability transitions such as adoption of pellet cook stoves, need to be designed to create incentives for beneficiaries in order to mobilise further support. A shift to more sustainable transitions requires significant structural changes in existing systems through policy reconfiguration of user preferences, cultural perceptions and market selection environments. Policy action has been argued overcomes market and system failures (Edmondson et al 2018).

Sustainable Livelihoods entails achieving both sustainability and equity in living standards of households. Sustainable Development has been an important discourse aimed at protecting the environment with less focus on economic development. However, it is important to note that in trying to protect the environment, this may affect the social life of a community where they are denied the use of natural resources that they have always relied on for their livelihoods. Efforts to provide energy for communities/ households, at an acceptable environmental cost, mean little without recognising the reality of the continued importance of woodfuels, Hence environmental security and social security need to be protected simultaneously by ensuring the livelihoods of people depending on the natural resource are well managed and empowered. The Sustainable Livelihoods conceptual framework, therefore, using a user centered approach was used to determine how the adoptability of the improved pellet cook stoves in view of government policies, could substantially address the socioeconomic impacts of the livelihoods' households. This focuses on five parameters namely, vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies and livelihood outcomes.

Diffusion of innovations expounds how innovations are adopted by a people. An innovation is a new method, idea or object amidst an audience. This theory departs from coercion or persuasion of individuals instead considers change as evolutionary of behaviour that is responsive and best fits its peoples' needs. Hence focus should be on the adopter's capacity and accessibility of benefits that lie within the innovation and also the socioeconomic statues of the system in which diffusion is taking place. Stumbling blocks in taking up innovations pertain to levels of income, knowledge/ information about the technology, and policy implications. The solutions should be stress free to the adopters through accessibility, affordability and acceptability to local circumstances.

4.1.1. Sustainable transition

Understanding policies of transition is key for the implementation of sustainability transitions. One important requirement for transition is the redirection and acceleration of technological change towards sustainability objectives. In order to succeed, the following stages of invention, innovation and diffusion of technological change with regard to market and institutions, practitioners have called for policy mix which combines several policy instruments. A policy mix is a combination of policy instruments, and how they emerge and interact (Rogge and Reichardt 2016).

Building blocks of the policy mix concept

A policy mix concept for sustainability addresses three basic requirements; the inclusion of strategic component, policy processes and characteristics of policy mixes. Policy strategy is defined as a combination of policy objectives and the principal plans for achieving them (Regge and Reichardt 2016). Therefore, the emphasis is on the output which comprises the ends and means of the strategy process. The first component of the policy strategy is about policy objectives associated with sustainability transitions with long term targets and quantified ambitions based on visions of the future. The second component of the strategy definition concerns the principal plans for achieving these objectives outlining the path governments undertake to achieve their objectives, guidelines strategic action plans and roadmaps. This strategy communicates both the means to achieve the ends and the ends in itself and thereby giving direction to actions and decisions. The strategic element of the policy mix, in order to change innovation strategies, needs to be substantiated with operationalization through concrete policy instruments.

Instruments: Policy instruments are the second element in the policy mix that constitute tools to achieve objectives. These are techniques introduced by governing bodies that address policy problems in order to achieve policy objectives. Two attributes of policy instruments relevant for innovation include instrument type and instrument design.

Instrument type: both empirical and theoretical studies have identified an instrument as a major determinant of environmental innovation.

Instrument design features: According to environmental economics literature, a policy instrument's design features is likely to be more influential for innovation than the instrument type. Hence a number of studies consider them when analyzing policy instruments and their innovative effects. In the context of sustainability transition, the following abstract design features are good to consider; level of support, predictability, flexibility.

The level of support: comprises the positive incentives provided by a policy instrument particularly relevant for instruments providing financial services. *Predictability* centers on the degree of certainty associated with a policy instrument and its future development. *Flexibility* captures the extent to which innovators are allowed to freely choose their preferred way of achieving compliance with the instrument. Evidence shows that countries with flexible environmental policies are more likely to generate innovations which are diffused widely and are more likely to benefit from innovations generated elsewhere.

4.1.2. Sustainable livelihoods framework

Figure 6 below illustrates on sustaiable livelihoods framework in relation to socioeconmic livelihoods and its impacts on adoptability of pellet cook stoves

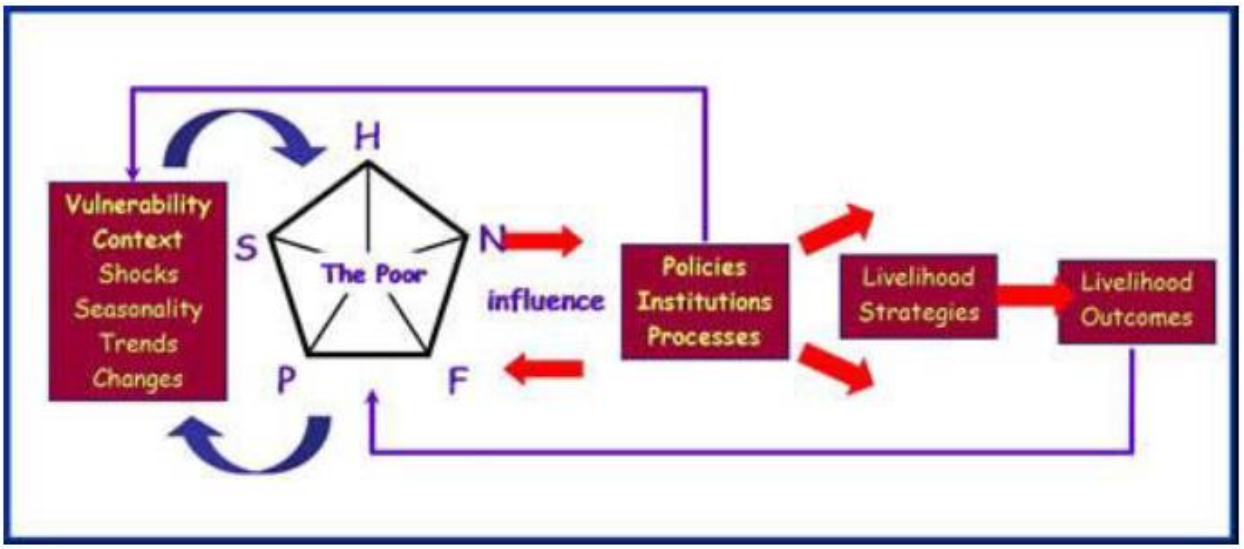

Figure 6: The sustainable livelihoods conceptual framework, S- Social capital, H-Human Capital, N-Natural Capital, F-Financial Capital, P-Physical Capital, Source: International Fund for Agricultural Development (IFAD), 2007

The livelihoods framework is a tool to improve our understanding of livelihoods, particularly the livelihoods of the poor. It has five parameters that are key in addressing sustainability namely; vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies and livelihood outcomes. It presents main factors affecting people's livelihoods and their relations. This is a people centred framework working in a nonlinear model. Its focus is on stakeholder engagement in structure and debate about a myriad of factors affecting livelihoods, their relative importance, and the way in which they interact. This gives direction of entry points favourable and suitable for support of livelihoods. It is important to understand the vulnerability context of livelihoods which yields livelihood outcomes. People- centred analysis focuses on investigating people's assets and their objectives (The livelihood outcomes which they are seeking and the Livelihood Strategies which they adopt to achieve those objectives). Therefore, Transforming Structures and Process and the Vulnerability Context; and Livelihood Outcomes and Livelihood Assets are crucial in this vein. In using the framework to eliminate poverty, analysis should be conducted in a participatory manner by engaging in meaningful dialogue with partners in addressing political and economic factors that perpetuate poverty.

Vulnerability context

The Vulnerability Context shows the external environment in which people live whose livelihood assets are affected by trends, shocks and seasonality on which they have little or no control. These have direct impact on people's asset status and the options available to them in pursuit of beneficial livelihood outcomes. Shocks can destroy and dispose of assets prematurely as a copying strategy on the very poor people. Trends also have an influence on rates of return to livelihood strategies. Seasonal shifts of prices is a hardship for poor people in developing countries.. Transforming Structures and Processes (e.g. change in policy) could be used to manage the vulnerability context. Critical institutions and organisations ought to be responsive to the needs of the poor. What is critical is identification of trends, shocks and seasonality important to livelihoods and their impacts and how to negate negative impacts. Understanding local livelihoods, their strategies and factors hindering them from achieving their objectives is of paramount importance. This requires a prior understanding of the nature of local livelihoods – what types of livelihood strategies. This is achieved through social analysis so that social groups and their relationship with factors within the Vulnerability Context can be identified.

Livelihood assets; DFID (1999) identifies five asset categories (Human, Natural, Financial, social and Physical Capital) on which lives are built and recognises access, ownership or right to use these assets in

support of livelihoods and poverty eradication. The asset pentagon as shown in figure 6 above lies at the core of livelihoods framework within the vulnerability context. This entails that people operate in the context of vulnerability where they have access to certain assets that gain their meaning and value in their existing social, cultural, institutional and organizational environment. Furthermore, transforming structures and processes of the environment influence the livelihood strategies and use of assets into beneficial livelihood outcomes befitting their livelihood objectives (DFID 1999).

Transforming structures and processes; Transforming structures and processes within the livelihoods framework include institutions, organisations, policies and legislation that shape livelihoods. Processes (policies) established and implemented through structures affect trends directly and indirectly. Institutions can restrict people's choice of Livelihood Strategies especially policies and regulations that affect the attractiveness of particular livelihood choices through their impact on returns. Responsive political structures implementing pro-poor policies significantly increase people's sense of wellbeing and this has impacts on livelihood outcomes. The correlation between various policies and the sustainability of resource use is significant and complex.

Livelihood strategies; The sustainable livelihoods approach seek an understanding of factors behind people's choice of livelihood strategy and fortify positive (factors which promote choice and flexibility) aspects and mitigate the constraints. Choice and value is cardinal in that it provides people with opportunities for self-determination, and flexibility to adapt over time. This is achieved by improving poor people's access to assets which are building blocks for livelihood strategies and make the structures and processes that transform these into livelihood outcomes that are responsive to their needs.

Livelihood outcomes; Livelihood Outcomes are the achievements or outputs of Livelihood Strategies. As outsiders, people should recognise and seek to understand the richness of potential livelihood goals and this gives an understanding of livelihoods' priorities, why they do, what they do and where the major constraints lie. It is important to analyse the extent to which aims are achieved. If specific social groups fail to achieve their aims, it is likely their aim conflict with the aims of other more powerful groups.

4.1.3. Diffusion of innovation

Rogers Everret (2003) uses the diffusion of innovation theory to explain how characteristic of different innovations shape the adoption process of a new innovation. These include relative advantage, compatibility, complexity, trialability and observability. These different stages are explained below.

Relative advantage refers to extent at which an innovation is perceived as better than the idea it supersedes. This can be measured in economic terms, convenience, social prestige and satisfaction. The important thing is how advantageous an individual perceives the innovation as opposed to what advantages it brings forth. Hence the greater the perceived relative advantage of an innovation, the more the rapid the adoption rate.

Compatibility is the extent to which an innovation is viewed as being consistent with existing values, past experiences and needs of potential adopters. If an idea is to be adopted, it needs to be compatible with the prevalent values and norms of a social system. Therefore, for easy adoption, an innovation has to be consistent with the existing societal values and norms.

Complexity is the degree to which an innovation is perceived as difficult to understand and use. Innovations that are easily and readily understood by members of a social system are adopted faster than are more complicated innovations. Generally, new simpler ideas that are easier to understand, are adopted faster than the innovations that need the adopter to acquire new skills and understandings.

Trialability is the degree to which an innovation may be experimented with on a limited bias. New ideas that can be tried on the installment plan will be adopted at a faster rate than innovations that are not divisible. A trialable innovation represents less uncertainty to a potential adopter because it is possible to learn.

Observability is the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more they are likely to adopt it. This visibility enhances discussion of new ideas amongst people who ask the adopter of performance/ results of the innovation. In a nutshell, innovations that are perceived by receivers as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted at a faster rate than other innovations (Rogers 1995).

4.1.4. Synthesis framework

Table 2 below shows the synthesis of the framework used in this study and how the three theoretical models correspond to the research questions:

Table 2: Synthesis Framework		
RQ	**Theory framework**	**Methodological approach**
1. What factors influence households' preference and choice of traditional and modern cook stoves?	Diffusion of innovations (Rogers 2003)	Household interviews. Focus group discussions
2. What challenges do households face in relation to their current cooking solutions and the options available to them?	Sustainable Livelihoods (Scoones 1998) and diffusion of innovations (Rogers 2003).	Household Interviews Focus group discussions
3. What knowledge do households have about available energy options, their sustainability impacts and their levels of cleanliness?	Sustainable Livelihoods (Scoones 1998) and diffusion of innovations (Rogers 2003).	Household Interviews Focus group discussions
4. How effective are government policies and strategies in promoting new cooking technologies (improved pellet cook stoves)?	Rogge and Reichhaedt (2016), Edmondson (2018) sustainable transition.	Semi structured interviews

As the synthesis framework (**Table 2**) illustrates on the different theories alongside with the research questions, it demonstrates that adoption of new innovations require and entail management of risks and uncertainties. Therefore, attempting change (innovations) should be beneficial and make sense to the adopters economically, socially, culturally, ergonomically and aesthetically to a superseding idea. Worth noting also, is that, the kind of policy instruments crafted by government could be used in the implementation process of new cook stoves. However, these policy instruments could either present opportunities or challenges for adopters of new innovations and hence they need to be in line with the needs of the communities and the economics must make sense at grassroots level. The social sustainability aspect of the households is equally important for a sustainable livelihoods. Households Sustainable Livelihoods are meaningful if both sustainability and equity in their living standards are met.

4.2. Methodology

This chapter discusses the methods that the researcher used in the study. Desai and Potter (2012 p118) allude to the fact that "qualitative research typically focuses on compiling a selection of micro-level case studies which are investigated using a combination of informal interviews, participant observation and more recently visual media like photography and video." According to Creswell (2014 p32) qualitative research is an approach for exploring and understanding the meaning individuals ascribe to a social or human problem. Therefore, in this study the researcher sought to understand the meaning that people ascribed to energy use. To this effect, interviews were conducted to get an all-inclusive and broad view of the respondents understanding of the subject under study. Hence, the various respondents shed light on their respective situations, beliefs and experiences. This is in tandem with the social construct approach indicating a focus on how the social world is interpreted and how reality is constructed by those involved in it and through their experiences (Robson and McCartan 2016). The researcher used qualitative study due to the approach, nature of the study and questions in order to get a holistic understanding of complex realities and processes where the questions emerged cumulatively as the investigation progressed (Desai and Potter 2012). The qualitative approach also helped the researcher to seek clarity on vague answers by probing further.

4.3. Sampling design and sample size

The technique of the study used was purposive sampling based on the nature of the study. The selection of the participants was based on their possession of particular characteristics being sought. Hence the sample was chosen based on the satisfactory to the needs of the study. A total number of ten (10) key informants working for government were identified. These involved three (3) government officers and two (2) councilors from the LCC, which was the implementing agency of the LuMa project and three (3) and two (2) government officers working for Departments of Energy and Forestry respectively. The government officers were selected based on their job description in line with the study. This was attributed to the fact that they were in position to give the in-depth information that was required in the study. Cohen et al (2011) note that purposive sampling is used to access 'knowledgeable people,' with in-depth knowledge about particular issues by virtue of their professional role, expertise or experience.

The community sample was equally chosen on a purposive sampling technique. The sampled community was Matero-George Compound of Lusaka who had received and used the improved pellet cook stoves under the LuMa project. These comprised fifteen (15) households. Additionally, five (5) more households that did not receive the pellet cook stoves (non-beneficiaries) were also interviewed. These were selected randomly from the same community (Matero-George Compound) aimed at getting views on the pellet cook stove from a non-user perspective.

4.4. Data collection methods

4.4.1. Document analysis

Document analysis is an effective way of collecting secondary data when answering research questions as it provides a useful check on information that is in existence about the researchers' study (Tesch 1990). Cohen et al (2011) mention that documents once located and examined do not speak for themselves but require careful analysis and interpretation. Similarly, the researcher analysed and interpreted different documents related to the study. In trying to understand what impacts policies had on households' choice of stove, the researcher reviewed a variety of written information, which included policy documents (e.g The National Energy Policy), mission statements, and annual reports (Hancock et al 2007). This was particularly

useful in trying to understand the philosophy of the different organisations. Analysis of the different documents provided insights into the kinds of assumptions that underlied policy reforms and revealed some of the contradictions and tensions that were inherent in policy (Cohen, Manion and Morrison, 2011). Additionally, an analysis of the current prevailing charcoal production use was done in order to address unsustainable energy use and promote alternative cooking solutions. This specifically involved ascertaining the meaning of Zambia's National Energy Policy (NEP) of 2008, Forestry policy and the National Strategy to Reduce Deforestation and Forest Degradation documents and other relevant documents in line with the study. The researcher sought to understand the information relayed in the policy documents, and its underlying values and arguments developed. And in doing so, comprehending the text and its wider context was eminent (Cohen et al 2012). Further, the context of the documents were examined while taking account of broad educational, social, political, economic aspects that helped explain the meaning of documents (Cohen et al 2012).

4.4.2. Semi-structured interviews

An interview is a tool for data collection encompassing verbal, nonverbal, spoken and heard multi-sensory channels. Face to face interviews offers the possibility of observing non-verbal cues which may give messages which help in understanding verbal responses, in extreme cases reversing its meaning (Robson & McCartan 2016). Interviewing was the main channel of information gathering and background that supported other forms of data collection that the researcher used (Desai and Potter 2012). This was because interviewing was a flexible and adaptable way of finding out on cooking and energy use in Lusaka by asking respondents directly what was taking place. Interviews are divided into structured, semi-structured and unstructured interviews. The researcher used semi structured interviews because of the nature of the study which needed to address the research questions and also due to the limited time to collect data. These sought an in-depth understanding of complex problems where lead questions were used to uncover in-depth issues about the study. These interviews allowed follow up questions for additional information and enabled a conversation between the researcher and the different interviewees. According to Atteridge et al (2013), semi-structured interviews with open-ended questions allow focused, conversational two way communication to generate not just answers but also the reasons for the answers. Through these interviews, the researcher used open ended questions and elicited views and opinions from the participants (Cresswell 2012).

In this study, the researcher used an interview guide to guide the progression of the interview that served as a checklist of topics to be covered and order for the questions, although the wording and order were modified based on the flow of the interview and additional unplanned questions were asked as follow ups on the interviewees statements (Robson & McCartan 2016). This enabled the researcher to modify her line of inquiry, following up interesting responses and investigating underlying motives. The researcher pressed for complete responses, complex and deep issues while controlling the order of the interview and also allowing for spontaneity (Cohen et al 2012). Through the use of this method, the researcher ensured that the important areas were covered while also providing the interviewees with opportunities to bring up their own ideas and thoughts (Desai and Potter 2012). Interviews, therefore helped examine processes, motivations and reasons for success or failures on energy use. In the same plight, the interviews helped the researcher examine the prevailing situation on the pellet cook stoves, charcoal usage, electrical stoves, and motivations behind the choice of energy use. The researcher constructed knowledge during the interviews with different stakeholders generating data. In light of that, the interviews enabled both the researcher and respondents to discuss the interpretation of the world in which they lived and how they regarded the situation from their own point of view (Cohen et al 2012).

Cohen et al (2012) postulate that bias is likely to creep in during an interview, however, to eliminate it, the researcher established rapport with the respondents, asked questions in an acceptable manner and developed mutual emotions that encouraged the respondents to be sincere and well-motivated rendering the obtaining

of accurate data. The interviewees included three government officers from the Departments of Energy, two government officers from the Department of Forestry, five government officers from the Lusaka City Council and fifteen and five low income households of Matero-Gerorge Compound that received and did not receive the improved pellet cook stoves respectively. The government officers were selected basing on their work relating to the study. At the department of energy, one interview was conducted in the boardroom while two were conducted in the offices of the interviewees because free space/ room could not be accessed at the point of interview. This was not without interruptions due to some people coming into the office and leaving and they were also shared offices. The two Department of Forestry government officers preferred not to be interviewed, instead they requested to answer the questions in few days, and hence the researcher left the semi structured interview guide so that they could answer at their own time. The five respondents from the Lusaka City Council that took part in the study included those that were involved in the implementation of the LuMa sustainable energy project. These comprised three government officers and two councilors. Of the five, two preferred to answer at their own time while three were interviewed. Information sought from the different institutions and households aimed to understand the subjectivity of responses in terms of different accounts of 'facts,' different meanings and different perceptions (Desai and Potter 2012). After the interview, the researcher asked the respondents if they had any questions. This led to revelation of new information that might not have been covered by the researcher. The researcher thanked the interviewees at the end of the interview and debriefed them about the study at the end. Data was collected through writing aided by recording (with permission from participants). However, some interviewees felt uncomfortable and thought the information could be traced back to them and hence preferred not to be recorded (Desai and Potter 2012). Data collected related to study research questions and reviewed clear patterns emerging from it that influenced decision making. Conclusion was then drawn from that.

4.4.3. Focus group discussions

A focus group is a qualitative technique for understanding and documenting attitudes, behaviours and the meaning of people's worlds particularly seeking to understand community dynamics and viewpoints (Desai and Potter 2012). It can also be referred to as a 'group depth discussion' conducted with around 6 to 8 participants and a good way to gather people from similar backgrounds or experiences to discuss a specific topic of interest. The researcher conducted a focus group discussion (FGD) comprising 7 people. This FGD consisted of the women local communities of Matero-George Compound, Lusaka, where the LuMa Sustainable Energy project was piloting. Of this group, two persons were not part of the pilot project and were not beneficiaries of the improved pellet cook stoves. The researcher used this method in order to allow the group to participate in a lively and natural discussion. It was used to explore the meanings of survey findings that could not be explained statistically and a range of opinions/ views on the topic and to collect a wide variety of information (Krueger1988, Morgan 1988; Stewart 1990). In this study, the researcher acted as a moderator and facilitated the interaction between members of the group without controlling the discussion and encouraged everyone to participate (Desai and Potter 2012). The FGDs were used as a method to allow for a more collective view or interpretations, getting information ranging from similar opinions and ideas to inconsistencies and variations in terms of peoples' beliefs, experiences and practices. Additionally, the FGDs were used as a way of triangulation and to validate the data obtained through the observations in the different households/ communities (Cohen, Manion and Morrison, 2011). The researcher used FGDs to ascertain information on the views of the social issues on pellet cook stove perceptions and to explore the groups' contradictions and uncertainties (Potter and Desai 2012). Thus it would be true to conclude that the FGDs provided an environment for understanding attitude and beliefs pertaining the improved pellet cook stoves. The participants interacted with each other rather than with the researcher. Hence the views of the participants emerged rather than the researcher's (Cohen et al). FGDs, however, on one hand also have a disadvantage of the more talkative dominating the discussion. Potter and Desai (2012) poignantly argue that groups can be subject to peer pressure and dominated by powerful voices

evoking controversial views to be silenced. However, the interview process was well managed in order to allow the less articulate to share their views and mitigate bias caused by the dominating extreme views (Robson & McCartan 2016). As a facilitator, the researcher controlled the domineering trend and encouraged everyone to participate so that everyone contributed equally (Krueger1988, Morgan 1988; Stewart 1990).

4.5. Data analysis

Analysis is the 'breaking up' of something complex into smaller parts and explaining the whole in terms of properties of, and relationships between these parts. This is a necessary process for a researcher as it works as a reductionist process of the data gathered in order to make sense of it (Robson & McCartan 2016). Cohen et al (2012) postulate that data analysis involves organizing, accounting for and explaining the data. The researcher took notes and recorded some interviews that were permitted. The researcher then transcribed the interview data for analysis. The researcher analysed the data by making sense of the of the participants' definitions of the situation, noting patterns, themes, categories and regularities The transcriptions provided vital detail and accurate verbatim record of the interview (Cohen et al). The researcher was careful not to miss or omit any word during transcribing. The researcher interpreted the information gathered through interviews by extracting themes ideal and relevant for the study and the research questions. This was done by rereading and listening to the recorded interviews. The researcher then came up with important information in line with the themes that emerged from the respondents. The researcher also reviewed the notes that were not recorded, and those aspects that were observed before and after the interview as Cohen et al (2012) notes that transcribes omit nonverbal aspects that may take place before and after the interview. The researcher found transcribing to be arduous and time consuming in line with Cohen et al (2011) sentiments that practically, transcriptions are very time consuming to prepare for instance one hour of an interview may take five to six hour to transcribe. Furthermore, in order to allow for anonymity, the researcher ascribed to the transcription conventions of giving each speaker a pseudonym such as respondent one or government officer two by not using the respondents names (Cohen et al 2012).

4.6. Validity and reliability

Validity and reliability are significant intertwined instruments of evaluation in social research. Cohen et al (2011) postulates that reliability is a necessary but insufficient condition for validity in research; reliability is a necessary precondition of validity. Validity is significant in research in order for a study to be valuable and useful or else it is considered worthless. It demonstrates that an instrument measures what it purports to measure. On the other hand, reliability is the dependability, consistency and replicability of a study over time, over instruments and over groups of respondents (Cohen et al 2011). It is concerned with precision and accuracy. Therefore, reliability is concerned with obtaining the same scores on a group of people reexamined over time and space. In this study, to ensure validity and reliability, the researcher used methodological triangulation by collecting data using different methods such as focus group discussions, document analysis and semi structured interviews. Also, the research tools were examined by experts before commencement of the research. Additionally, the researcher tested the research instruments before embarking on research. Furthermore, in order to align herself with validity and reliability in the study, the researcher tried to be as neutral as possible during the interviews. She avoided being biased by either understating or overstating the true value of an attribute under discussion (Cohen et al 2011).

4.7. Ethical consideration

Ethics refers to rules of conduct; typically to conformity to a code or set of principles. Cohen et al (2011) argue that the questionnaire is always an intrusion into the life of a respondent and qualitative data analysis raises the question of identifiability, confidentiality and privacy of individuals. To that effect, the researcher had ethical obligation to fulfil the requirements such as those mentioned above. During the study, the researcher considered the required ethics such as informed consent, privacy and confidentiality. Informed consent is important if participants are going to be exposed to stress, pain, invasion of privacy and it is the cornerstone of ethical behavior. This means the researcher was only able to carry out research, ask questions, and organise focus group discussions after explaining to the interviewees the reason of the study and the intended outcomes for both the researcher and the interviewees (Desai and Potter 2012). To support of this, Desai and Potter (2012) allude to the fact that results can only be achieved if people are willing to participate in a study and work with it. Answers were kept strictly confidential and never associated with names. This was in line with Desai and Potter (2012). The researcher also sought permission to record the interviews and also to take photographs for the respondents who were willing to be recoded and photographed. In an event that the interviewees felt uncomfortable do so, the researcher abided by their decision.

Figure 7 below shows different sizes of charcoal bags for sale to consumers.

Figure 7 above shows 10 and 25 kilogrammes of charcoal bags for sale to consumers.

Source: Atteridge (2013)

5. RESULTS

This chapter reports the findings of the study on the awareness, adoptability and sustainability of improved pellet cook stoves in view of government policies. This involved interviews of households (beneficiaries and non-beneficiaries of pellet cook stoves) in Matero-George Compound, and key informants from the Lusaka City Council, Departments of Energy and Forestry. Table (3) tabulates the interviewees groups.

Table 3: List of institutions and households interviewed

INSTITUTION	**TARGET**	**NUMBER OF RESPONDENTS**
Households	Beneficiaries of pellet cook stoves	15
Households	Non Beneficiaries of pellet cook stoves	5
Lusaka City Council	Implementing Agency	5
Department of Energy	Government Officers	3
Department of Forestry	Government Officers	2

The questions (appendixes 1 and 2) that were derived from this study were based on research questions related to households' preferences, cooking and heating choice and policy effectiveness and strategies on promoting improved cooking technologies (improved pellet cook stoves). They also included challenges and cooking solutions, knowledge and perceptions on sustainability impacts and policies. Firstly, the researcher outlines the responses (appendix 1) and findings from the households, thereafter, the key informants' responses will be outlined. Codes to present the respondents excerpts have been used to ensure anonymity.

5.1. Household responses

Three main types of energy were used by different households depending on their preference. The sources of energy mentioned included woodfuel (charcoal, firewood), electricity and the pellet cook stoves. The preferences were varying for all households, (others holding the same views while others were giving different views as outlined below). The determining choice of energy factors mentioned by households included accessibility, affordability, availability, efficiency, usability, health impacts, price, convenience, food type to be cooked (e.g roasting meat) and ease of use of the type of energy. The responses from the households were structured and categorized in four main themes emanating from the information collected. These included in/convenience, economic, health, and risks. The author outlines the responses of the information as guided by the sequence of the research questions presented in chapter 1. The responses influencing households' preference of traditional and modern cook stoves (research question 1) as answered by the households have been described below under in/convenience aspects.

In/convenience aspects

This aspect mainly centers on the factors that influence households' preference and choice of traditional or modern cook stoves (research question 1).

Electricity; Some households that used electricity to cook mentioned that it was quick to light, clean and there was no need to lighten up like it is with charcoal. They said they used charcoal when there was power cut (electricity interruption) or if the electrical units were about to finish. They said electricity interruption was an inconvenience because when power was interrupted they needed to switch to charcoal which required a process of lighting and it was time consuming and in other instances affected the cooking and tasty of the food. On the other hand, some households narrated that food cooked on electrical stove was not as tasty and flavored as that cooked on charcoal brazier. Meanwhile few households said that electrical stove and pellet cook stove were similar in usage, both have regulator though a pellet cook stove was faster.

Pellet stove vs Charcoal brazier/ firewood; Most households postulated that the pellet cook stoves allowed for indoor cooking, did not produce smoke, and did not give headaches and dizziness like charcoal brazier. They alluded to the fact that the pellet cook stove (figure 3) had no perforations (holes) like the charcoal brazier (figure 2), which emitted carbon monoxide as it produced its own air with a fan made in it. They also said it was faster to cook and light, it lighted like a gas stove or electrical stove and it could be charged with electricity. It also worked with solar to charge (in case of power cut) as it had a solar panel. The household members said that the pellet stove was not affected by wind as was the case with a charcoal brazier and it had no heat emitted to the outside causing discomfort when cooking unlike a charcoal brazier (due to the differences in the way they were made) (figure 2 and 3). They said the pellet cook stove also had a regulator (adjusting knob) to regulate heat (figure 3).

The respondents also mentioned some barriers with pellet stove such as limited supply of pellets (figure 5) especially that the pellets were manufactured/ produced from one main source on the Copperbelt province of Zambia. Another barrier with the pellets was that you just loaded once on the stove when cooking and so when the burning pellets finished, no further pellets would be added as the case with charcoal brazier which had to be replenished throughout the cooking process because you just shook off the ashes and toped up with more charcoal. Once the pellets ran out and formed into ashes, you needed to start all over again the lighting process and removing the ashes. Topping up with more pellets to the already burning pellets ignited smock which chocked and fire went off. However, other respondents gave a counteracting statement to the preceding narration of the replenishment pitfalls as an inconvenience in that you needed not to load or add pellets to the already burning/ combusting pellets as it is with charcoal. The households said that once you finished cooking one dish, you would add on the next thing you wanted to cook without any additional load of pellets and that made it convenient. One responded had this to say;

"For pellet cook stoves if the knob setting is put on the highest, you can cook many or more dishes using one load of pellets whereas for charcoal, you need to replenish with a number of loads to cook a similar dish and it is an inconvenience." (Respondent 1, 2019)

On the other hand, a different view was given by other respondents saying the pellet stove had two different combustion chamber plates, hence instead of adding more pellets to the already burning pellets you needed to put pellets to the other chamber pan and just top up with the diminishing burning pellets from the other chamber and continue cooking without being inconvenienced.

Some households also mentioned that pellet cook stoves were highly combustible and in some instances burnt the food if it was not regularly checked, despite having a regulator. Two respondents lamented how the hard flame from the pellet stove damaged their pots by causing holes at the bottom center of the pot. One of them had this to say

"My pot has a hole in the middle where heat from the stove is concentrated. The pellet stove should be designed in such a way as heat is distributed to the entire bottom of the pot unlike the concentrated heat on the central bottom rendering damage/ holes to the pot. Also, to counter this damage to the pots, the manufacturers of the stoves should introduce different pots with different metal suitable for the heat." (Respondent 2, 2019)

This departed from another view given by some households that, unlike, charcoal which had heat reduced as the charcoal burned. That entailed closer supervision and vigilance for pellet stove than charcoal brazier/ firewood. Meanwhile, other households bemoaned that charcoal on a brazier could not be regulated.

Some households bemoaned the size of the pellet stove. Some respondents expressed interest in bigger pellet cook stoves as opposed to the ones that were being used as they said bigger stoves would make more sense to cook for bigger families and also for public institutions like at the schools where two of them taught. They lamented how despite emitting so much smoke, they used wood fuel to cook a lot of food stuff to cater for many people. Additionally, big pots could not fit on the pellet stoves. Also, they posited some important considerations to be included in the makeup of the pellet cook stove. For instance they said it should have an oven and two plates so that you cook two or more dishes simultaneously.

Some households noted that pellets could be reused after putting out fire which was not the case with charcoal. Usually water was used to put out fire on a charcoal brazier which made charcoal wet and not reusable. The households said pellets would light up the same way as before when you put out fire by placing them out of the stove and apart. Pellets also produced less ashes than charcoal. However, some households also posited that pellet stove produced smoke if you did not put out fire correctly. Nevertheless, most households lauded the pellet stove with its feature of a fan that it helped in lighting fire whilst a charcoal brazier required using an external hollow pipe to light fire.

Some households, further, lamented that repairing a pellet stove required the expertise of the manufactures. This was opposed to a charcoal brazier which could easily be repaired and replaced. They narrated that, although, they were told (by manufacturer) the pellet cook stove had a life span of about 10 years, it was difficult to ascertain the authenticity as they had just used it for few months. Most households also deplored the delicacy that the pellet cook stove had to be treated with. It needed caution and precautionary measures in order not to have any water or oil spillages on the battery of the stove. One respondent pointed out that;

"*You need to clean the pellet cook stove just like an electrical stove and you do not need to spill water in it as it can damage the stove (and battery). You just have to follow instructions when using it and if you are poor at instructions, you will find it difficult to use. If you do not know how to operate it, you can easily damage the stove and hence you need to understand its usage. What is even more challenging is first time operation of the pellet stove as it is quite difficult, but becomes easier after you get acclimatized to its operation."* (Respondent 3, 2019)

Some households further pointed out that pellet cook stoves, unlike charcoal brazier, could not be used to cook certain food staffs for instance roasting meat. Some households applauded how cooking on charcoal brazier gave good warmth, great taste, flavour, aroma and savory to the food. One other important factor alluded to by the most households is that pellets were not readily available unlike charcoal/ firewood although they were also scarce in rainy and cold season. Also, in case of electricity interruption (no power) and no sun then it was not possible to charge the battery and hence the pellet stove could not be used. However, few households applauded that once the stove was charged overnight it took time to recharge as it did not drain fast. They said it could take as long as a month especially if it is was cooked between 0 and 1 on the regulation knob.

Some households extolled that with the use of the pellet stove, hands and pots remained clean unlike charcoal brazier as the hands and pots were darkened and hence difficult to clean or wash. Further, most households said that pellets did not produce smoke and gave comfort. On the other hand, other households mentioned that they could not cook on electrical stove because they were not connected to the national electricity grid and that they could only use electricity if they were connected to the electricity national grid.

On another hand, few households postulated that charcoal had no disadvantages just like firewood. This was their view on charcoal and firewood;

"Throughout our lives, from birth to date, we are used to both charcoal and firewood and find no difference at all with using charcoal /firewood. The smoke coming from charcoal does not affect and bother us in any way. We were born in charcoal and continue to use it. There is no fault or any problem with charcoal" (Respondent 4, 2019)

Another respondent alluded to the fact that there was no smoke from charcoal.

I am now 54 years old and I have never experienced any problem with charcoal and firewood and even my mother used charcoal and firewood for cooking so it cannot be a problem today. You can only be intoxicated with smoke from charcoal if you placed it in a newly painted house because of the paint." (Respondent 5, 2019)

Economic aspects

This aspect mainly centers on what challenges the households faced in relation to their current cooking solutions and the options available to them (research question 2).

Electricity, Pellets, Charcoal and Firewood; The mostly common used sources of energy by the different households were charcoal, firewood, electricity and pellet cook stoves depending on how each household perceived the affordability, cheapness and price of the energy type. When asked what challenges the households faced in relation to their current cooking solutions and the options available to them, they gave different narratives as follows; some responded that electricity was very expensive especially with the prepaid meters installed. Further they added that both charcoal and electricity were expensive but charcoal was more expensive than electricity. To the contrary, some households postulated that electricity was more expensive than charcoal and pellets. Meanwhile others said that the pellet stove was cheaper in the long run although it appeared expensive. However, most households bemoaned the price of the pellet cook stove irrespective of the slow mode of payment for it. They said the pellet cook stoves were too expensive. One respondent had the following to say;

"I usually use three 50 kilograms bags of charcoal per month and comparably to pellet improved cook stove the entire pack of pellets is used for a month and is only 45 kwacha compared to 300 Kwacha of that of charcoal. The price of charcoal has increased abnormally especially that it is seasonal. Both during rainy season and cold season it is ridiculously expensive because people travel long distances in order to produce the charcoal, bad roads, fuel for transportation has led to the hike in charcoal". The pellet cook stove is also very expensive going for 1400 Kwacha (140 usd). I cannot buy the stove if I had not been given, it is too expensive even I have to pay in instalments, it is not just affordable." (Respondent 6, 2019)

Here are other similar sentiments from an individual from a focus group discussion;

"It would be better if the manufacturers provided us with another type of stove that is a bit cheaper for us to enable us to use them. The new pellet cook stove is of high standard/ quality, more like an electrical thing and that is what makes it expensive. Even us who currently have these stoves and using them we cannot afford to buy them. We have benefited because it is a project and we were just given under the pilot project. Besides the purchase of the pellet cook stove, we also need the pellets which need to be purchased separately from the stove. And once the pellets finish, they need to be bought again." (Respondent 7, 2019)

Further some households pointed out that, there were no subsidies for the new cook stoves but it was possible to pay in installments over a long period of time for about one year six/ eight months. Upon finishing of the payment, you can get your stove. The stove costed 1400 kwacha (140 USD).

A respondent highlighted that charcoal was expensive amounting to 3 kwacha (0.24 USD) per load on a small sized brazier. Meanwhile, to cook slow cooking foods like beans and dry fish and fast cooking dishes like nshima and vegetables you only required 300 and 150 grams of pellets respectively. This meant if you were to cook for a big family you needed more charcoal than pellets. It was highlighted that charcoal was consumed a lot in the process of replenishment unlike pellets. Pellets stoves required a smaller quantity to

cook a lot of food while charcoal required more quantity. On one hand, some households said that a charcoal brazier was easily replaced and purchased at a cheaper price than the pellet cook stoves. Many households alluded to the fact that charcoal was used for heating bathing water and slow cooking dishes such as beans, fish which could not be cooked on the stove as it consumed a lot of electricity units. Some respondents said electricity was very expensive and in quest to save electricity units, they resorted to charcoal usage. They said "if electricity was reduced we would cook on electric stove only. But we cannot cook food like beans on a stove because it was too expensive. Another respondent said charcoal was cheaper than electricity hence reducing tariff for electricity would make me cook on stove. Conversely, some respondents said that they would not cook on electricity even if the tariff was reduced because food cooked on charcoal retained a richness of flavour.

A responded said that pellets were cheaper than charcoal and the pellets lasted longer than charcoal, For instance a 50kg of charcoal costed K130 while a bag of 20kg pellets costed K50 and lasted one month meanwhile the bag of charcoal lasted only three weeks if properly used but mostly two weeks. Some respondents said the pellet cook stove was expensive to buy once off but in the long run it was cheaper since it lasted many years unlike a charcoal brazier. Pellet cook stoves and electrical stove cooked almost in a similar manner but electricity was more expensive and consumed units quickly. Some households said that pellets were cheaper (60 kwacha) lasting for one moth whereas charcoal finished quicker and a bag of 90kg charcoal did not last a month meanwhile it costed 150 kwacha. In addition, other households narrated that electricity was more expensive than charcoal and would not cook on electrical stove but on a charcoal brazier.

Health aspects

This health section centers on what knowledge households had about available energy options, their sustainability impacts and their levels of cleanliness (research question 3).

Some households alluded to the fact that *Charcoal* had literally no advantage and that they used it for the sake of using it because it was readily available. They lamented some disadvantages of charcoal that included respiratory problems such coughing as a result of carbon monoxide which caused headaches and death. To the contrary, some households denied that charcoal emitted any smoke saying they were not bothered by any smoke from it. Meanwhile other households lamented that smoke from charcoal intoxicated and chocked them. They narrated that smoke intoxicated and caused suffocation and caused sleepless nights if you had a brazier in the house, as it caused headaches. Further, households postulated that charcoal usage caused lesions/ cuts in the hands with continuous touching and breaking the charcoal when placing it on a brazier. Conversely, the above narrative differs from that given in relation to the pellet cook stove and electrical stove as they were considered to be clean, did not produce carbon monoxide/smoke and allowed for indoor or enclosure cooking.

Risks aspects

The risk aspects centers on what knowledge households had about available energy options, their sustainability impacts and their levels of cleanliness (research question 3).

A respondent said charcoal usage was a driver of deforestation which destroyed the environment and also affected the rainfall pattern. "*Usually we have rains as early as October but this is not the case anymore because the tress are reducing. Nowadays we receive rain in January and only for a short period as opposed to the normal time frame of rain season. Hence it affects our climate change."* (Respondent 8, 2019)

Some households also pointed out that charcoal braziers were prone to risks such as burns, house infernos, and dangerous to crawling toddlers. Burns also from having to touch charcoal in trying to place in nicely on the brazier was another risk brought forth. Most households said that it was the opposite with the pellet cook stove, as it was safer and could not cause burns because it did not get hot on the outside and even a crawling baby would touch it without any risks of burning.

Risks associated with *electricity* according to some households were electrical shocks which caused death. Also, during power restoration electricity came back with force after interruption which destroyed electrical appliances such as stoves. Further, it caused massive burns, electrocution and fires in case of an accidents derived from an electrical fault.

5.2. Key informants responses

The findings on this section focus on the effectiveness of government policies and strategies in promoting new cooking technologies (improved pellet cook stoves) (research question 4). This is an integral part of the policies and how they shape households choices of energy. The responses outlined below are derived from relevant government officers from the Lusaka City Council (the implementing agency), and Departments of Energy and Forestry. In addition, this section looks into the policy documents such as the National Energy Policy (2008), Forest Act 2015, Forest policy 2014, Environmental Management Act, Energy regulation Act, National Forestry Policy (2014), National Policy on Environment, Climate Change Policy and the National Strategy to Reduce Deforestation and Forest degradation. The National Energy Policy 2008 is the overarching comprehensive document covering all energy sources such as wind and biomass, speaking about government intentions with regard to fuel source.

The different stakeholders were asked what policy instruments government had crafted with regard to dissemination, sensitization and communication strategies of deforestation and the new cook stoves. It was pointed out that policy instruments crafted with regard to deforestation included the National Forestry policy of 2014 which encouraged participatory forest management anchored on the active participation of local communities, traditional institutions, private sector and other stakeholders in the management and utilization of forest resources at all levels of decision making, implementation, monitoring and evaluation. Additionally the National strategy to Reduce Deforestation and Forest Degradation addressed the reduction of emissions from deforestation and forest degradation, conservation and enhancement of forest stocks and sustainable management of forests. This was developed to address reduction of emissions from forest degradation and deforestation, conservation and enhancement of carbon stocks as well as sustainable management of forests (REDD+ strategy). Its focus was to improve forest and land management and to ensure equitable sharing of carbon and carbon benefits among stakeholders. The National Policy on Environment focused on managing the impact of human activities on the environment that included biodiversity conservation, deforestation, and land degradation. Equally, the national tree planting programme and bamboo planting initiative which helped to combat deforestation had recently been launched in 2019. The bamboo tree was fast growing and used to produce charcoal which helped reduce dependency on indigenous tree species.

Conversely, it was alluded to the fact that currently there were no policy instruments specifically on cook stoves. Policy instruments on new cook stoves were nonexistence, although it was mentioned that they were in the process of developing energy efficient strategies on new cook stoves and energy efficient lighting and that was where there were gaps in energy sector. There were challenges of identifying the gaps from electricity usage, wood fuel usage and charcoal usage hence the reason for currently developing strategies to address those gaps. The focus of the policy instrument was on efficient use of energy for instance efficient use of wood fuel and efficient charcoal production. Therefore it spoke of efficient utilization of biomass resources and energy efficiency and also promoting efficient technologies. Additionally, it was pointed out that charcoal played a major role when it came to household usage across the country and it affected daily lives. At the moment, hence, Department of Energy did not have an instrument specifically for charcoal as there were no strategies developed on charcoal. It was further mentioned that since they did not have policy instruments on new cook stoves, they did not have strategies to disseminate and sensitize on them. On one hand, another respondent posited that policy dissemination and sensitization on new cook stove was ongoing, but not sufficient and hence actual end-user levels were low and households had low levels of knowledge. Furthermore another responded bemoaned that communication and sensitization on new cook

stoves needed to broaden up to reach many communities because people had no idea where to access these stoves. At present, only few people in piloted areas received information. There was, therefore, need for massive sensitization campaigns and rolling the projects to the whole country. Another respondent narrated that they were in the process of conducting research to see if what the producers of the stoves claim what the pellet cook stoves were, was what they really were, before starting to disseminate the information on the pellet cook stoves. The only information that they had at the moment was based on the manufacturer saying it was a very good stove and that is why they were trying/piloting it to 20 households in Matero.

Asked what policy incentives government had put in place for low income households to switch to new cook stoves or if not what suggestions on policy incentives could be made; most respondents felt the alternatives to charcoal were expensive for the locals as they were not subsidised. It was pointed out that most cook stoves came on board but shortly after a year or so they disappeared because they did not meet the needs of the households. It was mentioned that at the moment no incentives were put in place and that they had a dialogue hub to get all stakeholders on board to see what incentives could be put in place that could be sustainable. Another respondent pointed out that an incentive would be to reduce the cost of these stoves, introducing tax waivers on both locally manufactured and imported new cook stoves in order for them to be affordable and cheaper. It was also argued that it would be cheaper to produce the stoves locally and made similar to the charcoal brazier. It was pointed out that they would be submitting to Ministry of Finance for tax waiver of improved cook stoves as tax incentive could make the product half price. Ministry of Finance only granted import duty free to NPG/ LPG lights as opposed to new cook stoves.

The aforementioned stakeholders were asked if policies and strategies currently being implemented were appropriate for households to switch to alternatives fuels. This is what a respondent had to say;

"On paper, yes, but in practical terms and on ground they not appropriate because the communities lack the funds to be able to sustain to alternative fuels. For instance the use of wood fuel for households is something that they rely on and switching to an alternative prior putting up sustainable measures cannot be achieved. A number of private players and Non-Governmental Organisations come up with a number of alternative solutions to charcoal and firewood which mainly is business motived so much that actual implementation and uptake of these alternatives has been low. In most instances households are given these alternatives for free on pilot study but once the project or pilot is ended, they switch to their traditional energy and pack the alternative stoves given to them. Most people in the middle and low income households live on hand to mouth such that even a small amount such as K50 is hard to come by. Everything is given for free whilst the project is running and fails to continue at the end of the project." (Informant 1, 2019)

Furthermore, a respondent pointed out that she had a pellet cook stove and sometimes used it to cook. She said the design of the pellet cook stove needed to be charged before usage. It could not work if it was not charged unlike a charcoal brazier which did not need that process. What was highlighted was that the technologies behind these stoves were designed abroad, for instance, the pellet cook stoves could not be suitable for the local households as they did not have end users in mind when they are manufacturing those stoves. Further, a respondent pointed out that charcoal was readily available but pellets were not readily available and the cost of the charcoal repackaged in small plastic bags was ridiculously cheap (figure 4). Only the wealth working class people would be able to afford the alternative cook stoves, hence it was important to look into the economic situation of the charcoal users as they did not have money to buy off at once even the bulky bag of charcoal, what more the pellet stove? Another respondent pointed out that 70 percent of energy comes from woodfuel energy and it was the countries primary energy. Therefore, the usage of charcoal could not be banned and it was there to stay, unfortunately, whether we liked it or not. In some areas such as typical rural areas it was impossible to ban charcoal unless an alternative solution was provided which people adopted instantly. But it was impossible to implement that huge jump because it would have to be cost effective and the economics had to speak sense. Realistically was to ensure that people used charcoal efficiently, for instance they could use a bag of charcoal for 6 months and not a month or two. This translated into less cutting of tress and more people would use the tress more efficiently.

Another view expressed was that there were gaps in the appropriateness of the strategies and policies being implemented for households and hence the need for revision of policies time and again in order for policies to speak to the current technologies that were there.

Asked what alternatives could be provided to the charcoal value chain to curb the current unsustainable charcoal production/ deforestation and what options the government had for the entire value chain of charcoal production in order to support their livelihood; Some responses included; alternatives could be including the charcoal traders in the value chain to sell pellets if the number of pellet stove users increased. Right now there was no outright solution to say this was a super bullet we were going to use. The other response was promoting the use of briquettes, usage of LPG alternatives, biogas, rice husks, sawdust to produce pellets, forest waste/ agriculture, livestock waste and cow dung. It was pointed out that it was just a matter of fuel switch to substitute charcoal value chain.

A question was asked if it was possible to reduce electricity tariffs for low income households to enable them cook using electricity. It was pointed out that communities and households with lower incomes were subsidised up to 200 kilowatts if they consumed electricity within that figure. The 200 kilowatts targeted low income households. Zambia was a country in the region with the lowest tariffs because it was still not cost reflective. Going forward, we have to make our tariffs cost reflective. So for low income households if there was further subsidy it would mean we have to further subside beyond the 200 kilowatts to maybe 500 kilowatts. If electricity became cost reflective then the sector would be more vibrant and we would be able to connect the rural areas as well. It was also pointed out that ZESCO was not a charity, it was a business institution and it needed to generate profits and operate optimally in order to increase energy access. If it runs on a loss then it will not be able to connect new customers, hence low access to clean energy.

Asked if the fight against deforestation as well as environmental degradation through use of charcoal was being won, if so, how and why; It was pointed out by a respondent that the fight against charcoal was not being won as the rate of deforestation kept increasing as well as the rate of charcoal production. Another respondent posited that, for now, deforestation was not being won, they were still very far from achieving that because most of these alternative solutions were not as readily available as charcoal and they were not as cheap as charcoal. The buying power that the low income households had was now and today and not to save and get something that was more expensive although cost effective down the line, hence it was very difficult for them to get something that was expensive but cheaper in the long term. The other response was that the fight against deforestation was not being won because people did not have alternatives for their livelihoods. Additionally, another respondent had this to say; the fight against deforestation as well as environmental degradation is not being won due to the following factors;

"Lack of improved technology of charcoal production and utilization of wood fuel, lack of training to charcoal producers in better organisation on and management of charcoal production using the traditional kiln method, lack of eagerness to adopt other production techniques which are more efficient and convenient to users and which produce minimal emissions, lack of participation of various stakeholders such as women clubs and cooperatives as well as other government departments." (Informant 2, 2019)

On one hand, a responded said that charcoal was being demonized and blamed for deforestation when there were many other causes. It was pointed out that the main causes of deforestation were agriculture expansion and infrastructural development whilst charcoal production was put as the fourth cause of deforestation.

6. DISCUSSION AND INTERPRETATION OF RESULTS

The purpose of the study was to assess the awareness, adoptability and sustainability of the improved pellet cook stoves at household level in Matero George compound, using a user centred approach in view of government policies. This looked at policy, assessing perceptions, adoption rate, attitudes and knowledge and sustainability of the pellet cook stoves of the people of Matero George Compound in Lusaka. The results generated in this study are of interest to stove manufactures, suppliers, and policy makers due to potential market for ICS. This is due to the high initial price of ICS to the end users correlating with their low income, insufficiency of energy fuels (pellets) and failures of distribution network of the ICS. In this vein, in Zambia, where markets for modern clean energy clean cook stoves are nascent, it is imperative to understand the potential for implementation and scaling up of the pellet cooking system (Jagger and Das 2018). This section is divided into four sections and it is guided by the four research questions in the sequence that they have been presented in chapter one.

6.1. Factors influencing households' preference and choice of traditional or modern cook stoves

As diffusion of innovation theory illustrates on how characteristics of different innovations shape the adoption process of a new innovation, promotion of new technologies should be in line with what is suitable and needed for the end users. In plight of the aforementioned, it would be ideal to determine a correct stove for a given context. This is in line with what a respondent echoed on developing standards and quality for the cook stoves by which the cook stoves should be manufactured if they are to be adopted and appreciated by the users. These standards need to be developed to encourage adoption of these new cook stoves in order for households to get acceptable standard that is workable. If standards were not put into consideration, it bred a recipe for substandard technology and people would have a very bad perception, ultimately affecting adoption and dependency on these new technologies. Jagger and Das (2018) posit that stoves must be well suited to local conditions including cooking the types of foods prepared in the region and the cooking utensils such as pots and kitchen environments in the region. An explanation of some households' preference of charcoal could entail ill adaptation to the local setting and cultural norms/ factors in the way the pellet cook stove is designed. For instance, some pellet cook stove users lamented that it could not roast meat or fish and also its small size not ideal for big pots and cooking a lot of food. Some beneficiaries said they did not use the pellet stove for cooking dishes such as nshima (Zambia's main and staple food) because it could not accommodate the large pots that cooked nshima. Pertaining to likeness with a stove, some households bemoaned the pellet cook stoves' lack of oven and/ or a two plate cooker to enable quick and simultaneous cooking of different dishes.

Furthermore, some users of the pellet cook stoves lamented of how delicate the stove was (needed no water or oil spillages and always physical presence or vigilant when cooking to prevent splashing on the battery or quenching fire), hard flame difficult to regulate heat which made holes at the bottom of pots and burned food if left unchecked, battery running out especially in an event of power outages and when there was no sun to charge using solar. Therefore it would be important to correlate, suit and relate the physical elements of the pellet cook stove design to social realities if they are to be adopted on a large scale. It is of utmost importance to align the technologies to the local needs of the population without incorporating western standards of improvement. The technologies behind these stoves designed abroad for instance the pellet cook stoves should be made suitable for the end users in order to increase chances of adoption. For that reason, it is imperative to design more appropriate technologies befitting the conditions of the developing world than transferring technologies and practices of the western world that may be less beneficial. Additionally, to enhance its diffusion, may require a modification to something similar to a charcoal brazier, made from cheaper material and less functions embodied in it rather than something of high quality and

more expensive. This is likely to increase the uptake of the stove because it would be more affordable for the low income households.

On the other hand, Jagga and Das (2018) gave a differing view from the sentiments of some respondents in Lusaka households. They noted that a focus group discussion conducted in Rwanda narrated that the pellet cook stoves, unlike charcoal, did not damage the pots by making holes at the bottom. Jagger and Das (2018) instead cited an example of the Philips new cook stove that was found unfavourable due to its technical performance, and lack of interest of the manufacturers in making design adjustments to suit the Rwandan condition made its adoption unlikely. This may also point to the improved pellet stove with regard to some respondents' sentiments on the hard flame burning the food, despite the pellet stove possessing the adjusting knob (figure 3). This entails that there were difficulties in controlling the high exceeding temperature of the pellet cook stove. This might need to look into redesigning the adjusting knob for better heat regulation to avoid burning the food.

Some beneficiaries of the pellet cook stove reported not to be using the pellet stove citing non-availability of pellets while others were cooking on both charcoal and pellets. The short supply of pellets makes charcoal usage as the alternative available option. The urban demand of charcoal and readily available market provides opportunities for income generation for rural producers. This also provides urban households with affordable, convenient and reliable source of energy at relatively stable prices (Zulu 2013). The transition to pellet cook stoves is not straightforward due to high levels of poverty (affordability) and structural problems with access to alternatives (pellets) (Zulu 2013), as was the case with some respondents who stated that the pellets were not readily available as charcoal. A fuel mix is hence expected in the foreseeable future without complete transition to alternatives because of the continued dependency on charcoal. In as much as the switch from woodfuel to modern energy is the most desirable intervention, improving the sustainability of the existing woodfuel is a more practical solution. This requires the harmonization of woodfuel policies and the efficient production and consumption of charcoal should be improved as it is more feasible in the near future.

A study in Tanzania indicated that 80 percent of ICS which used both charcoal and firewood were purchased with cash, despite the liquidity constraints. This suggested that any intervention offering ICS that used both charcoal and firewood encouraged their adoption and thus reduced the demand for forest products. Iiyama et al (2014) argue that efforts to provide energy for all communities in Sub Saharan Africa, at an acceptable environmental cost, mean little without recognizing the reality of the continued importance of woodfuels, and should support reform of the sector to make it more efficient and sustainable, rather than discounting it in the future planning (Iiyama et al 2014). This is in line with the Sustainable Livelihoods framework elucidating the importance of a balance on environmental security and social security by ensuring the livelihoods of people depending on the natural resource are well managed and empowered. In Rwanda as Jagger and Das (2018) state, although adopter households continued to use charcoal stoves alongside newly introduced fan micro-gasification stoves, there were significant reductions in their charcoal expenditures in the 4 weeks prior to the survey. This finding was aligned with the firm's rationale of pricing the biomass pellets competitively with charcoal, with the aim of replacing it in the long run.

Attempts to market ICS in urban Zambia can be seen as examples of social innovation, being a novel solution to a social problem that is more effective, efficient, and sustainable (Pesa 2013). The urban Zambian has its economic rationality perceived on societal and market rationality as a whole rather than from an individual household perspective. Due to its highly efficient value chain, charcoal generates income for myriad individuals from charcoal burners to bicycle transporters and charcoal women. This generates livelihoods and ensures a cheap source of fuel for urban households. Conversely, pellets only generate income for few individuals, mostly foreigners. Hence even if charcoal might be slightly more expensive than pellets per unit- of-use, it is cheaper in the long run as it taps back money into the local economy via employment and ultimate profits accrued to traders and charcoal stove producers. It is on those lines that there is need for the ICS such as pellets that can compete with charcoal and sustainable.

Consequently, working alongside and learning from the 'old' and 'polluting' charcoal value chain might eventually prove to be a more effective strategy for ICS promotion (pellets) than trying to replace charcoal though households might save a bit of money by adopting sawdust pellets (Pesa 2013) . This elucidates that technology adoption is not only reliant on the efficiency of technology but also on the social construction of a marketplace and on value creation and social innovations to create lasting market demand. For adoption of the pellet cook stove to take place, no matter their cost efficiency and environmental friendly, there is need for efficient value chains, though they take time to build. (Pesa 2013). Also, what is of paramount importance is integrating the local artisans (charcoal brazier manufactures) in the mainstream production of improved pellet cook stoves. That would be another way to enhance diffusion of new technologies. These would be able to take care of the repairs, modifications and adjustments of the new stove rather than depending solely on the manufacturers of the pellet cook stoves. This, both empowers the local tins smiths and also reduces the costs of the stove as it is entails local manufacturing of the stove and employment of the local tins smith as well as giving entrepreneurial skills. Further it addresses the barriers outlined by some respondents on the needed expertise of the manufacturer to repair the pellet stove if it got damaged.

6.2. Challenges households' face in relation to their current cooking solutions and the options available to them

One of the reasons highlighted in the Zambia National Energy Policy (2008) for the highly dependence on woodfuel is the low income of the consumers. With the high poverty population rate prevailing, the focus of the people (particularly low income households) is on meeting daily needs as opposed to investing in the future. The alternative sources of energy are perceived to be expensive due to their initial price, even if they may be cheaper in the long run. The costs of the alternative fuels such as the pellet cook stoves affirms the dominance of charcoal. Therefore, the economic aspect of the pellet cook stove must make sense to the consumer's financial cost of investment which may be difficult to justify albeit involving intangible and non-financial benefits such as lack of smoke. These intangible benefits may not accrue to all consumers as was the case posited by some beneficiaries of the pellet cook stove. They reported that they were not affected by smoke emanating from charcoal and fire wood indicating that they had cooked on charcoal and firewood throughout their lives. Further, some respondents pointed out that charcoal did not emit any smoke. In support of this, Zulu (2013) and Arnold et al (2006) postulate that damage to health caused by emissions from stoves may be considered a low priority issue as compared to health problems related to water supply and sanitation. Therefore, economic benefits are deemed more conspicuous and meaningful to the low income households than intangible benefits.

In line with the issues (damage to pots, burning food, small size of stove) users in Matero- George Compund complained about, Pesa (2013) posits that low income users doubted whether cost savings from adopting saw dust pellets would truly be as pronounced as the company (manufacturer) claimed in its marketing campaign. Further, (Pesa 2013) added that, when asked, most consumers lamented, that, pellets and charcoal were roughly equally expensive, or even claimed that charcoal was cheaper than sawdust pellets. Additionally, the users lacked certainty of the lasting of the social innovation and feared adopting the new technology in vain in line with what the sustainable transition theory expounds (Pesa 2013). This also, aligns with a key informant's response who bemoaned that during a pilot project, everything was given for free whilst a project was running and failed to continue at the end of the project. In support of this, a respondent further lamented how most cook stoves came on board but shortly after a year or so they disappeared because they did not meet the needs of the households. Nonetheless, differing from the views of Pesa, some respondents in Matero said the pellets were cheaper than charcoal while highlighting that, what was expensive were the pellet cook stoves comparatively with a charcoal brazier. Albeit, these claims, about what is cheaper, usually remain untested as few households specified how the price of charcoal relates to price of sawdust pellets. Kulindwa et al (2018) in agreement elucidates that it is often difficult to estimate the effect of price in developing countries such as Zambia where a major part of energy consumption is met by traditional fuels that are gathered informally with no cash outlays. This could explain why the social

innovation may fail to penetrate the market among the lowest income consumers it intended to serve (Pesa 2013).

On the other hand, some respondents said the price (K1400-140usd) of the pellet stove was commensurate and equivalent to the numerous components it had such as fan, solar panel, and its long lifespan. However, the general attitude of most households was that the pellet cook stove was too expensive and could only be acquired by wealthier households. This explains the dependency on charcoal/ firewood and its poor energy services and opportunities by the urban low income households attributing to non-affordability of the alternative cooking fuels (pellet cook stoves). This is in line with recount of relative advantage (economic) of the diffusion of innovation theory. This is irrespective of what advantages the innovation (pellet cook stove) brings forth. If it is seen to be more expensive than the charcoal brazier, it is unlikely to be adopted. Hence, the dependency on charcoal is linked to poverty and/ or material deprivation. This is despite the developers marketing the technology to low income households claiming environmental, health and financial benefits upon adoption (Pesa 2017; Zulu 2013). What is important to note, as shown in the results, is that the low income households purchasing power was 'now' and not 'futuristic'. This was evidenced in the low income households' purchase of smaller packages of charcoal in plastic bags (figure 4) which translated to paying a higher price per kilogramme in aggregate terms whilst wealthier households purchased larger quantities for a lower price per kilogramme (figure 7) (Pesa 2017; Atteridge 2013).

As elucidated by some key informants that strategies currently being implemented for households to switch to alternatives fuels were not appropriate and practical because low income households lacked funds to be able to sustain alternative fuels without sustainable measures been put in place. It was highlighted, that, a number of private players and Non-Governmental Organisations came up with a number of alternative solutions to charcoal and firewood and in most instances households were given these alternatives for free on pilot study but once the project or pilot ended, they switched to their traditional energy and packed the alternative stoves given to them. This is in line with Kulindwa's (2018) argument that offering and distributing ICS free of charge is arguably an uneconomical and risky way of promoting adoption. Therefore, little is learnt about household preferences regarding ICS versus the traditional cooking stove. There is a possibility that the few households who adopted improved pellet cook stoves accepted them because they were given free of charge, even if they did not like their attributes (Kulindwa 2018). This was clear from the views opined by some households that they would not be able to afford the pellet cook stokes due to their high price (K1400-140usd) but for the pilot project they benefited.

Another respondent (non-beneficiary of the pellet stove) from the focus group discussion, taking on the diffusion of innovation theory (observability) explained that despite not having been given the stove, she had observed from her neighbours how the pellet stoves worked and lamented not being part of the pilot project as that was going to benefit her with the stove. This entailed that she would not be able to purchase the pellet stove because of its price. Therefore, the envisaged accurate measure of adoptability should be demonstrated by the willingness of the low income households to purchase the pellet cook stoves in the crude state as the manufacturer intends to sell them in future. The act of distributing the pellet stoves for free is an indication that the low income households could not have afforded the stoves and hence they resorted to giving them.

Additionally, households that had benefited free of charge as opposed to households that purchased the pellet cook stoves with their own income were more likely to be biased as they gave the narratives of the positive and negative attributes of the stoves to the manufacturers and the implementing agency being the Lusaka City Council. This is in line with an accord which says there is a personality under which a person is bound to give information such as lying or a tendency to give socially desirable responses under certain conditions (Cohen et al 2012). Mobaraka et al. (2012) on the other hand, adds that the low adoption rate of alternative cooking technology offered free of charge validates the need to find out what ICS attributes households find more attractive. This fortifies some of the sentiments brought forth by some households on

features of the pellets cook stoves such as cleanliness, easy to light, non-emittance of smoke, its ability for indoor cooking and fastness to cook.

6.3. Knowledge households have about available energy options, sustainability impacts and levels of cleanliness

It was highlighted by some Matero households that the pellet cook stove was hygienic, clean (did not darken hands and pots unlike charcoal), fast to cook, suitable for indoor and enclosure cooking, easy to light, durable and did not emit smoke. This is also similar to findings of the households in Rwanda who shared similar sentiments. Jagger and Das (2018) posit that a community health worker in Rwanda mentioned that people understood that air pollution caused respiratory illness and other diseases such as lung problems and hence understood the importance of using clean energy such as pellet cook stoves to cook. This was clear from the few households who alluded to the fact that sawdust pellets could generate environmental, economic and social benefits for consumers, by reducing carbon dioxide emissions, indoor air pollution and saving costs Pesa 2013). Additionally, some households pointed out that cooking on charcoal had health risks lamenting that it caused respiratory problems such coughing as a result of carbon monoxide which caused headaches and death. Further, households postulated that charcoal usage caused lesions/ cuts in the hands with continuous touching and breaking the charcoal when placing it on a brazier. Some households also pointed out that a charcoal brazier was prone to risks such as burns, house infernos, and dangerous to crawling toddlers. Most households said that the pellet cook stove was safer and did not cause burns because it did not get hot on the outside and hence also safe for a crawling baby. Some households additionally bemoaned that charcoal usage caused deforestation and climate change which affected the rainfall pattern.

Paradoxically, the awareness and adoption rate of the social innovation is low for something stated to have positive attributes named above. This highlights a puzzle as to why the new technologies such as pellets cook stoves remain largely unknown and unadopted if they possessed the beneficial characteristics aforementioned. This points to the fact that charcoal was readily available, easily accessible (unlike pellets), and the price of the charcoal brazier was cheaper compared to the pellet cook stoves. This may also point to the reason as to why some beneficiaries were still cooking on traditional charcoal braziers (as seen in figure 2) despite possessing the improved pellet cook stoves. Atteridge (2013) posits that with little innovation in the stove market in terms of higher-efficient models, households appear reluctant to buy anything but the cheapest available stove. Implicit in this is a willingness to trade off lower utility or greater health impacts for a lower stove price. This attitude appears to be linked specifically with the charcoal brazier-*mbabula* (Atteridge 2013). Therefore, aligning the price of the pellet cook stove and pellets competitively with a charcoal brazier and charcoal would be an ideal solution for quicker adoption.

6.4. Effectiveness of government policies and strategies on promoting improved pellet cook stoves (new technologies)

The complexity of charcoal and poverty subject call for multifaceted and integrated approaches on the production and demand side. From the research findings, it is clear that there are gaps in the institutions and framework regarding woodfuel sector. The policies currently are lacking, disjointed across relevant sectors, restrictive on charcoal bans and inadequate to address the challenge of reliable woodfuel production and supply and poverty reduction. A thorough thought on promoting pro poor and sustainability charcoal policies coordinated amongst various departments including forestry, energy, water, and municipalities is envisaged. The greatest challenge is that the wood fuel in Zambia is highly informal. Three quarters of charcoal is produced in traditional means using traditional kilns which is inefficient. It is challenging to regulate the charcoal industry and lacks framework because it is highly informal and requires concerted efforts from stakeholders and the communities themselves. To this effect as Zulu (2013) explains, legalisation or formalization of charcoal production, distribution and trading would expand economic

opportunities for poverty reduction. The structural inequities, incapacity to implement charcoal policy/ improved cook stove policy and sustainable woodfuel production need to be addressed.

What was highlighted in the research findings was that knowledge on the new technologies such as the pellet cook stove was still very scanty. This shows that there is a big gap in information dissemination on the pellet cook stoves as indications showed that only the people in the pilot projects were aware because they were privy to the information. Additionally, the beneficiaries of the pellet cook stoves had no knowledge on them until the inception of the project. Similarly, non-beneficiaries of the pellet cook stove who were randomly interviewed within Matero- George Compound expressed ignorance about the pellet cook stoves and where they could be found. This points to lack of sensitisation, dissemination and communication strategies at policy level. This calls for the need for massive sensitization campaigns and rolling of the projects to a wider spectrum and population. One reason attributing to the lack of broad sensitization and advocacy on the pellet cook stoves is because the LuMa project was mostly initiated externally though executed with technology developers and partner agencies of Zambia which is the implementing country. The possibilities that the manufacturers are actively more involved in marketing the stove is very high as compared to government sensitization on the stove. This fundamentally entails absence of policy dissemination on the new technologies as mentioned by some key informants that since they did not have policy instruments on new cook stoves, they did not have strategies to disseminate and sensitize on them. Pesa (2017) confirms that the fate of an innovation depends on the active participation of the developers. This is because they need a for profit, self-sustaining business to market high quality expensive stoves.

It was further pointed out that currently there was no tax exemption for clean energy in Zambia, which made it more expensive than regular traditional energy sources such as charcoal. Therefore, the incentivisation by exemption of import tax on the energy efficient technologies, it is expected that the pellet cook stoves would be reduced in price for the end user. With the current price of 140 USD (1400 kwacha), it was almost impossible for the low income households to afford the stoves except for the current beneficiaries of the pilot project. Hence, if the government subsidised the stoves by waving tax on the improved pellet cook stove, it would be easier to adopt the new technology as that would translate to the reduction in price of the stove. The current price, although, with financing mechanism enabling slow pay for the pellet stove over a long period of time is still not efficacious for low income households. Some users of the pellet cook stoves posited that the stove was too expensive irrespective of the mode of payment, and advocated for a reduction in the price of the stove for more people to be able to afford it and eventually adopt it. It would therefore be more sensible in economic terms to subsidise the stove and make profits from the pellets or design a cheap well-functioning efficient stove.

Charcoal is readily available, with stable supply and market relative to pellet cook stoves. It is therefore imperative that improved cook stove initiatives as pellet cook stoves be understood within a technical, social and economic context (Pesa 2013). In as much as the charcoal is labeled as unhealthy and environmentally polluting, it is a competitor to the pellet cook stove adoption due to its value chain arranged efficiently and supports livelihoods. If the pellet cook stove structure/ organization replicates the charcoal value chain, adoption would be anticipated. The pellet cook stoves inability to create their charcoal value chain which could be a source of employment and profits is a hindrance to its adoption. At policy level, there is no properly defined and reliable alternative to the charcoal value chain. Some of the alternatives to charcoal highlighted by some key informants such as agricultural waste, biogas, LPG, briquettes are either too expensive, inaccessible or unavailable as woodfuel. Therefore, by adopting the pellet cook stove, the end users would be pushing the burners, transporters, retailers and market women out of business and hence reinforcing poverty and material deprivation in the charcoal value chain. In agreement to this, Pesa (2013) argues that even though adopting sawdust pellets would save costs comparatively with cooking on charcoal, sawdust pellets have not managed to socially construct a marketplace which is able to compete with the charcoal economy. Pellets may be economically reasonable and sensible to individual end user but irrational from the perspective from the economic and social logic of the entire market (Pesa 2013).

7. CONCLUSION

This study has sought to assess the levels of awareness, adoptability and sustainability of improved pellet cook stoves in view of government policies using a user centred approach in Matero- George compound, Lusaka. The study was guided by sustainable livelihoods, sustainable transitions and diffusion of innovations theories. The results suggest that the awareness levels of the pellet cook stoves were low attributing to lack of sensitisation, dissemination and communication strategies as there were no policy instruments specifically on cook stoves. The focus of the policy instrument was on efficient use of energy for instance efficient use of wood fuel and efficient charcoal production as charcoal had specific meaning embedded in Zambian urban culture and society. The market penetration and adoption of the pellet cook stoves was attributed to affordability of the end user, availability of alternative energy sources (e.g pellet), cultural norms, awareness/ sensitisation levels, cheapness of traditional cook stove (brazier-*mbabula*), usability and efficiency of the cook stove. The motivation factor to switch to alternative fuels such as the pellet cook stoves would be incentives such as subsiding the new technologies in order to reduce their price, increasing the availability of pellets, sensitisation and awareness campaigns to magnitudes of people. One of the important determinants of household energy demand and fuel mix is the price of a fuel. Hence, the vitality of a choice of energy is driven by demand and currently the psychological need of the pellet cook stoves is low and this can be attributed to the gaps in climate education in Zambia especially to peri-urban households. Demand is also necessitated by the affordability and availability of the energy sources and its continued use. It is important to note that reducing household dependency on charcoal needs coordinated policies providing alternative income opportunities for entire charcoal value chain, provision of affordable alternative sources of energy for peri-urban households and efficient and sustainable production and use of woodfuel. In as much as the switch from woodfuel to modern energy (e.g pellet cook stoves) is the most desirable intervention, there is need to put up sustainable measures. Therefore, improving the sustainability of the existing woodfuel is a more practical solution as open fires are inefficient requiring more fuel. This requires the harmonization of woodfuel policies and the efficient production and consumption of charcoal should be improved as it is more feasible in the near future.

7.2. Recommendations for future research

Integration of the charcoal value chain into the pellet cook stove value chain to enhance adoptability of the pellet cook stoves.

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9. REFERENCES

ALEM Y, HASSEN S, KO¨HLIN G. (2013). The dynamics of electric cookstove adoption: panel data evidence from Ethiopia. Working Papers in Economics No. 557 at University of Gothenburg.

ATTERIDGE, A., HENEEN, M., SENYAGWA, J. (2013). Transforming household energy practices among charcoal users in Lusaka, Zambia: A User-Centred Approach. Stockholm Environment Institute Working Paper No 2013–04.

ARNOLD JEM, KÖHLIN G, PERSSON R. (2006). Woodfuels, livelihoods, and policy interventions: changing perspectives. World Dev 34(3):596–611.

BAILIS R, COWAN A, MASERA O. (2009). Arresting the killer in the kitchen: The promises and pitfalls of commercializing improved cookstoves. World Dev;37 (10):1694–705.

BEYENE AD, KOCH SF (2013). Clean fuel-saving technology adoption in urban Ethiopia. Energy Economics 36:605–613

BRELSFORD, W.V., (1947). Copperbelt markets: a social and economic study. Government Printer.

CEDEFOP; OECD (2015). Green skills and innovation for inclusive growth. Luxembourg: Publications Office of the European Union. Cedefop reference series.

CHAIX J.K. (2011). The black sheep in Africa's renewable energy family. The Charcoal Project.

COHEN, L., MANION, L., & MORRISON, K. (2011). Research Methods in Education (7th ed.). London: Routledge.

COLIN ROBSON & KIERAN MCCARTAN (2016). Real World Research: A resource for users of Social Research, Methods in applied settings, 4th edition: John Wiley & Sons Ltd, United Kingdom.

CRESPI F. (2015). A systemic policy perspective for the transition towards the green economy. Luxembourg: Publications Office of the European Union. Cedefop reference series.

DEPARTMENT FOR INTERNATIONAL DEVELOPMENT (1999) Sustainable livelihood guidance sheets.

DESAI, V., & POTTER, R. B. (Eds.). (2006). Doing development research. Sage.

EDMONDSON, DUNCAN. FLORIAN, KERNA. KAROLINE S. ROGGEA. (2018). The co-evolution of policy mixes and socio-technical systems: Towards a conceptual framework of policy mix feedback in sustainability transitions; a SPRU- Science Policy Research Unit, Jubilee Building, University of Sussex, Brighton, BN1 9SL, UK

FOOD AGRICULTURE ORGANIZATION (2017). The charcoal transition: greening the charcoal value chain to mitigate climate change and improve local livelihoods, by J. van Dam. Rome, Food and Agriculture Organization of the United Nations.

GEOPOLL SPECIAL REPORT (2018). Cooking fuel Consumption in Nigeria, Uganda and Kenya.

GEBREEGZIABHER Z, MEKONNEN A, KASSIE M, KÖHLIN G (2012). Urban energy transition and technology adoption: The case of Tigrai, northern Ethiopia. Energy Economics 34(2):410–418

GORDON, S. B., BRUCE, N. G., GRIGG, J., HIBBERD, P. L., KURMI, O. P., LAM, K.-B. H., MORTIMER, K., ASANTE, K. P., BALAKRISHNAN, K., BALMES, J., BAR-ZEEV, N., BATES, M. N., BREYSSE, P. N., BUIST, S., CHEN, Z., HAVENS, D., JACK, D., JINDAL, S., KAN, H., MEHTA,

S., MOSCHOVIS, P., NAEHER, L., PATEL, A., PEREZ-PADILLA, R., POPE, D., RYLANCE, J., SEMPLE, S. & MARTIN, W. J. (2014). Respiratory risks from household air pollution in low and middle income countries. The Lancet Respiratory Medicine, 2, 823-860.

HLPE. 2017. Sustainable forestry for food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

INDC. 2015. ZAMBIA'S INTENDED NATIONALLY DETERMINED CONTRIBUTION (INDC) TO THE 2015 AGREEMENT ON CLIMATE CHANGE. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Zambia%20First/FINAL+ZAMBIA'S+INDC_1.pdf

IIYAMA M, NEUFELDT H, DOBIE P, JAMNADASS R, NJENGA M, NDEGWA G. (2014) The potential of agroforestry in the provision of sustainable woodfuel in sub-Saharan Africa. Curr Opin Environ Sustain; 6C:138–47. http://dx.doi.org/10.1016/j.cosust.2013.12.003.

JAGGER, P., DAS, I., HANDA, S., NYLANDER-FRENCH, L. A., & YEATTS, K. B. (2018). Early adoption of an improved household energy system in urban Rwanda. (In review at EcoHealth).

JAGGER, P., DAS, I. (2018) Implementation and scale-up a biomass pellet and improved cookstove enterprise in Rwanda. Energy for Sustainable Development 46:32–41

KALUMIANA, O. (2004). Energy Services for the Urban Poor in Zambia. AFREPREN/FWD Working Paper No. 318. AFREPREN/FWD, Nairobi, Kenya.http://www.afrepren.org/Pubs/WorkingPapers/wpp318_sum.htm.

KRUEGER, R.A. (1988) Focus Groups: A practical guide for applied research. Sage, UK.

KULINDWA, J., LOKINA, R., AHLGREN . (2018). Driving forces for households' adoption of improved cooking stoves in rural Tanzania. Energy Strategy Reviews 20:102-112

MASINJA A. KASARO .C, JULIAN. D, JONCKHEARA. I. (2012), Preliminary study on the drivers of deforestation and potential for REDD+ in Zambia. UN-REDD Programme.

MOBARAKA, A. M. DWIVEDI,P. BAILIS, R. HILDEMANN,L. MILLER, G (2012), Low demand for nontraditional cookstove technologies, University of Minnesota, St. Paul, MN 109 (27) 10815e10820.

MORGAN, D.L. (1988). Focus Group as qualitative research. Sage, UK.

PEŠA IVA (2017). Sawdust pellets, micro gasifying cook stoves and charcoal in urban Zambia: Understanding the value chain dynamics of improved stove initiatives. Netherlands: Leiden University

REPUBLIC OF ZAMBIA (2006a). Fifth National Development Plan 2006-2010. Poverty Reduction Strategy Paper. Prepared by the Government of the Republic of Zambia in consultation with the World Bank and the International Monetary Fund, Lusaka.

http://www.imf.org/external/pubs/ft/scr/2007/cr07276.pdf.

REPUBLIC OF ZAMBIA (2006b). Vision 2030: A Prosperous Middle-income Nation by 2030.Government of the Republic of Zambia, Lusaka.

REPUBLIC OF ZAMBIA (2002). Poverty Reduction Strategy Paper. Prepared by the Government of the Republic of Zambia in consultation with the World Bank and the International Monetary Fund, Lusaka. http://www.imf.org/external/np/prsp/2002/zmb/01/

ROGERS, E. (2003) Diffusion of Innovations, 5th Edition. Simon and Schuster.

ROGGE, K. S. & REICHARDT, K. (2016). Policy mixes for sustainability transitions: An extended concept and framework for analysis. Research Policy, 45, 1620-1635.

SANDER K, GROS C, PETER C. (2013). Enabling reforms: analyzing the political economy of the charcoal sector in Tanzania. Energy Sustainable Dev;17:116–26.

SCOONES, I. (1998). Sustainable rural livelihoods: a framework for analysis. Working Paper — Institute of Development Studies, University of Sussex. 22 pp.

SMITS, R.E. ET AL. (2010). Introduction: a systemic perspective: the innovation policy dance. In: Smits, R.E. et al. (eds). The theory and practice of innovation policy: an international research handbook. Cheltenham: Edward Elgar, pp. 1-22.

STEWART, D.W. AND SHAMDASANI, P.N. (1990) Focus Groups: Theory and Practices. Sage, UK.

UNITED NATIONS (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. New York: UN Publishing.

VINYA, R., SYAMPUNGANI, S., KASUMU, E.C., MONDE, C. AND KASUBIKA, R., (2011). Preliminary study on the drivers of deforestation and potential for REDD+ in Zambia. Lusaka, Zambia: FAO/Zambian Ministry of Lands and Natural Resources.

ZAMBIA GENDER AND ENERGY MAINSTREAMING STRATEGY (2011 -2013). Part One, Gender Analysis of the Energy Sector ENERGIA, International Network on Gender and Sustainable Energy. Government of the Republic of Zambia, Lusaka.

ZULU L.C, RICHARDSON R.B. (2013). Charcoal, livelihoods, and poverty reduction: evidence from sub-Saharan Africa. Energy Sustainable Dev; 17(2):127–37.

APPENDICES

Appendix 1: Households' interview guide

My name is Mukuka Mpundu Mulenga and I am a Masters student at Uppsala University in Sweden conducting a research on the provision and uptake of energy households in (Matero Compound) Lusaka. The information you are going to give me is for academic use only and not any other purpose and it will also provide relevant insights to policy makers. I will therefore be grateful for about 1 hour of your time to conduct this interview with you. Your answers will be kept strictly confidential and never associated with your name. During the interview, you are free to opt out should you feel uncomfortable to answer questions. You can also choose not to answer specific questions. Are you ready to start?

1. What is the common source of energy you use in your household?

a. wood b. charcoal c. kerosene d. electricity e. several sources e.g wood and charcoal f. gas g. Paraffin

2. For how long have you been using this mode of source of energy?

3. What would you say are the advantages of using that source of energy from your experience?

4. What would you say are the disadvantages of using that source of energy from your experience?

5. If the answer from question 2 above is charcoal, for how long have you been cooking using it?

6. What is your main source of charcoal?

a. charcoal vendor b. charcoal producer c. market

7. Why do you use charcoal as a source of energy?

a. due to price b. convenient to use c. reliable d. availability

8. What is your experience with charcoal usage? Do you encounter any problems with it? Please describe the problems?

9. Are you bothered by the smoke from charcoal?

10. Have you ever used any other source of fuel for cooking other than charcoal? Please mention these energy sources.

a. If so what was it and how did you find its usage? Comparatively to charcoal?

11. Do you know about the new stoves that do not require the use of charcoal but pellets?

a. If yes, how did you know about them?

b. Have you used them before?

b. If yes, how do you find the use of the pellets cook stoves and do you appreciate them?

c. How do you find their usage compared to charcoal?

d. If not, would you use them if they were made available to you?

12. Have you received any information/ communication from the council on pellets cook stoves?

13. How did you find the communication and sensitization strategy from the council?

14. How did you feel about these strategies and policies?

15. What are the general attitudes and perceptions of households of the improved cook pellet stoves and how might they influence their adoption process?

16. Is your house connected to the national electricity grid?

17. Are you using electricity for cooking?

a. If yes how do you find its usage? Is it affordable, expensive?

18. Which one do you find affordable between electricity and charcoal as a source of energy and why?

19. If electricity tariff plan was reduced would you prefer to cook on electrical stoves?

20. What would motivate you to use the improved pelletised stoves as opposed to charcoal brazier?

21. What are the most important considerations when you select energy fuel?

22. Are energy costs important to you?

23. Have the energy costs increased in the recent years?

24. What are the barriers for starting to use the pellets cook stoves?

Appendix 2: Interview guide for key informants, Energy and Forestry Departments and Lusaka City Council

My name is Mukuka Mpundu Mulenga and I am a Masters student at Uppsala University in Sweden conducting a research on the provision and uptake of energy households in (Matero Compound) Lusaka. The information you are going to give me is for academic use only and not any other purpose and it will also provide relevant insights to policy makers. I will therefore be grateful for about 1 hour of your time to conduct this interview with you. Your answers will be kept strictly confidential and never associated with your name. During the interview, you are free to opt out should you feel uncomfortable to answer questions. You can also choose not to answer specific questions. Are you ready to start?

1. What policy instruments has government crafted with regard to dissemination, sensitization and communication strategies of deforestation and the new cook stoves?

2. Since when have they been in place and would you say they have been progressive or not in attaining the objective?

a. If not, why would you think has been the cause for not reaching the goal?

3. Is policy dissemination and sensitization/ communication on new cook stoves sufficient to households? Why do you say/ think so?

a. How does the community view of these strategies and policies?

4. Are the government policies and strategies currently being implemented appropriate for households to switch to alternative energy fuels?

5. How do these policies shape opportunities or create challenges for households in their energy use?

6. What policy incentives has government put up for low income households in order to switch to new cook stoves?

a. If not, what suggestions do you think you can make on policy incentives which government can give to low income households in order to switch to new cook stoves?

7. What alternatives could be provided to the charcoal value chain to curb the current unsustainable charcoal production/ deforestation?

8. What options does the government have for the entire value chain of charcoal production in order to support their livelihood?

9. Does Forestry and Energy department have any policy synergies driven by deforestation due to charcoal demand?

a. If so what kind of synergies do they have?

10. Is it possible to reduce electricity tariffs for low income households to enable them cook using electricity?

a. If yes, what do you think it would take to reduce the tariffs for low income households?

b. What effect would that have on the government and Zambia electricity supply corporation (Zambia's only electricity utility company?

11. Who has the government helped promote the use of new cooking stoves?

12. Are there any incentives that the government has put in place for those making or importing new cook stove?

a. If so, how - in your view - has that helped curb on the use of charcoal and deforestation?

b. and has it affected the local tin smiths that make the braziers/ *mbabula*?

c. How do you think it has affected them?

13. What challenges do households have in relation to their current cooking solutions and the options available to them (new cook stoves)?

14. What are the general attitudes and perceptions of households of the emerging cooking solutions and how might they influence their adoption process?

15. Would you say the fight against deforestation as well as environmental degradation through use of charcoal is being won, if so, how and why?

16. What are the main goals for policies related to household energy?

Appendix 3: Responses from households categorised in different themes

	TOPIC				
RESPONDENT 1 • Beneficiary of improved pellet stove (USER) • Most common source of energy was **charcoal** and **electricity** before the LuMa project. Charcoal has been used from a long time. • FALLBACK: Charcoal is useful in instances of power cut	HEALTH	ECONOMIC	CONVENIENCE	RISKS	DETERMINANT OF ENERGY CHOICE
	1) DISEASES: Charcoal include respiratory problems such coughing as a result of carbon monoxide which can also cause death.	1) COST: Both charcoal and electricity are expensive a) **Electricity** is very expensive especially with the prepaid meters installed. b) **Charcoal** is more expensive than electricity. The price of charcoal has increased abnormally especially that it is seasonal. Both during rainy season and cold season it is ridiculously expensive because people travel long distances in order to produce the charcoal, bad roads, fuel for transportation has led to the	1) EFFICIENCY & USABILITY: a) **Electricity-** cooking is quick, no need to lighten up unlike charcoal b) **Pellet stove** is cheaper, it does not give headaches and dizziness like charcoal. It has got no holes like charcoal brazier and can be used indoors, it is faster, lights like a gas stove and electrical stove and it can be charged with electricity and it works well. It also works with solar to charge (in case of power cut) as it has a solar panel and it produces its own air with a fan made in it. It is not affected by wind blows	1) POWER DISRUPTIONS: Sometimes restoration of power after interruption comes with force which can destroy electrical appliances such as stoves, also affects the taste of the food when power is interrupted whilst cooking 2) SHOCKS: Electrical shock which can cause death. 3) BURNS: it can cause massive burns in case of an accident. Burns also from having to touch charcoal in trying to place in nicely on the brazier 4) Charcoal usage also is a driver of deforestation which is destroying the environment and	1) Most important factor in determining my choice of energy is health impacts, price is also important.

		hike in charcoal. c) **Pellets**: These improved pellet cook stoves are cheap and allow for indoor cooking. d) **Charcoal quantity vs pellets;** I usually use three 50 kilograms bags of charcoal per month and comparably to pellet improved cook stove the entire pack of pellets is used for a month and is only 45 kwacha compared to 300 Kwacha of that of charcoal. 2) FLEXIBLE PAYMENT: a) **Subsidies**; there are no subsidies for the new cook stoves but it is possible to pay in installments over a long period of time	as the case with charcoal brazier and you just switch it on as you please, and you can regulate the heat. c) **How to use improved stoves;** Initially had problems to switch to improved pellet cook stoves because they have used charcoal from their childhood and they did not see any problems with it as it has always helped to cook food. d) **Combustiblenes ss**; Pellet cook stove is also highly combustible and in some instances it may also burn the food if you do not check regularly. 2) LIGHTINING: During rainy season it is difficult to light charcoal because it is usually wet and	also affecting the rainfall pattern.	

		for about one year six/ eight months. Upon finishing of the payment, you can get your stove. The stove costs 1400 kwacha (120 USD). 3) Electricity and charcoal price have increased in the recent past	time consuming, takes long for it to light up in readiness for cooking 3)INCONVENIENCES: a) with charcoal, you cannot cook in an enclosure because of the smoke/ carbon monoxide and as a result you are always forced to cook from outside. That is why the brazier is made of so many holes to allow air ventilation which releases a lot of smoke. b) **Replenishing pitfalls**; Pellets you just load once on the stove when cooking and so when the burning pellets finish, you beginning the lighting process all over again. 4) ACCESS: Barriers to new cook stoves is limited supply of pellets especially that the pellets are		

			manufactured/ produced from one main source on the Copperbelt province of Zambia.		
RESPONDENT 2 • Not beneficiary of improved pellet stove • Common source of energy is **electrical stove**	1) HEALTH: Charcoal does not produce smoke and does not have any health related risks	1) COST: a) **Electricity** usage is very affordable and cheaper than charcoal. b) **Reducing cost**; I would only use the improved pellet cook stoves if they reduces the prices because at the moment they are costing 1400 Kwacha (120 USD). c) **Subsidies**; there are no subsidies for buying the new cook stoves. d) Barriers to use new cook stoves; i) costly price ii) lack of information on	1) EFFICIENCY AND USABILITY: a) Electricity is clean, convenient, and available when you need it. 2)INCONVINIENCES a) Charcoal is wet sometimes and made from trees that are bad standard and cant heat up and difficult to light. 3) **Richness of flavour** Charcoal brings richness of flavor and taste to the food		1) DETERMINANT OF ENERGY CHOICE: a) convenience, b) ease of use c) affordability.

		the improved pellet cook stoves. Little is known about the new cook stoves and they are highly viewed as expensive.			
RESPONDENT 3 Beneficiary of improved pellet stove (NOT USER) • Charcoal is mostly used source to cook but expensive • The most important factor in choosing a fuel is the **price.**	1) DISEASES: a) Charcoal usage ignites smoke leading to headaches.	1) COST: a) Used **Pellet Cook stoves** before and it's cheaper than charcoal, last longer and it is faster to cook. b) **Electricity is expensive** than charcoal and pellets. If electricity tariff was reduced I would cook on stove. c) **Subsidizing**; The pellet cook stoves are not subsidized and too expensive.	EFFICIENCY AND USABILITY 1) COOKING VARIETY: For electricity you cannot cook things like fish and beans because it requires cooking for more than an hour but it is possible with charcoal. 2) EFFICIENCY: pellet cook stoves are faster to cook 3) REPLENISHING INCONVENIENCY: with new cook stoves pellets, you cannot **replenish** them when you are in	1) CHOCKINGS: If you try to top up with pellets to the already burning pellets, you just ignite smock which chocks and it goes off.	1) DETERMINANT OF ENERGY CHOICE: Most important factor in determining my choice of energy is price

			the processing of cooking as the case with charcoal. 3) I use charcoal because the school is not connected to the electrical grid.		
FOCUS GROUP DISCUSSION (5 BENEFICIARIES AND USERS OF PELLET COOK STOVES AND TWO NON BENEFICIARIES) • Mostly common used is **charcoal**	1) HEALTH: Charcoal has no advantages because it causes health problems such respiratory problems, we only use it because it is readily available and we lack affordable alternative sources.	1)**COST** a) Charcoal is expensive amounting to 3 kwacha per load on a small sized brazier and going for 180kwacha for 90kg bag. b) I use electricity is but it is very expensive and I cook beans and fish on charcoal brazier in order to save electricity units c)Charcoal is cheaper than electricity c) The pellet cook stoves are not subsidized and too expensive. Maybe if they could provide us with a cheaper stove differently made. Despite the expensive stove, we also need to purchase the	1)EFFICIENCY AND USABILITY a)LIGHTING: Charcoal delays in lighting when its wet especially during rainy season b) Charcoal is readily available despite not possessing any advantages. Also, we are not connected to the national electricity grid and two of us do not have pelletised stoves c) Pellet cook stoves allow for indoor cooking d) Pellets unlike charcoal can be reused after putting out fire and produce less ash than charcoal. e) Pellets are not readily and easily available/ accessible	1)BURNS: Charcoal pops a lot which can cause burns, causes house infernos, dangerous to toddlers (crawling children) 2) DEATHS: Smoke from charcoal chocks and intoxicates and can lead to death 3) Charcoal is affecting the rainfall pattern due to deforestation.	1) DETERMINANT OF ENERGY CHOICE: Most important factor in determining my choice of energy is health impacts, price, convenience, affordability and fastness in cooking.

		pellets separately. 2)**Charcoal quantity vs pellets** a) I have observed how the pellet cook stove works with my neighbour and it uses less pellets as compared to charcoal I would switch to it if I had a pellet cook stove.	f) **Replenishing inconveniency**: with improved pellet stoves, you cannot replenish them when you are in the processing of cooking as the case with charcoal. g)Pellet cook stove has a fan which enables easy lighting unlike a charcoal brazier which requires use of a hollow pipe h)**Repair inconvenience in case of stove damage**: Use of pellet stoves requires precautionary measures and should be taken to manufacturer for repair in case of damage unlike a charcoal brazier which can easily be repaired and replaced		
RESPONDENT 4 • Beneficiary of improved pellet stove (USER) • Most common source of	HEALTH 1) CUTS AND BURNS : Charcoal causes massive cuts/ lesions burns with continuous touching and	1)COST: a) Pellets are cheaper than charcoal and last longer e.g 50kg of charcoal costs K130 and lasts three weeks	EFFICIENCY AND USABILITY 1)CONVINIENCY: a)Pellet stove is cheaper, it is faster, less consumption of	RISKS 1) CUTS AND BURNS : Charcoal causes massive cuts/ lesions burns with continuous touching and breaking the	1) DETERMINANT OF ENERGY CHOICE: Most important factor in determining my choice of

energy is pellet cook stove • I use firewood to cook a lot of food	breaking the charcoal in trying to place in nicely on the brazier, it also causes headaches from the smoke which leads to intoxication and suffocation	and if properly used it lasts two weeks while a 20kg of pellets cost K50 and lasts one month. b) I cannot cook using electricity because it is very expensive and highly consumed despite being connected to the national electricity grid c)Pellet cook stoves are expensive d) Charcoal and electricity are both expensive	pellets, easy to light up, no additional load of pellets needed whilst cooking b)Pellet cook stoves unlike charcoal allow for indoor cooking 2) INCONVINIENCY: a)Pellet cook stoves are not easily accessible and cannot be used to cook certain foods for instance roasting meat. b) First time use of the pellet stove is difficult (lack of technical knowhow and expertise) and it is not easy to shift to pellet cook stove because I am used to charcoal. c) When the charcoal is wet it is difficult to light up.	charcoal in trying to place in nicely on the brazier, it also causes headaches from the smoke which leads to intoxication and suffocation	energy is affordability, cheapness and the type of food to be cooked e.g roasting meat cannot be done on a pellet cook stove.
RESPONDENT 5 AND 6 • Beneficiaries of improved	1)HEALTH a) DISEASES: smoke from charcoal affects us by causing	COST 1)High consumption of electrical units and expensive	EFFICIENCY AND USABILITY 1)CONVINIENCY	POWER DISRUPTIONS: 1)Sometimes restoration of power after interruption can cause accidents	1) DETERMINANT OF ENERGY CHOICE: Most important

pellet stove (USERS) • Commonly use electricity as fuel • FALLBACK: Charcoal is useful in instances of power cut and when electrical units are running out (about to finish)	coughs and headaches	2)Pellets are cheaper than charcoal and lasts for a month purchased at a cost of 50 kwacha 3) Charcoal is expensive than electricity 4) The pellet cook stove is expensive to buy once off but in the long run it is cheaper since it has a longer life span than charcoal.	a) Electricity is faster to cook and light unlike charcoal b)Pellets are easy to light and allow for indoor cooking unlike charcoal c)Pellet stove has the provision to charge using solar in case of power interruption d) Pellet cook stove has an adjusting knob to regulate heat 2)INCONVINIENCY a) Pellets are not readily available like charcoal b) Charcoal is mostly wet and difficult to light in the rainy season c)Pellet cook stove is also a delicate because the battery should not come in contact with water d)In case of damage, the pellet cook stove can only be repaired by the company (manufacturers)	such as electrocution	factor in determining our choice of energy is affordability, fastness in cooking, accessibility, availability, price

			d) As the pellet stove is rechargeable, it would not be possible to use it if there is power disruption and no sun to charge the battery e) With improved pellet stoves, you cannot replenish them when you are in the processing of cooking as the case with charcoal entailing beginning all over again to light up when the first load of pellets is finished.		
RESPONDENT 7 AND 8 • Beneficiaries of pellet cook stoves and (USERS) • Commonly used energy is pellet cook stove, before used to use charcoal and electricity • FALLBACK: Reverted to charcoal because pellets given during the	1)HEALTH a) Charcoal causes intoxication due to smoke	COST 1)Pellets are cheaper, able to use one bag as opposed to that of 3 bags of charcoal in a month 2)Charcoal is used for heating bathing water and slow cooking dishes like beans because electricity consumes a lot of energy, also charcoal is	EFFICINCY AND USABILITY 1)CONVINCIENCY a) Pellets cook stoves are faster, quick to light, do not make hands and pots dirt, do not cause smoke and intoxication, no risks such as burns and inferno accidents because of the enclosure.	1)RISKS a)BURNS: charcoal causes burns, infernos, b) Charcoal causes intoxication due to smoke c) Electricity can cause fire and accidents	1) DETERMINANT OF ENERGY CHOICE: Most important factor in determining our choice of energy is affordability, fastness in cooking, accessibility, availability, price, safety, size of stove (bigger is preferred with more than one plate and oven

project are finished and are not available and not known where to buy them		readily available 3)Charcoal quantity vs pellets: Pellet stoves require a smaller quantity of pellets than charcoal brazier requires charcoal to cook same amount of food 4)Electricity is more expensive than charcoal especially for cooking things like dry fish 5)Energy costs for both electricity and charcoal have increased e.g 90kg of charcoal can cost 250kwacha in scarce periods such as rain reason 6) Electricity price is unpredictable and every time you buy electricity the units are always different. 7) Pellet cook stoves are very expensive	b) Pellet stove works on rechargeable battery and takes a month or so to drain 2)INCONVINCIENCY a)Pellet cook stove not ideal for bigger pots b) Pellet cook stove requires vigilance/ close supervision to avoid any spillages/ it is delicate, also the flame is hard to easily burn food. c)Charcoal causes dirt in the hands and pots unlike pellets d) Charcoal is scarce, wet and more expensive in the rain season.		to allow for simultaneous cooking.
RESPONDENT 9	1)HEALTH a)SMOKE from firewood	COST 1)Charcoal and firewood is	EFFICIENCY AND USABILITY	1)RISKS a) SMOKE from firewood and	1) DETERMINANT OF ENERGY

• Beneficiary of improved pellet stove (USER) • Commonly used energy is firewood and charcoal	and charcoal is a disadvantage and can cause breathing problems	expensive and scarce on the rainy season 2)Charcoal quantity vs pellets; Charcoal braziers use more quantity of charcoal compared to pellets for cooking similar amount of food 3)Pellets are more affordable than charcoal because a bag of pellets (60 kwacha) lasts longer than a bag of charcoal (150 kwacha), consumption of pellets for every load is less than that of charcoal load 3) Pellet cook stoves are very expensive, the institution cannot afford to buy but for the pilot project	1)CONVINIENCY: a) Firewood and charcoal it is easier to cook using big pots and also cook a lot of food at once b)Pellets allow for indoor cooking as they do not produce smoke and cook faster c)Pellets do not allow hands to get dirt like charcoal INCONVINIENCY a)Non availability of firewood during rainy season and it is usually wet hence difficult to light b)The pots are difficult to wash due to the smoke from firewood and charcaol that attaches itself to the pots c)Use pellet stoves to only cook relish because they are small for big pots d)Pellets cook stove require presence when cooking because of the hard	charcoal is a disadvantage.	CHOICE: Most important factor in determining our choice of energy is harmless energy, cheaper emery, less consumption and availability

			flame unlike charcoal. e)Most people do not know where to buy the pellets and the stove f)In an event of power interruption the pellet cook stove cannot be used because it needs to be charged.		
RESPONDENT 10 Beneficiary of improved pellet stove (USER) • Most commonly used energy is pellet cook stove since October 2018 • Also use charcoal and electricity		COST: 1) Electrical stove and pellet cook stove are similar in that both have a regulator though pellet stove is faster. 2) Pellet stove is cheaper than electricity 3)Charcoal is costly in the rainy season costing between 180-200 kwacha lasting 2-3 weeks 3)Pellet cook stoves are expensive	EFFICIENCY AND USABILITY 1)CONVINIENCY: a) Pellets are economical, durable, cook faster, and allow for indoor cooking. b)Pellet cook stove- you can cook food with one load of pellets while to cook similar type of food on a brazier requires many loads of charcoal replenishment 2)INCONVINIENCY a)Charcoal does not allow indoor cooking due to smoke b)Charcoal makes hands dirt		1) DETERMINANT OF ENERGY CHOICE: Most important factor in determining our choice of energy is cheapness, cost, durability, cleanliness, health hazard, hygiene considerations

			requiring washing all the time after touching it c)Charcoal cannot regulate heat like pellet cook stove		
RESPONDENT 11 and 12 Beneficiaries of improved pellet stoves (USERS) • Commonly used energy is charcoal / firewood	1)HEALTH a)SMOKE coming from charcoal does not affect us in anyway. There is no faulty or any problem with charcoal. I am 54 and I have never experienced any problem with charcoal and so as my mother who has been using charcoal and firewood for cooking so it cannot be a problem today b)There is no smoke from charcoal	COST: 1)Electricity is expensive ever since the electrical prepaid metres were installed 2)Charcoal is cheaper than electricity and used to cook slow cooking dishes such as beans and dry fish, it lasts longer unlike electricity which is consumed very fast 3) If electricity tariff was reduced I would still cook on charcoal/firewood because it retains flavor if cooked traditionally. Only foods like vegetables and breakfast meal are ideal to cook on electrical stove.	EFFICIENCY AND USABILITY 1)CONVINIENCY: a)Pellets cook very fast, allow indoor cooking, no smoke, does not emit heat causing discomfort like brazier b)Charcoal and firewood has got no disadvantages and have used it throughout our lives, it is readily available c) Food cooked on charcoal has great taste, aroma, savory and warmth unlike that cooked on electrical stove d) If the pellets on a loaded cooking pan run out you just switch to another pan and use the remains of the previous	RISKS 1)INTOXICATION: smoke cannot intoxicate you unless you place it in a newly painted house because of paint 2)BURNS: The charcoal brazier has risks of burning such as crawling children unlike the pellet cook stove in the way it is made (enclosed)	1) DETERMINANT OF ENERGY CHOICE: Most important factor in determining my choice of energy is the consumption rate of energy, availability, and price.

		4) The stove is very expensive I cannot afford it if I was not in the project and even the payments in instalments is not affordable.	pan to light the new pan and you continue cooking. e)The pellet cook stove can be charged by solar when there is no electricity f)The pellet cook stove has adjusting knob to regulate heat unlike a charcoal brazier 2)INCONVINIENCY a) Pellets can burn food if left unchecked, the flame is too hard that it damages pots at the bottom by causing holes at the center of the pot. My pot has a hole at the centre where the heat is concentrated. The stove should be designed in a way as to distribute heat to entire bottom of the pot b)The pellets are not readily available like charcoal c) Replenishing pitfalls; Pellets you just load once on the stove when		

			cooking and so when the burning pellets finish, you beginning the lighting process all over again.		

Appendix 4: Ethical clearance

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Forest Economics
Anders Roos

2019-04-03

To whom it may concern

Ethical considerations in MSc Thesis

Miss Mukuka Mpundu Mulenga is a Zambian student enrolled in the Master programme "Sustainable Development" at Uppsala University, Sweden. This semester (spring 2019) she is writing her Thesis entitled "Assessing the levels of awareness of new cooking solutions of households in Lusaka city (Zambia) in view of government policies using a user centered approach". I am her supervisor. Hopefully, Miss Mulenga's study can contribute to successively more sustainable energy use in urban households in Zambia.

It is of utmost importance that Miss Mulenga's work adhere to ethical codes and principles for research. These are for instance described in the publication "Good Research Practice" by the Swedish Research Council (2017). When planning her research we made the following ethical considerations and came to the following conclusions:

We found that the interviews in Lusaka concerning cooking and energy use would not be sensitive or likely to be seen as indiscreet by the respondents. The questions circle around uncontroversial aspects of cooking habits and preferences. Hence no formal ethical review would be motivated.

Before her interviews and focus group discussions, Miss Mulenga underscored in her introduction to the respondents that all statements and answers would be treated anonymously in the analysis and the subsequent publication.

She also, before the interviews and group discussions, informed with emphasis that participation was voluntary, and respondents always could abstain from answering questions or leave the interview if they wished.

Hence, we believe that necessary ethical considerations have been respected.

Please contact me for additional information about Miss Mulenga's Thesis work.

Sincerely,

Anders Roos

Professor

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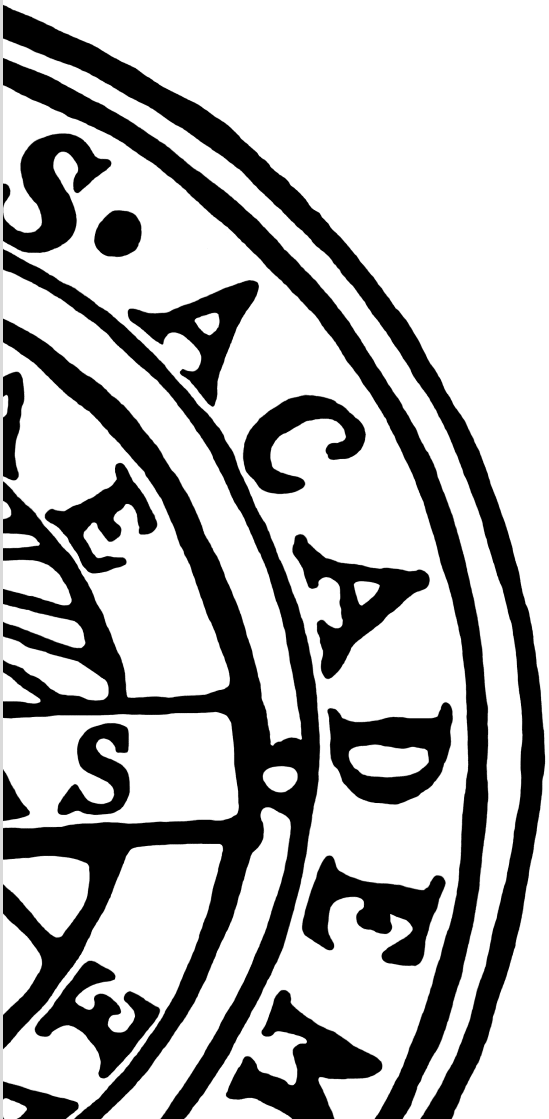
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