

**ENERGY CONSERVATION PRACTICES AT HOUSEHOLD LEVEL IN
CHALIMBANA WARD, CHONGWE DISTRICT**

**BY
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**A dissertation submitted to the University of Zambia in partial fulfilment of the
requirements for the award of a degree of Master of Science in Environment and
Natural Resources Management**

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DECLARATION

I, **Alfred Chewetu** , do hereby declare that this report represents my own work and that it has never been previously submitted for a degree at the University of Zambia or any other University. All published work or material from other sources incorporated in this dissertation have been duly acknowledged and referenced.

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CERTIFICATE OF APPROVAL

This dissertation by Alfred Chewetu (2019099373) has been approved as a partial fulfilling requirement for the award of Master of Science in Environment and Natural Resources Management at the University of Zambia.

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Supervisor	Signature	Date

DEDICATION

I dedicate this dissertation to the Almighty God for giving me strength, wisdom and good health throughout my educational journey in pursuit of a Degree of Master of Science in Environment and Natural Resources Management. In addition, I dedicate this dissertation to my late father John Sikapite Chewetu, my late mother Judith Namfukwe and my family for their support and encouragement.

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ABSTRACT

Energy conservation is a subject that has continued to attract global attention as it is essential in ensuring that the growing energy demand does not pose a threat to the environment. In view of this, the current study aimed at finding out the household energy conservation practices used in Chalimbana ward of Chongwe District, Zambia. The study adopted a convergent mixed method research design. Qualitative data from 10 purposively sampled key informants was collected through in-depth interviews using semi-structured interview guides. Additionally, quantitative data from 175 households selected through cluster sampling technique was collected using a questionnaire. The qualitative data was analysed through content analysis, whereas quantitative data was analysed through descriptive statistics and multiple linear regression.

The study found that most households in Chalimbana ward depend on traditional biomass energy (Charcoal and firewood). Through multiple linear regression, the study found that expenditure on household energy consumption in the study area was influenced by social and economic factors such as family size, house size and education. To conserve energy, the households in this area used a variety of conservation methods, of which the most used involves switching or putting off unused household energy appliances or sources. The energy used among these households is perceived to cause air pollution, habitat loss, land use change, and exposure to hazardous waste, among other environmental atrocities. While the study findings show that households in Chalimbana ward do practice energy conservation, this is not done at a substantive level that can yield sustainable environmental, economic and social benefits of household energy conservation.

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LIST OF ACRONYMS

CBD	Central Business District
CSO	Central Statistical Office
GRZ	Government for the Republic of Zambia
GHGs	Green House Gases
HIV	Human Immunodeficiency Virus
IAPRI	Indaba Agricultural Policy Research Institute
ICS	Improved Cooking Stove
IEA	International Energy Agency
IJHSSE	International Journal of Humanities Social Sciences and Education
ITCZ	Intertropical Convergence Zone
JAP	Journal of Agriculture Policy
LWSC	Lusaka Water and Sanitation Company
MGEE	Ministry of Green Economy and Environment
MIM	Ministry of Information and Media
MLNR	Ministry of Lands of Natural Resources
MLGRD	Ministry of Local Government and Rural Development
MoE	Ministry of Energy
MoH	Ministry of Health
NBSC	National Bureau of Statistics of China
NGO	Non-Governmental Organisation
REA	Rural Electrification Authority
SPT	Social Practice Theory
TV	Television
UNZA	The University of Zambia
USAID	United States Agency for International Development

CHAPTER ONE: INTRODUCTION

1.1 Background

Globally, energy conservation is a subject that has continued to attract debate and attention, more especially after the 1990s when climate change topics were at peak (Malama *et al.*, 2015). The debate has been anchored on various environmental and climate change concerns resulting from energy generation and utilisation. In 2017 for instance, global energy related Carbon Dioxide (CO₂) emission rose by 1.6% after three years and early data suggest continued growth in the proceeding years, far above a trajectory for global climate change goals (International Energy Agency (IEA), 2018). In Africa, the energy sector accounts for 4% of the world's energy related CO₂ emissions as observed in 2018 (IEA, 2019).

The discussion about energy conservation has included global diverse energy forms which exist and are used at various scales: global, regional, national, community and household level. Among these scales, the household level is considered as the terminal link for energy consumption and sustained environmental protection (Yue *et al.*, 2016). This is because household energy consumption does not only directly affect the scale and growth of energy consumption and carbon emissions, but also drives the emission of the construction, transportation and service industries (Yue *et al.*, 2013). Currently, households encompassed in the residential sector are responsible for 17% of global CO₂ emissions in the world and constitutes the third-largest major energy consumer worldwide (Nejat *et al.*, 2015). Therefore, it is right to argue that household energy conservation is the key to building a low-carbon society and environmental protection as their share in global energy consumption keeps increasing. For example, in 2013, the National Bureau of Statistics of China (NBSC) (2015), noted that direct household energy consumption accounted for about 10.9% of the total energy consumption in China, which has almost doubled since 2005. This energy consumption in China is further posed to present a fast growth momentum due to the changed policy on family planning.

Household energy conservation also remains key in meeting social economical needs and alleviating the energy deficits experienced in the African continent due to the rising population and under-developed energy systems (Ouedraogo, 2017 and Kojima *et al.*, 2016). Over 620 million people, almost two-thirds of Africans, do not have access to electricity and nearly 730 million rely on traditional solid biomass inform of charcoal and firewood for cooking (Ouedraogo, 2017). Those that do have access to electricity rely on a very expensive,

low-quality energy supply (IEA, 2014). Kojima *et al.* (2016) quoting the World Bank and IEA (2015) further reports that Sub-Saharan Africa lags behind all other regions of the world in household access to electricity per capita power consumption, and installed generation capacity. This is despite the fact that energy resources are more than sufficient to meet energy demands. Meeting the increasing energy demand for the growing population and ensuring universal access to modern energy services with respect to the environment are thus the principal goals of African countries (IEA, 2014). To this end, energy management strategies must ensure that energy supply-demand related policies and investment decisions consider all feasible demand and supply-side options which are consistent with global goals of sustainability (Ouedraogo, 2017).

In Zambia, household energy conservation is also vital in meeting the increasing energy demand largely consumed by the mining sector (51.1%) followed by household consumption (33.2%) (MoE, 2019). The country is undersupplied with renewable energy with the majority of households still reliant on traditional biomass from charcoal and firewood (Mudenda *et al.*, 2018). This traditional biomass energy accounts for more than 70% of total local energy requirements (MoE, 2019 and IEA, 2020). The reliance on inefficient biomass energy is necessitated in the low-income earning households of Zambia is because it comes free (as collected firewood), or is inexpensive compared to other household energy forms (Baltruszewicz *et al.*, 2021).

Considering the most used energy sources, the need to conserve energy resources at household and other levels in Zambia poses a variance which is imperative to the need for development. This is despite the fact that the country has been challenged with energy deficits and lack of electricity access of which in 2015 only about 22% of the urban population were connected to the national electricity whereas in rural areas the rate drops to 3% (World Bank and IEA, 2015). Efforts to conserve energy resources in Zambia have been tailored through various national government policies and strategies that recognize the need of addressing energy use at household level as a focus of tackling poverty, development and environmental goals (Mudenda *et al.* 2018, MoE, 2019 and IEA, 2020). For instance, Zambia's Vision 2030 describes an ambition to reduce the share of fuel wood to 40% by 2030 and to achieve a productive and well conserved natural resource for sustainable development (GRZ, 2006). It is thus essential that a study within a Zambian community such as

Chalimbana ward is undertaken to find out the household energy conservation practices used for all available forms of energy at household level.

1.2 Statement of the Problem

Zambia's need to invest in the energy sector has been a major concern in the past years. This is due to the energy deficits and limited access to electricity experienced in the country (IEA and World Bank, 2015). However, the growing energy sector has also posed concerns on climate change and the environment in Zambia as it accounts for 19% national Green House Gases (GHGs) emissions from anthropogenic activities (United States Agency for International Development (USAID), 2015). At household level, lack of a national energy efficiency policy and household knowledge on energy conservation also act as a significant barrier in promoting environmental protection through sustainable use of resources for energy generation (Mwamba *et al.*, 2020). Energy conservation is arguably also not practiced because the country undersupplied with renewable energy with the majority of households still reliant on traditional biomass from charcoal and firewood (Mudenda *et al.*, 2018). The reliance on inefficient biomass energy is necessitated in the low-income earning households of Zambia is because it comes free or is inexpensive compared to other household energy forms (Baltruszewicz *et al.*, 2021).

Efforts to conserve energy resources in Zambia have been tailored through various national government policies and strategies that recognize the need of addressing energy use at household level as a focus of tackling poverty, development and environmental goals (Mudenda *et al.* 2018, MoE, 2019 and IEA, 2020). As such, it can also be argued that lack of household energy conservation practices also significantly constrains national efforts for environmental protection and climate change response such as commitments to the 2015 Paris Climate change agreement. This is because households account for the second largest share of energy consumption in the country which stood at 33.2% in 2019 (MoE, 2019). Therefore, if not managed well through household energy conservation or efficient energy consumption, increased energy demand poses a threat to the environment. This environmental threat especially for non-renewable energy is seen in terms of deforestation, air pollution, habitat loss, land use change, exposure to hazardous waste, and soil erosion among other environment effects (Dlamini *et al.* 2016, Kasaro *et al.* 2019 and WHO 2018). Chalimbana ward the study area is attributed to these problems due to the high reliance of biomass energy in form of charcoal and firewood (Mudenda *et al.*, 2018). It is with this

regard that this study investigated on household energy conservation practices in a Zambian community such as Chalimbana ward of Chongwe district.

1.3 Aim

The aim of the study was to investigate the household energy conservation practices used in Chalimbana ward of Chongwe district, Zambia.

1.4 Objectives

- i. To identify household energy technologies used in Chalimbana ward.
- ii. To investigate the energy consumption patterns among households of Chalimbana ward.
- iii. To identify the main factors that influence household energy expenditure in Chalimbana ward
- iv. To investigate the perceived environmental implications of the energy consumptions patterns among households of Chalimbana ward.

1.5 Research Questions

- i. What are the sources of household energy in Chalimbana ward?
- ii. Which type of energy is used according to household purposes in Chalimbana ward?
- iii. How much is spent on energy consumption among households of Chalimbana ward?
- iv. Do social economic factors influence household expenditure on energy consumption in Chalimbana ward?
- v. How do Chalimbana ward households conserve energy?
- vi. Which factors influence energy conservation among households of Chalimbana ward?
- vii. Does household energy have any adverse environmental implications according to ward households?
- viii. What are the perceived adverse environmental implications of energy used among Chalimbana ward households?

1.6 Research Hypothesis

The overall research hypothesis is that there are socio-economic factors influencing energy conservation practices. The influence could be positive or negative depending on the factors.

1.7 Significance of Study

The study findings provide vital information that can be used by researchers and other scholars in developing energy conservation strategies which will aid environmental protection and climate change mitigation. They add to academic scholarly information for conserving energy through both modern and indigenous practices. In addition, the findings provide vital information that the Government of Zambia through the Ministry of Energy (MoE) can use in developing and implementing modernised mechanisms for household energy conservation. This in-turn aids in reducing energy deficits. The findings of the study are also vital to the Ministry of Water Development and Sanitation, Ministry of Lands and Natural Resources (MLNR), Ministry of Green Economy and Environment (MGEE) and Non-Governmental Organisations (NGOs) that seek to protect the environment and mitigate climate change through sustainable energy conservation practices. The findings are vital in providing information for promoting behavioural change towards energy conservation in Zambian communities at household level. They provide economical and sustainable strategies that households within Chalimbana ward and other Zambian communities can use to conserve or efficiently use energy.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter present a review of literature based on a number of studies that have been undertaken on energy conservation. The subsections are presented starting with the theoretical framework used in the study. The review of literature on energy conservation is given from a global perspective to a Zambia perspective. A sub-section on the existing knowledge gap in the literature is later presented at the end.

2.2 The Concept of Energy Conservation

Available literature shows that various definitions are used to describe the concept of Energy conservation. Dincer (2018) notes that the term energy conservation is prone to be confusion and is often misleading. It is nothing more than a statement of the principle of conservation of energy, which is embodied in the first law of thermodynamics, which states that energy is always conserved; it cannot be created or destroyed. In essence, energy can be converted from one form into another. However, in contrast to law of thermodynamics the term energy conservation normally also means something much different when it is used by various people in different contexts (Dincer, 2018). In this study, it shall be related to solving problems regarding energy generation resources and household energy technologies. It is used with respect to un-wasteful household energy consumption.

Existing literature as provided by Wei and Jones (2014), Frederiks *et al.* (2015) and Urban and Scasny (2012) also shows that energy conservation when described with respect to reduction of energy use is associated with concepts such as energy saving, energy efficiency and energy consumption. Energy conservation in literature by Wei and Jones (2014) and Frederiks *et al.* (2015) also focuses on ‘human behaviour’ and thus is associated with concepts such as efficiency behaviour, energy usage behaviour, curtailment behaviour and energy related behaviours. However, without focusing on the human behavioural or psychological aspects influencing energy conservation, this study wanted to understand the practical measures been undertaken by households of Chalimbana ward in order to conserve energy. Social economic factors such as household income and education were used to understand how they influence household energy conservation in Chalimbana ward.

2.3 Global Energy Conservation Practices

Globally, a number of studies such as the ones done by Wei and Jones (2015), Frederiks, *et al.*, (2015), Zhou and Yang (2016), Fujimi *et al.* (2016) and Gupta (2011), have been undertaken on household energy conservation practices as it has continued to attract global debate and attention. Among these, the study conducted by Zhou and Yang (2016) specifically was undertaken to understand household energy consumption behaviour as an effective way of improving energy efficiency and promote energy conservation. This study uses the economic paradigm (including demand response) and the behaviour-oriented paradigm (including intervention strategies) as research streams for understanding household energy consumption behaviour.

The study by Fujimi *et al.* (2016) indicates that household energy conservation can be enhanced through effective energy policies. They add on to note that factors of residents' psychological characteristics and intentions for energy consumption are traditionally important factors to formulate effective energy policies. In line with findings by Fujimi, *et al.* (2016), this study endeavoured to investigate the factors influencing energy conservation in Chalimbana ward and its finding are vital in providing recommendations for formulating measures and policies for energy conservation in Zambia.

Gupta (2011) revealed that the major hindrance in promoting sense of efficiency in energy utilisation among households are lack of information and awareness by households and lack of monitoring and regulation by relevant authorities. Similar to Gupta (2011), this focused on energy conservation practices and accompanying factors which affect it. However, the concept used for investigation in this study is energy conservation and not efficiency as done by Gupta (2011). The study in a similar perspective of Gupta (2011) also sought to understand if lack of information and awareness on the importance of energy conservation a constraint for promoting a sense of conservation among households of the study area. It further also investigated on the available energy conservation regulations available in Chalimbana ward and how this influences energy conservation.

Lack of energy conservation is also associated with environmental effects. Reviewed literature by Agbede *et al.* (2021), notes that rapid increases in energy consumption and economic growth over the past three decades are considered the driving force behind rising environmental degradation, which remain a threat to people and healthy environment. Shah *et al.* (2021) adds on to literature by noting that primary energy has become a vital part of

society from mobility, heating, and cooling to refrigeration to preserve food as well as for simple communication methods, such as texting. As such, pollution and environmental concerns regarding the impact of human activities has become main stream and efforts have been made to reduce solid wastes as well as CO₂ and greenhouse gas emissions (Shah *et al.*, 2021). This study will as such build on these finding by investigating the percieved environmental implimcations of household energy among household chalimbana ward.

2.4 Energy Conservation in Africa

Available literature in a study conducted by Ouedraogo (2017) shows that the long-term forecasting of energy supply and demand is of prime importance in Africa due to the steady increase in energy requirements, the non-availability of sufficient resources, the high dependence on fossil-fuels to meet these requirements, and the global concerns over the energy-induced environmental issues. The study by Ouedrago (2017) models the possible future paths for Africa's energy future and the related emissions. Future energy demand is forecasted based on socio-economic variables such as gross domestic product, income per capita, population, and urbanisation. However, this study in line with forecast provided by Quedrago (2017) wanted to understand how energy conservation can be used as a tool for promoting steady energy supply at household level while meeting the global concerns over energy induced environmental issues.

In Kenya, a study was undertaken by Mutua and Kimuyu (2015) to estimate the drivers and possible savings for household energy conservation. The study estimated conservation models for five household fuels-fuel wood, charcoal, kerosene, LPG, and electricity and generated information to predict not only the odds for household energy conservation but also the levels of possible savings. Using secondary data obtained from the National Energy Survey Data for Kenya 2009, its findings reveal that demographic variable such as the household head's gender and occupational and educational attainment, as well as household location and size, are key determinants of not only the propensity to conserve energy but also levels of actual energy savings. However, this study would arguably be criticised to fall short in its investigations as it only based its finding on secondary data obtained from the National Energy Survey Data for Kenya 2009. This study as such also included primary data collection from Chalimbana ward household themselves. The study was not be limited to the five household fuels as done by Matua and Kimuyu (2015) but included any another form that was used by the study participants. The study also wanted to understand how social economic

factors such as household income and family size variables influence household energy conservation in Chalimbana ward.

2.5 Energy Conservation in Zambia

A study undertaken by Malama *et al.* (2015), investigated households' energy consumption behavior in low- and high-income areas of Kitwe. In this study, descriptive and inferential statistics was used to investigate relationships between the two income groups; Bulangililo (low income) and Riverside (high income) and various energy consumption-related variables such as knowledge about energy reduction measures, energy saving strategies, barriers to using of energy saving strategies, and motives for using energy reduction strategies.

Key findings in the study by Malama *et al.* (2015) showed that whereas the descriptive statistics revealed behavioural differences between the two income groups, the inferential statistics showed that there is no relationship between income level and the energy efficiency variables. One can thus argue that the findings by Malama *et al.* (2015) cannot be vividly validated to understand the existing relationship between income groups and energy consumption. Furthermore, the study does not take into consideration or mention the fact that some households may be located in a low-income area such as Bulangililo of Kitwe but still own energy appliances similar to those in high income areas and vice versa. This study therefore did not investigate the relationship between two income groups of different localities. It was done within a single locality with people of similar and different income levels. It also wanted to understand the relationship between social economic factors and energy conservation in Chalimbana ward.

Another study undertaken in Zambia by Ngoma *et al.* (2018) to investigate how Zambian households adapted their energy consumption to cope with load-shedding shows that fuel-switching, load-shifting and conservation strategies were widely employed. These strategies differed due to the social-economic dimensions of the households. The study by Ngoma *et al.* (2018) was done as a response to crises of energy deficits experienced in the country from the year 2015. Accordingly, the study by Ngoma *et al.* (2018) does not show how household energy conservation can be used a tool for promoting environmental sustainability. This study as such takes up a proactive approach to understand how household energy conservation is being implemented in Chalimbana ward so as reduce current and possible future causes of energy deficits in Zambia as well as meet various environmental concerns.

A study by Mutale (2018) evaluated the communication strategies of the Ministry of Energy (MoE) in order for the organisation to effectively communicate energy saving initiatives and use of alternative sources. The Study was undertaken in Kabwata area of Lusaka using 175 self-administered questionnaires and in-depth interviews from energy experts. The study findings by Mutale (2018) indicated that respondents are aware of the communication strategies the Ministry of Energy uses. However, there was a variation in responses when respondents were asked to determine the effectiveness of the communication strategies used. Majority of the respondents said there was a language barrier for those that were uneducated, and the audience was not properly segmented to design specific messages for specific groups.

The study by Mutale (2018) on focused on communication strategies for energy saving by the MoE and did not seek to understand how what is to be communicated is being practically implemented among the households. This study as such builds on the findings by Mutale (2018) by investigating the practical ways of energy conservation among Chalimbana ward households. This assists in understanding that even when effective energy saving communication strategies are implemented, energy conservation may be or may not implemented by the end users based on various reasons such as social economic factors.

A review of literature by USAID (2017) also notes that The Zambian Ministry of Energy has set a goal to reduce energy usage by 2% per year from 2018 until 2030 (approximately 223 GWh off a 2015/16 base), and has partnered with the European Union (EU) to formulate a roadmap to achieve these objectives. While several Energy Efficiency (EE) and Demand-Side Management (DSM) pilots have been launched, more is required to unlock EE and DSM in Zambia: the implementation and scale-up phase of the roadmap has not yet been approved. This study as such provided opportunity for investigating on how energy efficiency can be promoted through household energy conservation and thereby contributes to the reduction of energy usage by 2% per year from 2018 until 2030 set by the government of Zambia as noted by USAID (2017).

A study by Baltruszewicz *et al.* (2021) investigated on the links between household consumption, collective provision, and well-being on energy footprints in Zambia. The study results line with other studies (Mutale, 2018 and Malama *et al.*, 2015) as demonstrates a positive association between income and indirect energy foot print, particularly for clothing, transport and recreation and culture. However, indirect energy footprint is negligible for the lower income half of the population according to Baltruszewicz *et al.* (2021). Indirect energy

footprint could increase with upward social mobility, development of rural and urban areas and improved provision of infrastructure and electrification as households with more disposable income might follow the steps of the affluent households. Baltruszewicz *et al* (2021) also notes that further research is needed to improve the understanding of the association between energy use and needs satisfaction as it is crucial for addressing decarbonisation and human development agendas. As such, this study also investigated how social economic factors influence expenditure on household energy consumption in Chalimbana ward

2.6 Theoretical Framework

Several behavioural models have been developed in socio-psychological research to provide a comprehensive explanation of energy conservation in households. This study however adopted the Social Practice Theory (SPT) in its facilitation. The theory refers to a routinized type of behaviour which consists of several elements interconnected to one other (Reckwitz, 2002). It seeks to explain the social and cultural world by analysing the basic bodily, knowledge-based practices that interconnect to form more complex social entities (Nicolini and Monteiro , 2016). The social Practice theory was used in this study as it is useful in the analysis of human behaviour, particularly in the context of energy conservation as shown in available literature. For example, Higginson *et al.* (2014) notes that the theory is useful in this context as it seeks to go beyond more established behaviour change approaches in recognition that energy is not used for its own sake but as part of the accomplishment of socially and materially shared practices in the service of normal everyday life. The theory offers an alternative approach to promoting a reduction in resources consumed (Breadsell *et al.*, 2019). The primary insights of this theory focus not on individual behaviour but on social practice and on the interaction of people's practices and in particular their material contexts (Shove and Walker, 2014).

In a similar perspective to Higginson *et al.* (2014), the Social Practice Theory was used in this study as a guide for understanding energy conservation practices reflecting from social actions in Chalimbana ward households. It was used to understand how households participating in multiple and variable social contexts of Chalimbana ward conserve energy. This led to understanding why certain household energy conservation practices are done, and how and why wasteful energy consumption practices can be prevented in Chalimbana ward. The prevention was understood in a similar perspective to the study by of Spurling *et al.*

(2013) who indicate that there three different ways in which the social practice theory can inform sustainable energy policies by individuating three different points of policy intervention. They suggest that policies informed by practices can either aim to re-craft single practices by changing their constituting elements, or to substitute whole practices with alternative ones, or to change how practices are interlocked. However, this study unlike Spurling *et al.* (2013) did not only have a policy intervention focus but wanted to understand how household conservation practices in Chalimbana ward can be implemented or positively reinforced through various mechanisms.

2.7 Knowledge gap

Literature from some of the exiting studies has revealed that domestic energy consumption depends not only on the location and design of a building, but also on the behaviour of the householders. Other studies have revealed that stumbling blocks towards promoting the sense of conservation are the lack of information and awareness by householders, and the lack of monitoring and regulation by relevant authorities. This study therefore wanted to understand if findings from other studies can also relate to the energy conservation patterns in Chalimbana ward. It wanted to find out if lack of monitoring and regulation by relevant authorities is a contributing factor on how Chalimbana households conserve energy. The study bridges the knowledge gap of unavailable information on how households in Chalimbana ward conserve energy from different sources. It provides information on how social economic factors influence household energy conservation and therefore can be a tool for promoting efficient household energy consumption in Chalimbana ward and other Zambian communities.

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA

3.1 Introduction

This chapter presents description of the study area. It presents the biophysical and social economic characteristics of Chalimbana ward.

3.2 Location of Study Area

Chalimbana ward is located in Chongwe district of Lusaka province, Zambia. It lies about 35 Kilometers off Great East Road from Lusaka city. The ward is located between 15°20'15.01"S, 28°40'6.59"E and 15°22'55.96"S, 28°45'42.25"E Global Position System (GPS) coordinates. It has an area size of 147.7 km² and borders with Kanakantapa, Chongwe, Nkatatindi, Lukoshi, Manyika, Machilele and Nyangwena wards of Chongwe district. Its location is as shown in figure 1 and appendix six.

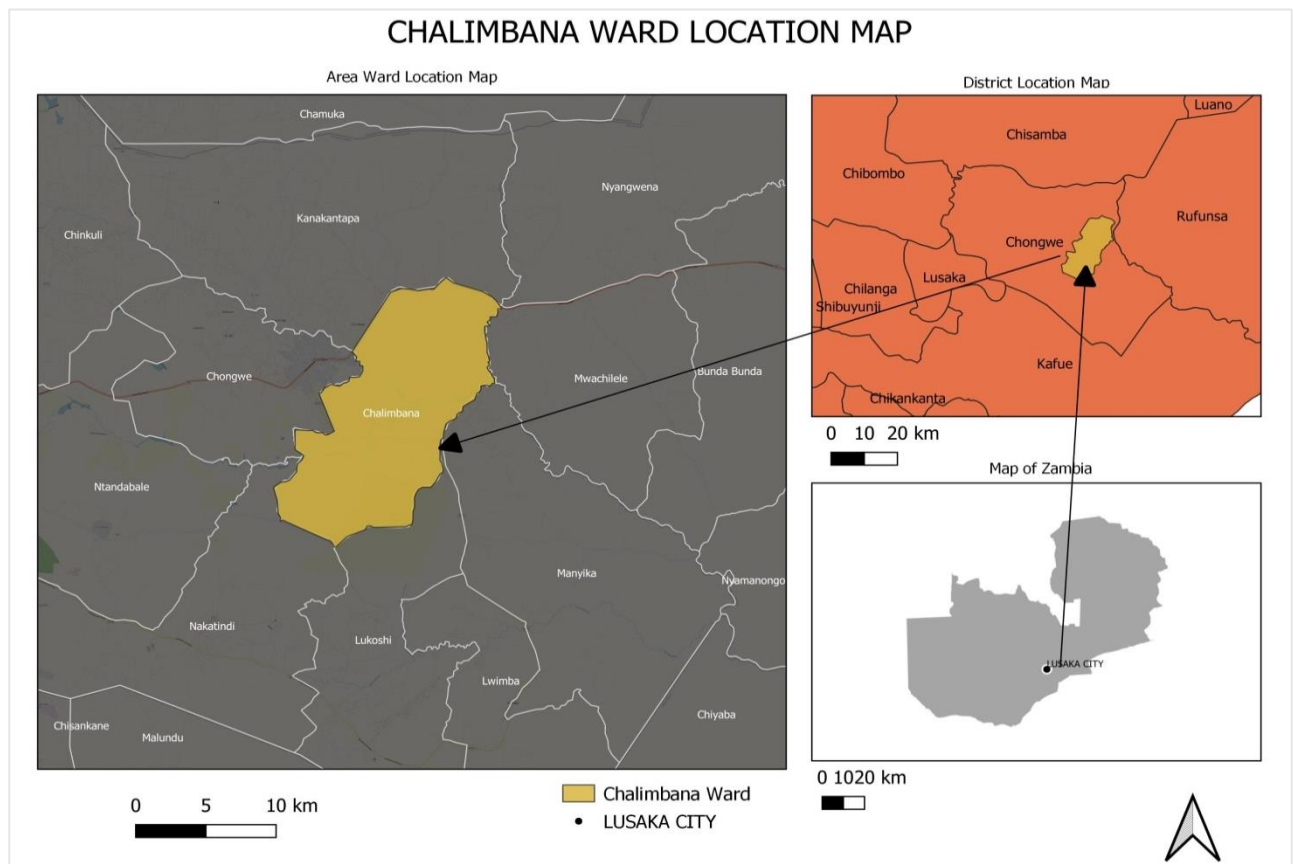


Figure 1: Chalimbana ward location map.

Source: Author (2023)

3.3 Physical Characteristics

3.3.1 Climate

Chalimbana ward of Chongwe district has a savanna type of climate. It falls in Agro-ecological region IIa of Zambia which has three main seasons, namely cool and dry from May to August, and hot and dry from September to October and warm and wet season from November to April. This region is mainly characterized with rainfall of between 800-1000mm per year (Mubanga, 2020). Most of the rainfall is influenced by the inter Tropical Convergence Zone (ITCZ) and gives a moderate wet ground on the plateau area of the region (CDDP, 2006). The cold season is characterized by cool breeze, wind and dust. The temperature in the cold season ranges between 10 and 18 degrees Celsius. The dry season beginning in August to October has temperature ranging between 18 and 27 degrees Celsius (Nick, 2015).

3.3.2 Hydrology

The Chalimbana catchment mainly forms the hydrology of the study area. The Chalimbana River is a sub catchment of the Chongwe River which is part of the middle Zambezi catchment. The Chalimbana catchment has an area of about 654km² and the river has a length of about 37km with several tributaries into it before it finally drains into the Chongwe River (Nick, 2015). It flows eastwards to its confluence with the Chongwe River. The river has several (recharge) tributaries flowing into it from the northerly and southerly directions, which include Mukamunye, Kapilyomba, Kashikili, Buyuni and Njolwe (Partnership for Africa's Water Development (PAWD), 2007).

3.3.3 Geology

The geology of Chalimbana ward is largely dominated by Katanga schist and Quartzities. Extending this area, the prevailing lithologies in Chongwe district as a whole are schists, quartzites and basement complex rocks. The metasedimentary cover dominating the southwestern half of the Chongwe River catchment comprises mainly of the Cheta formation's schists and carbonates. The north-eastern half this catchment is underlain by the basement complex with Muva quartzites and schists (Nick, 2015).

3.3.4 Vegetation

The vegetation in the study the area is characterised by tempered vegetation due to settlement, charcoal production and agriculture. However, the vegetation was historically dominated by dry miombo (*Brachystegia*) woodland, mopane (*Colophospermu mmopane*) woodland, and munga (*Acacia*) woodlands (Mulupi *et al.*, 2020).

3.4 Social Economic Characteristics

3.4.1 Administration

Chalimbana ward is located in Chongwe district of Lusaka province Zambia. Land in this area falls both under the jurisdiction of State land (council area) and Traditional land (Yasini, 2012). However, most of the land in Chalimbana ward falls under the jurisdiction of traditional land headed by Senior Chieftainess Nkomeshya Mukamambo II of the Soli people.

3.4.2 Demography

As of 2022 national census, Chalimbana ward has a population of 14,811 human beings (Zambia Statistical Agency, 2022). The population hence grew from 10,418 (5,277 females and 5,141 males) which was recorded in 2010 (Central Statistical Office (CSO), 2010).

3.4.3 Economic Activities

Agriculture is the main economic activity by residents of Chalimbana ward. Commonly cultivated crops in the area include maize, cassava and sweet potatoes (Mubanga, 2020). The agriculture activities in the area are also associated with poultry farming, rearing of goats, and cattle. These agriculture activities are very common in the area because of its proximity to Lusaka city where the products find a ready market (Milupi *et al.*, 2020). Few community members in the ward are also engaged in formal employment at government institutions such as schools and clinics. Others in the informal private sector are engaged in petty trade of charcoal, grocery retail goods and other micro entrepreneurship activities.

3.4.4 Social Services

3.4.4.1 Education

Chalimbana ward has two higher learning institutions which include Chalimbana University and the Chalimbana Local Government Training Institute. It has a number of primary and secondary schools which among them include Chishiko primary school, Chalimbana basic

school, African Vision of Hope secondary school and Mukamambo Girls high school. Inadequate teaching facilities, teachers as well as depilated school infrastructure are some of the challenges experienced in the education sector of the ward. In addition, the retention rate for female teachers is poor especially in rural schools located further away from Chongwe Central Business District (CBD) (Mwagana, 2016).

3.4.4.2 Health

Chalimbana and Bimbe clinic are some of the health facilities in the study area. The residents of Chalimbana ward are also able to access health services from Chongwe district hospital and Chongwe clinic, with some going as far as Lusaka city. Some of the major health issues in the area are associated with the inadequate health workers and health facilities. The common diseases affecting residents in the area as it is in Zambia at large include Malaria, HIV/AIDS, Respiratory infections, Tuberculosis, Diarrheal diseases among others (MoH, 2020).

3.4.4.3 Water & Sanitation

The water supply for the Chalimbana ward varies from rivers, streams, wells and hand pumped boreholes. However, most of the households in the ward do not have access to clean water. The boreholes are not sufficient, and even where they were dug by various utility firms and organisation, some of the pumps are broken down and, in some instances, the underground water is not suitable for human consumption. Some of households with clean water access are supplied by piped water from Lusaka Water and Sanitation (LWSC). These water works however have no filtration facility and suffer from constant breakdowns due to age (Phiri, 2015).

3.4.4.4 Transport and Communication

The road network in Chalimbana ward is generally poor with gravel roads connecting most of the human settlements. The main road (Chalimbana road) linking the Chalimbana ward to the capital city, Lusaka, branches off from the Great East Road, leading to Eastern province of Zambia and beyond to Malawi and Mozambique (Yasini, 2012). With regards to communication, most of the areas in the ward have connections to all or atleast one of the three (Airtel, MTN and Zambia) mobile network service providers available in Zambia.

3.5 Reason for Choice of the Study Area

Chalimbana ward of Chongwe district was selected as a study area because it provides a general but substantive representation of Zambian rural communities. It has households connected to the national ZESCO electricity grid as well as those using traditional household energy sources such as firewood and charcoal. Its proximity to the capital city of Zambia has contributed to high deforestation in the area. This is caused by high demand for charcoal energy to meet household needs in the growing human population of Lusaka city. Understanding household energy conservation in an area prone to these energy demands is thus a good call for environmental protection and climate change mitigation.

CHAPTER FOUR: METHODOLOGY

4.1 Introduction

This chapter describes the research design, sampling procedures, data collection tools and methods as well as the data analysis techniques that were used for this study.

4.2 Philosophical Orientation

This study adopted a pragmatic philosophical orientation which is based on the proposition that researchers should use a philosophical and/or methodological approach that works best for the particular research problem being investigated (Morgan, 2014). Therefore, in terms of ontology and epistemology, the philosophical orientation of this study was not committed to any single system of philosophy. Reality in the adopted pragmatic philosophy is actively created as individuals act in the world, and it is thus ever changing, based on human experience, and oriented toward solving practical problems (Kaushik and Walsh, 2019). Accordingly, the major underpinning of pragmatist epistemology is that knowledge is always based on experience. A person's perceptions of the world are influenced by our social experiences. Each person's knowledge is unique as it is created by her or his unique experiences. Nevertheless, much of this knowledge is socially shared as it is created from socially shared experiences. Therefore, all knowledge is social knowledge (Morgan, 2014). Pragmatist epistemology does not view knowledge as reality. Rather, it is constructed with a purpose to better manage one's existence and to take part in the world (Goldkuhl 2012).

4.3 Research Design

The research design used in this study is a convergent mixed method research design. In this research design, a researcher collects both quantitative and qualitative data, analyses them separately, and then compares the results to see if the findings confirm or disconfirm each. Its key assumption is that both qualitative and quantitative data provide different types of information and together they yield results that should be the same (Cresswell, 2014). Therefore, the two data sets in this study were collected and analysed concurrently but separately using typical quantitative and qualitative analytical procedures. After data analysis, the researcher then reached a point of interface and worked on merging the results from the two data sets. The merging included directly comparing separate results or transforming results to facilitate relating the two data types during additional analysis. The researcher in the final step then interpreted the extent and ways the two sets of results

converge, diverge from each other, relate to each other, and combine to create a better understanding in response to the study's overall purpose (Cresswell and Cresswell, 2017).

The convergent mixed method research design was used in this study because both qualitative and quantitative carry equal weight in addressing the research questions. It is a cost and time efficient research design, in which both types of data were collected during one phase of the research at roughly the same time. It also brought together the differing strengths and non-overlapping weaknesses of quantitative and qualitative methods and thus provide a better understanding of the overall research purpose (Cresswell, 2014).

4.4 Sampling and Sampling Procedure

Households in the study area were sampled using the two-stage cluster sampling technique. This is a probability sampling method in which clusters of participants that represent the population are identified and included in a sample. It involves identification of clusters for participants or sub-groups of homogenous characteristics that will represent the entire population (Jackson, 2011). In this study, clusters that represented the entire household population of Chalimbana ward were made up of the existing 9 villages (*Mwampikanya, Kabeleka, Kapamangoma, Chishiko, Kapuka, Buundu, Maoma, Chisengo and Mukankaulwa*) in the area. From these villages, five (*Kapamangoma, Chishiko, Kapuka, Maoma and Mukankaulwa*) of them were randomly selected to make up the sample frame. Later on, households within the five villages were sampled systematically by selecting every fifth household along a road, river or any prominent feature within the area. Cluster sampling was used because it is the most time-efficient and cost-efficient probability technique for large geographical areas such as Chalimbana ward (Taherdoost, 2016).

Additionally, purposive non-probability sampling was used to sample key informants of the study. This sampling technique entails that the researcher used his or her own judgement when selecting study participants (Black, 2010). Accordingly, this sampling technique was used to sample key informants from employees of energy institutions operating in the area, the local headmen, the area ward councillor and employees of Chongwe district municipal council. These key informants were selected on amount of their knowledge of the subject. This sampling technique was therefore used because the researcher believed that selecting the key informants purposively provided a representative sample to obtain the much-needed data

for study objectives. It was also used because it is also a cost-effective and time-effective sampling method (Saunders, Lewis and Thornhill, 2012).

4.5 Sample Size

The sample size for this study was made up of **175** households and **10** key informants from an energy institution operating in Chalimbana ward, the local headmen, the area ward councillor and employees of Chongwe district Municipal Council. With the total household population of Chalimbana ward standing at 1, 792 according to CSO (2010), a confidence level of 95%, and 5% margin of error, the study sample size was calculated using an online sample calculator with a formula stated below:

$$X = Z(c/100)^2 r(100-r)$$

$$N = \frac{N_x}{((N-1)E^2 + x)}$$

$$E = \text{Sqrt} \left[\frac{(N-n)x}{n(N-1)} \right]$$

Where, x is the sample size, E is the Margin of error, N is the population size, r is the fraction of responses that you are interested in, and $Z(c/100)$ is the critical value for the confidence level (Raosoft, 20004).

The formula used above entailed that 317 households were to be part of the sample size if the whole household population of Chalimbana award is considered at 95% confidence level. However, 317 was divided by 9 which means that 35 households were sampled from each village. From here, only 5 villages (clusters) randomly selected were part of this study.

4.6 Data Collection procedures and tools

Primary data collection methods that were used in this study are in-depth-interviews for qualitative data and a research survey for quantitative data. The data collection tools and how data were collected during the interviews and survey are as described in the next sub-sections.

4.6.1 Semi-Structured Interviews

During the In-depth-interviews, semi-structured interview guides attached in appendix two, three and four were used to collect data from key informants. The semi-structure interview guide provided a framework of themes to be explored in response to the study questions (Edwards and Holland, 2013). It was used because it allowed the researcher to bring up new

ideas as a result of what the key informants say. It enabled the key informants express their opinions and ask the researcher questions which encouraged them to provide more useful data.

4.6.2 Questionnaires

A questionnaire attached in appendix one was used to collect data from sampled households during the survey. A questionnaire is a data collection tool or research instrument which consists of a series of questions used to gather data from study participants (Young, 2016). Therefore, with standardized questions, questionnaires administered to the study participants were used to collect data from households in Chalimbana ward. This tool allowed for cost and time efficient collection, compilation and analysis of data using quantitative procedures.

4.7 Data Analysis

Quantitative data was analysed through descriptive statistics. The quantitative data was also analysed through multiple linear regression analysis in order to investigate how social economic factors influence expenditure on household energy consumption in Chalimbana ward. The study using multiple linear regression investigated on the social economic factors which influence amount spent on energy in a month.

The social economic factors which accordingly were the independent variables included: household head monthly income, household head number of years in school, number of household members, number of house rooms, gender of the household head and household head marital status. These were selected as they were assumed to be the most common basic social economic factors in the study areal. The dependent variable was average monthly amount spent (in Zambian kwacha) on all energy sources (ZESCO, solar, charcoal, firewood, biomass residues, petroleum products and cell batteries) used among Chalimbana ward households that took part in the study. The hypothesis was tested through the multiple linear regression analysis is as stated below:

Null Hypothesis: Social economic factors do not influence average monthly amount spent household energy consumption in Chalimbana ward

Alternative Hypothesis: At least one social economic factor influences average monthly amount spent on household energy consumption in Chalimbana ward.

Qualitative data collected through in-depth interviews was analysed through content analysis. The objective of this analysis method was to systematically transform a large number of texts as obtained from the interviews into a highly organised and concise summary of key results which are valid and reliable (Moretti *et al.*, 2011). The analysis was done from lower-levels abstraction (close to the text and manifest content) to the higher levels of abstraction (reflecting the interpreted, latent meaning of the text) (Christen and Petra, 2017).

This method entailed that all the data collected through in-depth interviews from the study key informants was analysed from lower level abstraction to high level of abstraction. This gave meaning and interpretation to the data that was provided by the key informants. The researcher was able to do this by identifying the presence of themes, or concepts within some given qualitative data provided through in-depth interviews which were designed to stimulate depth of meaning from the perspective of the participants. The questions administered during these interviews were made with reference to the study question. They hence in general sought to respond to the overall study aim which was to investigate the household energy conservation practices among Chalimbana ward. The dependent variables were household energy whereas conservation practices were the independent variables.

4.8 Ethical Considerations

As noted by Parveen and Showkat (2017), research ethics in this study were upheld to ensure that the researcher does what is morally and legally right in research. Therefore, the researcher first obtained approval from the University of Zambia Ethics Committee to carry out the study. The ethical approval obtained is attached in appendix five. After approval, other ethical considerations were also facilitated during the data collection process. Notably, informed consent was achieved by giving an introductory letter to respondents before data collection. The letter was used to seek permission from the study participants and also to explain that all data collected will be used for academic purposes only.

The researcher explained to the study participants that their participation in the study was voluntary, and they were free to withdraw at any point of the data collection process. The research did not involve any award of financial or material possessions to participants. This was done to ensure that any form of ambiguity is not attached to the study and answers given are not influenced by material award.

Confidentiality and anonymity were assured by not recording names of respondents on the data collection tools or elsewhere. The data collection tools were coded with numbers and all names for study participants were withheld to ensure that the shared information does not cause any harm on them, and they are free. In addition, the culture within the study area was respected through having respectful conversations and respectful body language during primary data collection.

CHAPTER FIVE: FINDINGS OF THE STUDY

5.1 Introduction

This chapter presents findings obtained from the field data collection of the study. The findings include the demographic characteristics of the study participants and the distribution of responses given in line with the study objectives.

5.2 Study Demographics

The study found that out of the 175 Chalimbana ward households that participated in the study, 69.7% of these households were headed by males and the remaining 30.3% are headed by females. When categorised according to the five villages of Chalimbana sampled for this study, it was still observed that males were the prominent household heads except for Chishiko village (51% male headed household and 49% for female headed households) which had a slight difference as shown in figure 2.

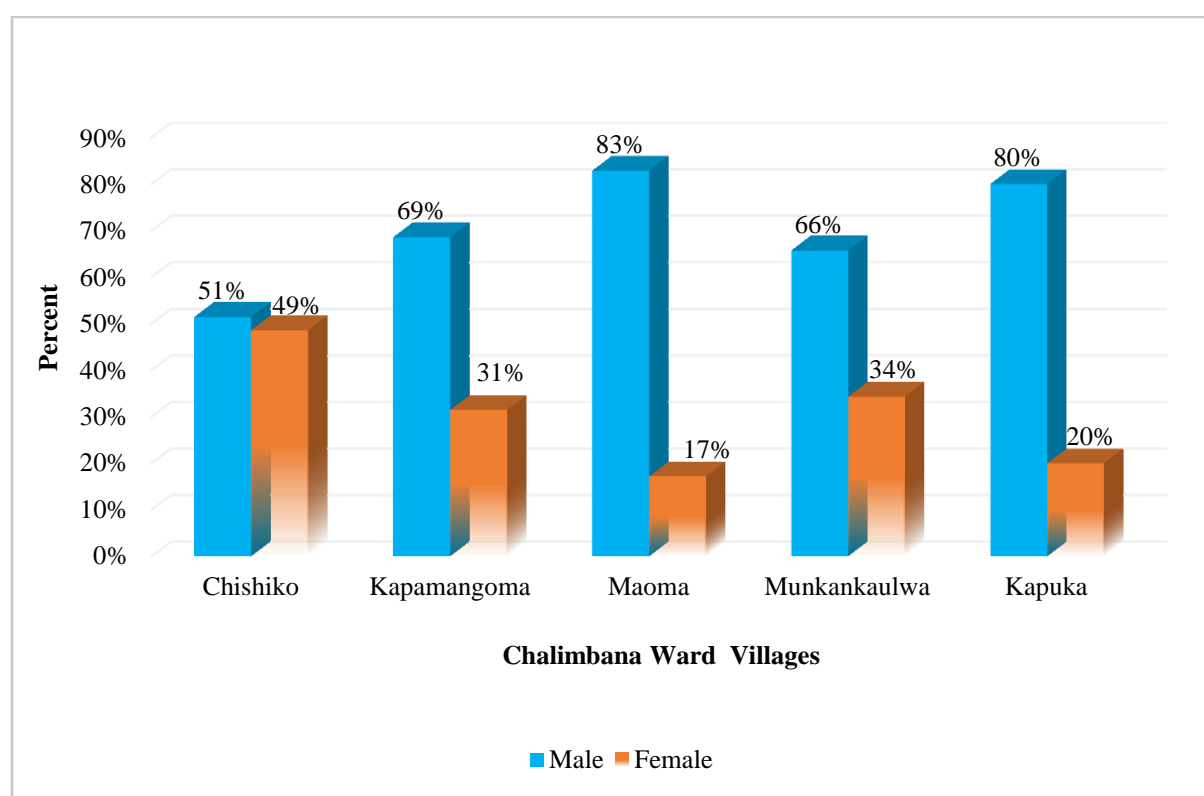


Figure 2: Sex Distribution of household heads in the sampled villages of Chalimbana ward.

Source: Field data

With regards to marital status, the study findings revealed that Chalimbana ward was dominated by household heads that were married (66.9%). The distribution for household head marital status is as shown in figure 3.

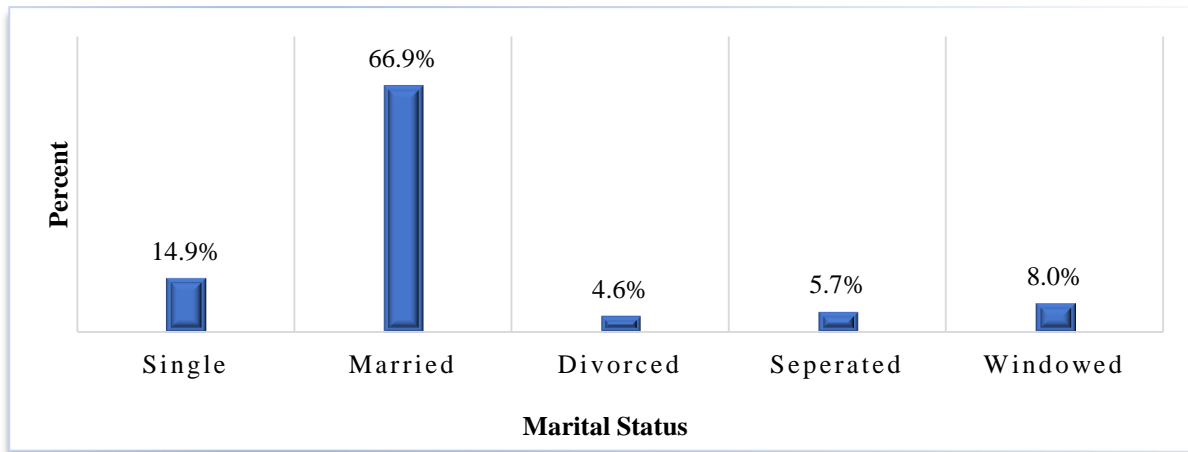


Figure 3: Household head marital status in Chalimbana ward.

Source: Field data

The study also found that Chalimbana ward was dominated by people in the informal sector of employment. This is because majority of the household heads involved in the study were subsistence farmers (33.7%) as agriculture is the main economic activity in the area. Other occupations such as general worker (15.4%), business personnel (12.0%), builder (5.7%) and carpenter (1.1%) which characterise the informal sector employment accounted for more than 60% of the household occupation distribution as shown in figure 4.

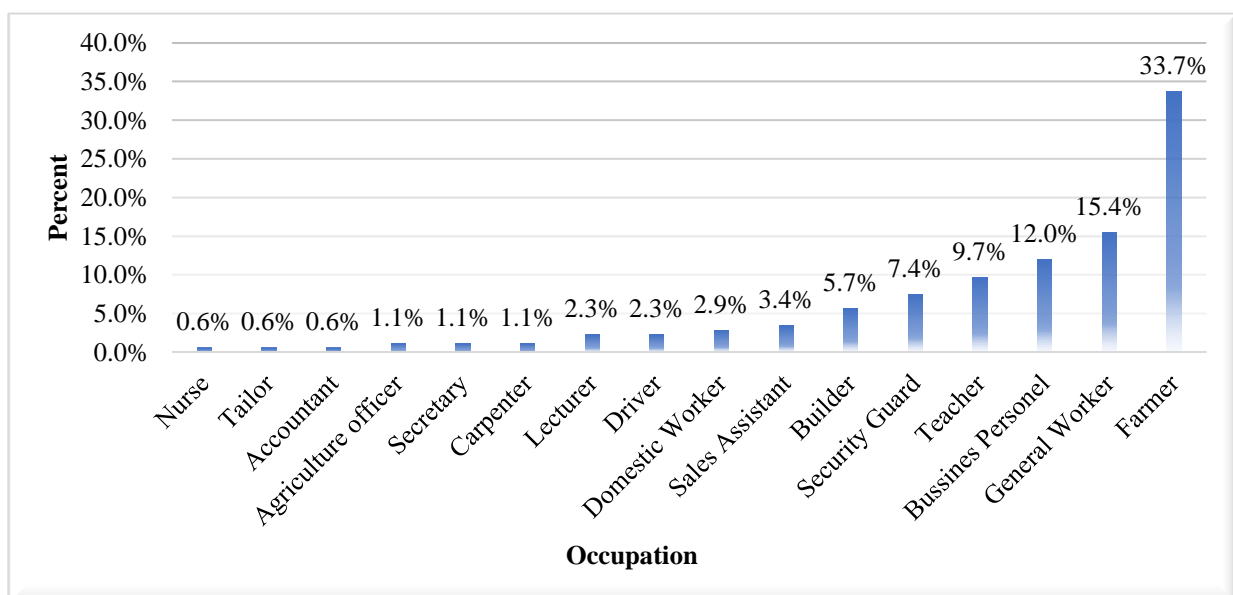


Figure 4: Distribution for household head occupation in Chalimbana ward

Source: Field data

The study found that most of the households in the study area had low-income earnings. The study area was also associated with low school progression rate as majority of the household head that took part in the study have not gone through tertiary education. Mostly, secondary school education level as measured through number of years of school was the highest education qualification obtained by the household heads of Chalimbana ward that took part in the study. Other social economic characteristics prevailing in Chalimbana ward according to the study participants are presented in Table 1.

Table 1: Descriptive statistics for the household social economic characteristics

Social Economic Factor	Minimum	Maximum	Mean	Std. Deviation
Average household monthly income (ZMW)	100	25,000	2,284.7	3,573.9
Number of rooms in the house	1	12	3.3	1.6
Age of household head (Years)	22	69	40.2	10.8
Number of household members	1	15	4.9	2.3
Number of household occupants aged between 0-7 years	0	5	1.1	0.8
Number of household occupants aged between 8-17 years	0	6	1.4	1.1
Number of household occupants aged between 18-35 years	0	4	0.9	0.9
Number of household occupants aged between 36-55years	0	2	0.3	0.5
Number of household occupants above 55 years	0	2	0.1	0.4
Household Head Years in Formal School	0	20	10.0	4.1
Number household members who have never been into formal education except the household head	0	5	1.4	1.0
Number of household members with primary education only except the household head	0	10	2.0	1.3
Number of household members with secondary education except the household head	0	5	1.2	1.1
Number household members with tertiary education except the household head	0	3	0.3	0.6

Source: Field data

5.3 Household Energy Technologies Used in Chalimbana

The study findings show that biomass in form of charcoal (28%) and firewood (24%) was the major source of energy among Chalimbana ward households. Some households used biomass residues mostly obtained from agriculture fields and petroleum products such as kerosene and diesel. A few of the households also used ZESCO electricity (15%), and less than 15% of the Chalimbana ward households used renewable energy accessed through solar. Figure 5 shows the distribution of used energy among the Chalimbana households involved in the study.

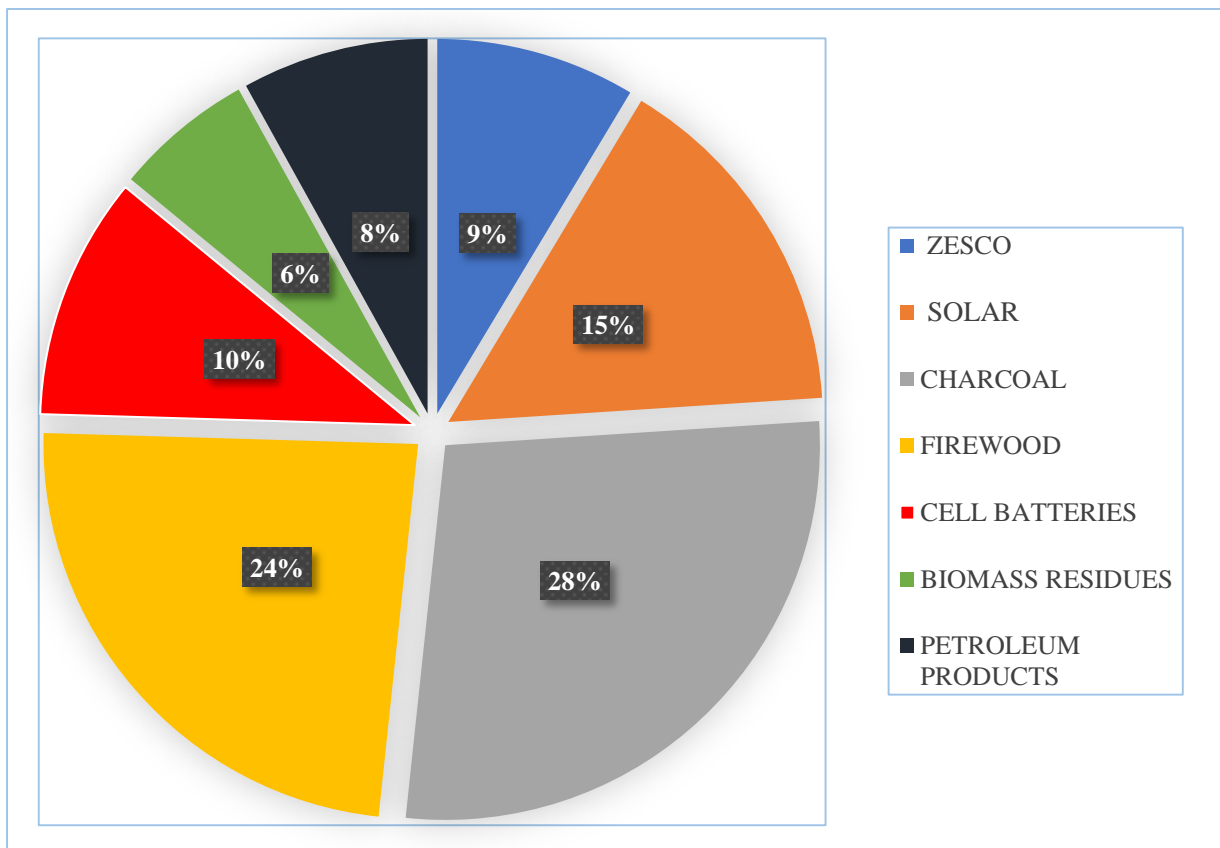


Figure 5: Percent distribution of most used energy among Chalimbana ward households.

Source: Field data

Table 2 shows percentage distribution of the energy presented in figure 5 according to the five villages that were sampled. The table shows how much each village accounts for the specific energy used as presented in figure 5.

Table 2: Distribution of energy used according to the sampled Chalimbana ward villages

Village Name	Energy Used						
	ZESCO	Solar	Charcoal	Firewood	Cell Batteries	Biomass Residues	Petroleum Products
Chishiko	71.7%	11.0%	22.3%	7.1%	1.8%	0%	9.3%
Kapamangoma	19.6%	18.2%	20.3%	19.9%	21.4%	9.4%	9.3%
Maoma	8.7%	22.0%	18.2%	21.3%	21.4%	21.9%	27.9%
Munkankaulwa	0%	25.6%	18.2%	26.8%	19.6%	62.5%	23.3%
Kapuka	0%	23.2%	20.9%	25.2%	35.7%	6.3%	30.2%
Total	100%	100%	100%	100%	100%	100%	100%

Source: Field data

To confirm the previously presented findings in figure 5 and table 2, the study also inquired about this through Key Informants (KI). The responses given by these key informants are presented in Table 3. The table presents what each of the study key informed perceived as the most used energy source and the reason to why the energy is mostly used.

Table 3: Energy used by Chalimbana ward households according to the study key informants

KI No.	Most Common Sources Energy Sources	Reasons For Behind Using the Energy Sources
1.	Charcoal	“Because it is affordable”
2.	Charcoal and firewood	“Charcoal is commonly used by Chalimbana households because it is affordable. The same applies to firewood which they can fetch without paying. The two are also commonly used because some houses are not connected to ZESCO electricity”
3.	Charcoal and firewood	They affordable for the Chalimbana households
4.	Charcoal, firewood and ZESCO electricity.	They are affordable and easy to access
5.	Charcoal, firewood and ZESCO electricity. Other also use solar and candles for	“The energy used in my opinion is dependent on the required purpose.”

KI No.	Most Common Sources Energy Sources	Reasons For Behind Using the Energy Sources
	lighting.	
6.	Charcoal	It is cheap
7.	Charcoal and firewood	They are the most common available sources of energy in the area
8.	Charcoal and firewood	Most houses in the area do not have ZESCO electricity
9.	Firewood	It is easy and cheap to find
10.	Charcoal and firewood	Because most of the households in Chalimbana cannot afford to connect their houses to ZESCO electricity

Source: Field data

The distribution of energy used in Chalimbana ward is also dependent on the household needs or required purpose. According to the study findings, biomass in form of charcoal (42.6%) and firewood (37.4) was the major source of energy used for cooking in Chalimbana ward. Some of the few households connected to ZESCO grid (9.7%) also depended on electricity to meet their cooking needs. Additionally, the households utilized Improved Cooking Stove (ICS) technologies powered by biomass residues (9.7%) obtained from agriculture fields and the general surrounding environment. A few of the households in Chalimbana ward had cooking technologies or appliances that involve the use of petroleum products (0.6%). Table 4 shows how the study participants responded when asked on the energy used for cooking.

Table 4: Distribution of energy used for cooking among Chalimbana ward households

Energy Sources	Responses	
	Number of Households (N)	Percent
ZESCO	33	9.7%
Charcoal	145	42.6%
Firewood	127	37.4%
Biomass Residues	33	9.7%
Petroleum Products	2	0.6%
Total	340	100.0%

Source: Field data

With regards to household lighting, the study findings reveal that renewable energy accessed through solar powered lighting technologies (36.4%) was dominant among the households of Chalimbana ward. Additionally, ZESCO, petroleum products and cell battery powered lighting devices were also used among Chalimbana households as shown in Table 5.

Table 5: Distribution of energy used for lighting purposes among Chalimbana ward households

Energy Sources	Responses	
	N	Percent
ZESCO	46	20.0%
Solar energy	76	36.4%
Cell Batteries	44	21.1%
Petroleum Products	43	20.6%
Total	209	100.0%

Source: Field data

Availability of entertainment devices such as Televisions (TV), radio or sound systems also define the energy technologies used in Chalimbana ward. In this regard, the study findings revealed that ZESCO electricity (45 households), home generated solar (31 households) and cell batteries (27 households) energy were used for entertainment purposes among Chalimbana households that took part in the study. The percentage distribution of the most used energy sources for entertainment purposes is as shown in figure 6.

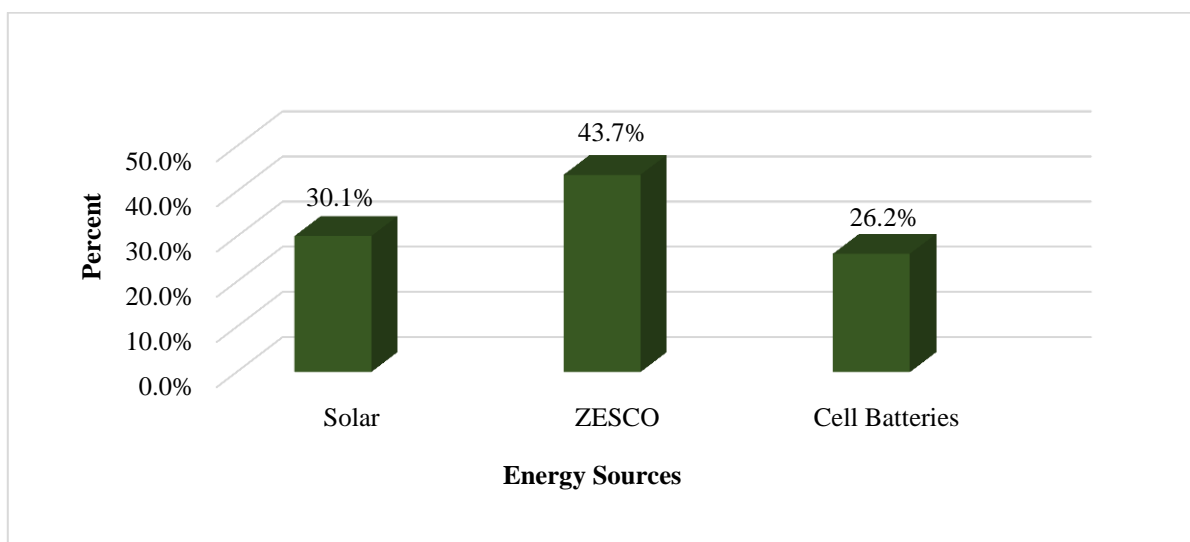


Figure 6: Percent distribution of household energy used for entertainment devices in Chalimbana ward

Source: Field data

In terms of laundry, the study findings show that only ZESCO (38 households) and charcoal (35 households) energy were used for this purpose in Chalimbana ward among the study participants. Charcoal was used for ironing cloths were as ZESCO was used for ironing and washing cloths among other laundry purposes. See figure 7 for the Percent distribution.

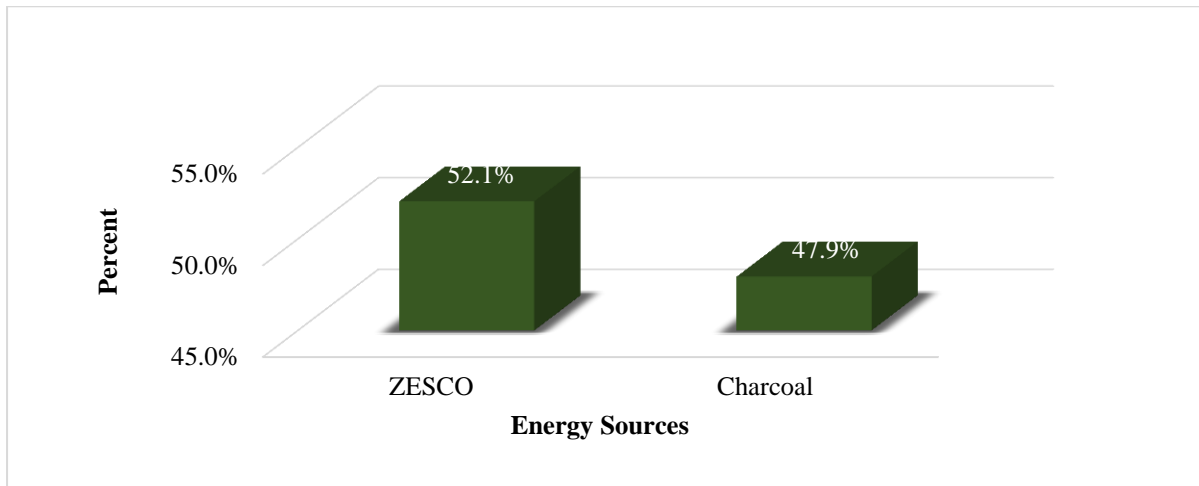


Figure 7: Percent distribution of energy used for household laundry appliances in Chalimbana ward.

Source: Field data

When it comes to refrigeration, the study found that households with refrigeration appliances in Chalimbana ward used ZESCO (41 households) and solar energy (4 households) to power these appliances. Figure 8 shows the Percent distribution for these findings.

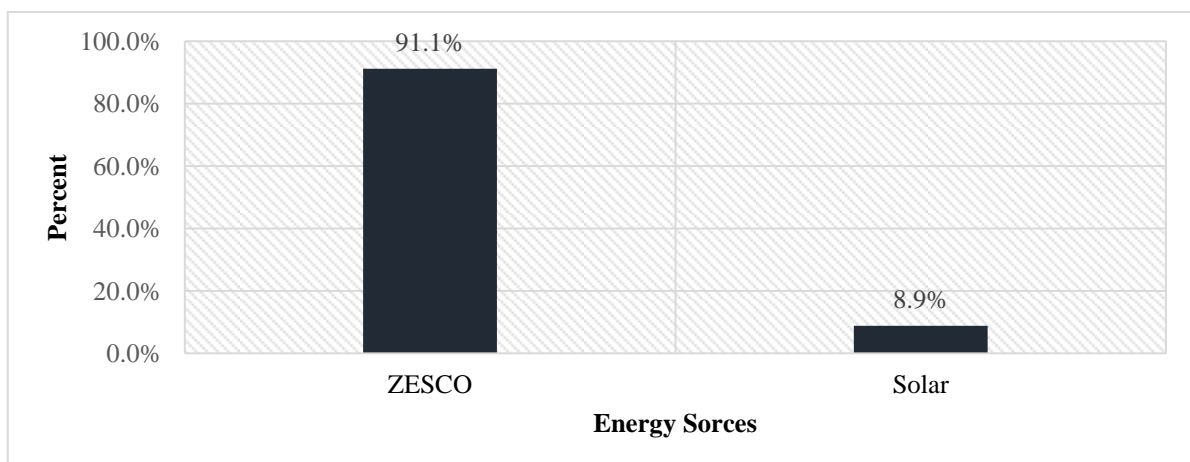


Figure 8: Distribution of energy used to power household refrigeration appliances in Chalimbana ward

Source: Field data

In terms of household cleaning, the study findings show that only 5.7% (10) households that participated in the study used ZESCO electricity energy for cleaning purposes. With regards to household temperature control, households of Chalimbana ward noted that they only use ZESCO (21 households) and charcoal (4 households) for temperature control purposes. ZESCO is used for cooling and heating purposes among the households with appliances such as a fan, heater and air condition system. Figure 9 shows the Percent distribution of energy that was used for temperature control among the Chalimbana households

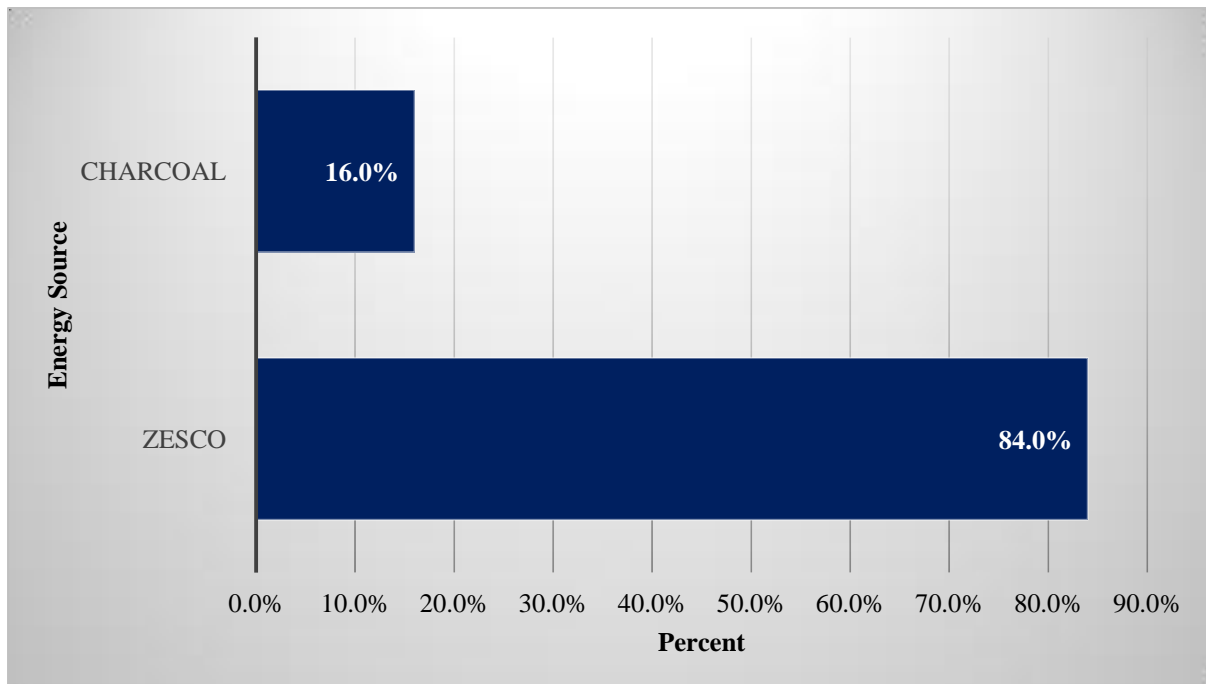


Figure 9: Distribution energy used for household temperature control in Chalimbana ward

Source: Field data

Table 6 shows the distribution of energy that was used to charge or power communication devices in Chalimbana ward according to the study participants.

Table 6: Energy used to power or charge household communication devices in Chalimbana ward

Energy Source	Responses	
	N	Percent
ZESCO	46	47.4%
Solar	51	52.6%
Total	97	100.0%

Source: Field data

5.4 Energy Consumption Patterns Among Households of Chalimbana

Table 7 shows the estimated monthly amount spent on different energy sources used among Chalimbana ward households. The estimates in table 7 are based on households that were using each specified energy source. The listed energy sources apply only to those for which the households in the ward were spending on in order to access or use.

Table 7: Estimated amount spent on energy consumption in a month for specific Chalimbana ward households

Energy Sources	No. Of Households	Minimum (ZMW)	Maximum (ZMW)	Sum (ZMW)	Mean (ZMW)	Std. Deviation
Firewood	127	0	80	270	2.1	12.0
Petroleum Production	43	10	100	1050	24.4	14.2
Cell Batteries	56	10	80	1275	22.8	13.5
ZESCO	46	50	650	9860	214.3	119.0
Charcoal	148	0	500	15653	105.8	81.1

Source: Field data

With reference to all sampled households, the estimated amount spent on energy consumption is as shown in Table 8

Table 8: Estimated amount spent on energy consumption in a month among for all sampled Chalimbana ward households

Energy Sources	No. Of Households	Minimum (ZMW)	Maximum (ZMW)	Sum (ZMW)	Mean (ZMW)	Std. Deviation
Firewood	175	0	80	270	1.54	10.27
Petroleum Production	175	0	100	1050	6.0	12.7
Cell Batteries	175	0	80	1275	7.3	13.1
ZESCO	175	0	650	9860	56.34	112.32
Charcoal	175	0	500	15653	89.45	83.79

Source: Field data

5.4.1 Social Economic Factors Influencing Household Expenditure on Energy in Chalimbana ward

With respect to the amount spent on household energy in Chalimbana ward, the study using multiple linear regression investigated on the social economic factors which influence amount spent on energy in a month. The study investigated the influence of social economic factors (household head monthly income, household head number of years in school, number of household members, number of house rooms, gender of the household head and household head marital status) on average monthly amount spent (in Zambian kwacha) on all energy sources (ZESCO, solar, charcoal, firewood, biomass residues, petroleum products and cell batteries) used among Chalimbana ward households that took part in the study.

The findings of this analysis are presented in the next segments.

Regression Hypothesis

Null Hypothesis: Social economic factors do not influence average monthly amount spent household energy consumption in Chalimbana ward.

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$$

Alternative Hypothesis: At least one social economic factor influences average monthly amount spent on household energy consumption in Chalimbana ward.

H_1 : At least one β_i is not equal to 0, where i = six social economic factors given below:

β_1 is Household Monthly Income

β_2 is Household Head Years in Formal Education

β_3 is Number of Household Members

β_4 is the Number of Rooms in the House

β_5 is the Household Head Gender

β_6 is the Household Head Marital Status

Multiple Regression Analysis Output

Table 9 for the analysis of variance shows that *F-value* is 37.45 and *P-value* 0.000 for the regression. Here the *p-value* (0.000) is less than given level of significance (0.05). Other output results for the Analysis of Variance or ANOVA are as shown in table 9.

Table 9: Analysis of variance

<i>Source</i>	<i>DF</i>	<i>Adj SS</i>	<i>Adj MS</i>	<i>F-Value</i>	<i>P-Value</i>
<i>Regression</i>	6	54785.8	9130.97	37.45	0.000
<i>Household head monthly income</i>	1	2132.4	2132.39	8.74	0.004
<i>Household head years in formal education</i>	1	1540.1	1540.05	6.32	0.013
<i>Number of household members</i>	1	0.7	0.67	0.00	0.958
<i>Number of rooms in the house</i>	1	7865.3	7865.28	32.25	0.000
<i>Household head gender</i>	1	1116.7	1116.65	4.58	0.034
<i>Household Head marital status</i>	1	23.3	23.27	0.10	0.758
<i>Error</i>	168	40966.8	243.65		
<i>Lack-of-Fit</i>	158	40881.7	258.75	30.43	0.000
<i>Pure Error</i>	10	85.0	8.50		
<i>Total</i>	174	95752.6			

Source: Field data

Table 10 shows that the coefficient of determination is *R-Squared* is 55.22%. This means that 55.22% of the total variation monthly household expenditure on energy consumption is explained by the variation in the six independent variables whereas 44.78 % remains unexplained.

Table 10 also shows that, the coefficient of determination is *R-Squared (adjusted)* is 55.69%. This indicates that no matter how we measure the coefficient of determination, the models fit are good.

Table 10: Model summary

<i>S</i>	<i>R-sq</i>	<i>R-sq (adj)</i>	<i>R-sq (pred)</i>
15.6157	57.22%	55.69%	50.61%

Source: Field data

Table 11 shows the analysis output for the coefficients. The intercept coefficient (-8.44) indicates that the average monthly household expenditure on energy consumption in Chalimbana ward when all the independent variables are zero. The positive coefficients for independent variables shown in Table 11 indicate that an enhancement in each of these social economic factor results to increased average monthly expenditure (i.e in Zambian kwacha) on household energy consumption in Chalimbana ward. The coefficient for categorical variable Male (-6.73) indicates that shift from a female headed household to a male headed household will decrease expenditure on household energy consumption by ZMW-6.73.

Table 11: Coefficients

<i>Term</i>	<i>Coef</i>	<i>SE Coef</i>	<i>T-Value</i>	<i>P-Value</i>	<i>VIF</i>
Constant	-8.44	5.43	-1.56	0.122	
Household head monthly income	0.001543	0.000522	2.96	0.004	2.48
Household head years in formal education	0.947	0.377	2.51	0.013	1.74
Number of household members	0.033	0.633	0.05	0.958	1.47
Number of rooms in the house	6.81	1.20	5.68	0.000	2.47
Household head gender					
Male	-6.57	3.07	-2.14	0.034	1.43
Household head marital status					
Not married	1.03	3.35	0.31	0.758	1.60

Source: Field data

Table 12 shows the regression equation for the multiple liner regression model that was used for this investigation.

Table 12: Regression equation

Average amount spent on all energy used among households of Chalimbana ward	$ \begin{aligned} & -8.44 + 0.001543 \text{ Household Head Monthly Income} \\ & + 0.947 \text{ Household Head Years in Formal} \\ & + 0.033 \text{ Number of Household Members} \\ & + 6.1 \text{ Number of Rooms in the House} \\ & + 0.0 \text{ Gender_Female} - 6.57 \text{ Gender_Male} \\ & + 0.0 \text{ Marital Status_Married} + 1.03 \text{ Marital Status_Not} \\ & \text{Married} \end{aligned} $
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Source: Field data

5.4.2 Energy Conservation Methods among Chalimbana Households

Table 13 shows the distribution energy conservation methods that were used among households of Chalimbana ward according to the study participants. Table 13 shows that Switching or putting off unused energy appliances or sources (70.1%) was the most used method of conserving household energy among the study participants. This distribution of the other two methods are shown in table 13

Table 13: Chalimbana ward household energy conservation methods

Conservation methods	Responses	
	N	Percent
Not using many household appliances or sources at once	5	3.0%
Switch or put off unused energy appliances or sources	117	70.1%
Substitute one energy source for another depending on the required purpose	45	26.9%
Total	167	100.0%

Source: Field data

Table 14 shows the reasons for why households of Chalimbana ward conserved energy according to the study participants. According to the table reducing household expenditure (55.9%) is the most common reason of why the study participants conserved energy.

Table 14: Suggested reasons for household energy conservation in Chalimbana ward

Conservation methods	Responses	
	N	Percent
Reduce household expenditure on energy	85	55.9%
Conserve available energy resources	63	41.4%
Protect the environment	4	2.6%
Total	152	100.0%

Source: Field data

Table 15 shows the responses that were given by all the study key informants when asked about energy conservation methods used by households in Chalimbana ward and the factors which influence household energy conservation.

Table 15: Energy conservation methods and factors influencing the household energy conservation in Chalimbana ward according to the study key informants

KI NO	Are the households in Chalimbana practicing any energy conservation methods? If any, name them.	Factors which influence household energy conservation
1	“Yes, some have switched to use of Lighting Emitting Diode (LED) lights from ordinary incandescent lights”	The motive is to reduce household expenditure on energy
2	Some do practice energy conservation but this is not done by the majority in my own opinion. Some of the methods used to conserve include use of energy efficient appliances such as LED lights and switching off unused household appliances	“Energy conservation is usually influenced by household social economic factors such as monthly earnings of the household head or available of financial resources to purchase household energy.”
3	“Yes, by putting off firewood or charcoal after use”	Reducing expenditure on energy
4	Yes, by switching off electricity appliances when not in use.	Save household income
5	Yes, some by switching off some electricity appliances	Reducing expenditure on energy
6	Yes, some switch off electricity appliances not in use.	No stated
7	Some switch off unused energy appliances. Other substitute energy to be used in the house depending on the required purpose. For example, the household will use charcoal to cook food such as beans instead of using ZESCO electricity. This is done to save the ZESCO power because beans takes a lot of time to be cooked.”	Reducing household expenditure on energy
8	“Yes, we are also using ICS provided by an NGO which are efficient and do not require much biomass. For them we use agriculture residues.”	Reducing household expenditure on energy
9	“Yes, by putting off fire after cooking”	To reduce workload of fetching for firewood when it finishes as well as save money for buying charcoal
10	Was not sure	NA

Source: Field data

The study also investigated on household energy conservation in Chalimbana ward through use of efficient and non-efficient energy. However, only households with ZESCO electricity took part in this investigation as shown in figure 10 and 11.

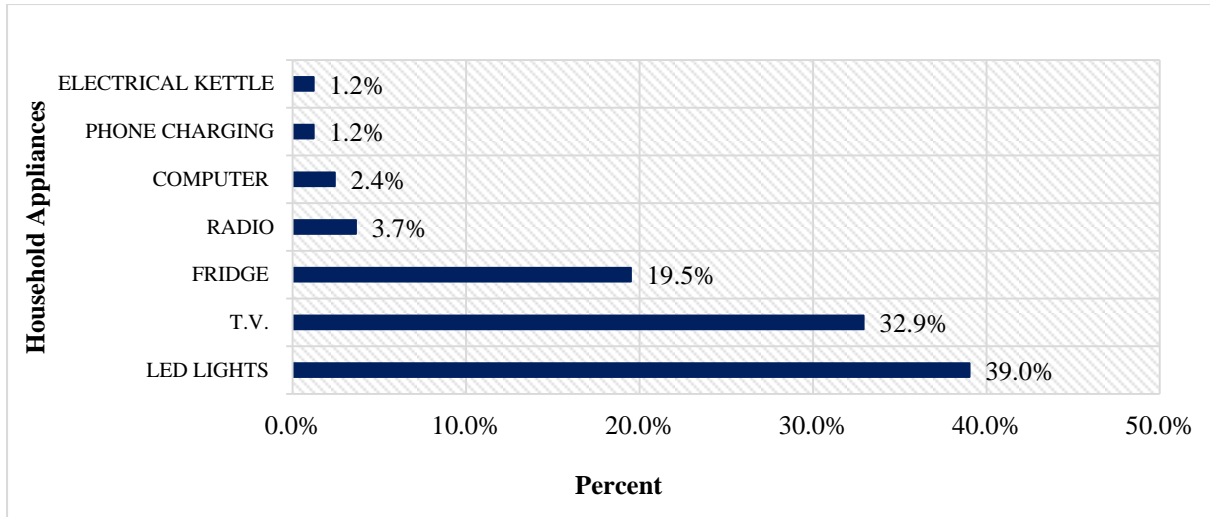


Figure 10: Perceived energy efficient household appliance for ZESCO electricity users in Chalimbana ward
Source: Field data

Figure 11 shows the distribution of the perceived high energy consumer appliances among the study participants who had access to ZESCO electricity.

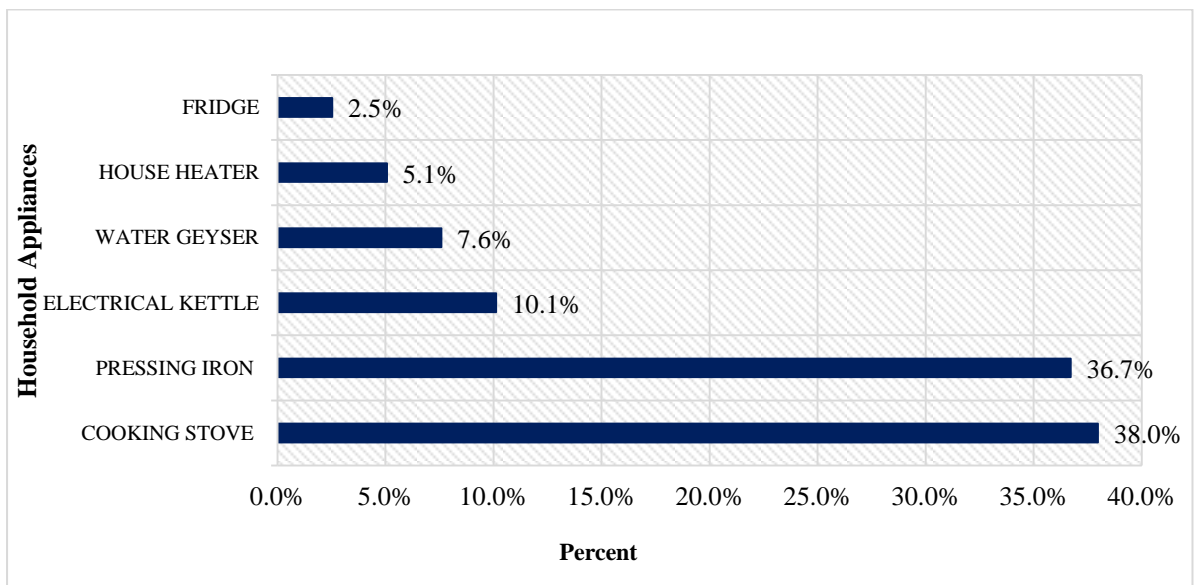


Figure 11: High energy consumer household appliances among ZESCO electricity users of Chalimbana ward.
Source: Field data

5.5 Perceived Environmental Implications of the Energy Consumptions Patterns Among Households of Chalimbana Ward

Figure 12 shows how the households that participated in the study responded when asked if the specific energy type shown in the figure 12 has adverse environmental implications.

The responses given were categorised as “No”, “Yes” and “I do not know” as shown figure 12.

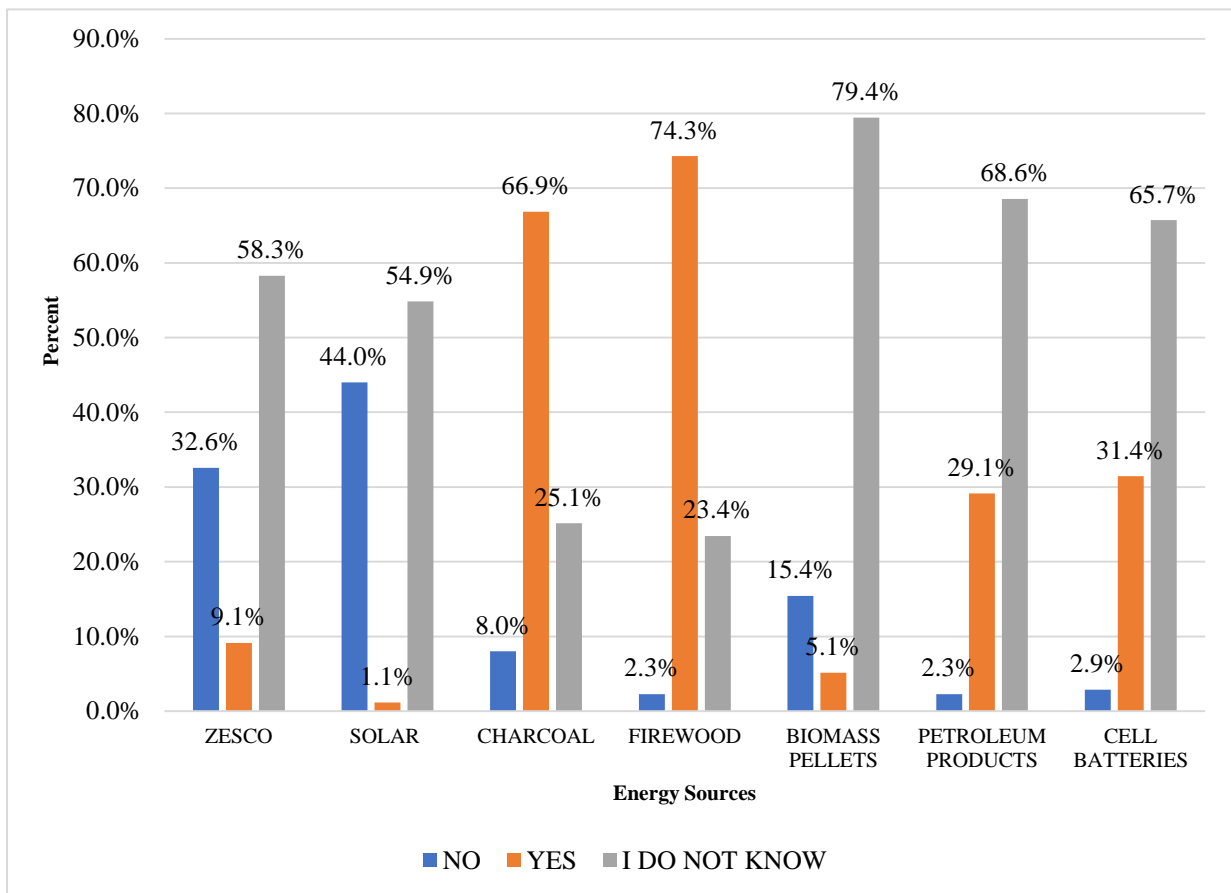


Figure 12: Does household energy have any adverse environmental implications?

Source: Field data

With respect to the participants who answered that “Yes” different house energy consumption patterns have various adverse environmental implications as shown in figure 12, distribution of the perceived adverse environmental impacts are shown in table 16.

Table 16: Distribution suggested adverse environmental implications of household energy by households of Chalimbana ward

Environmental Impacts	Energy Sources							Total
	Firewood	Charcoal	Petroleum Products	ZESCO	Biomass Residues	Cell Batteries	Solar	
Deforestation	50.8%	47.6%	0.0%	1.6%	0.0%	0.0%	0.0%	100%
Air Pollution	42.5%	16.9%	34.5%	0.0%	6.1%	0.0%	0.0%	100%
Soil Erosion	87.5%	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
Habitat Loss	25.0%	25.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100%
Weather patterns Alteration	50.0%	46.2%	0.0%	3.8%	0.0%	0.0%	0.0%	100%
Exposure to Hazardous Materials	0.0%	0.0%	0.0%	0.0%	0.0%	96.5%	3.5%	100%
Land Use Change	11.1%	0.0%	0.0%	88.9%	0.0%	0.0%	0.0%	100%
Loss of Aquatic Life	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100%
Groundwater contamination	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100%

Source: Field data

Responses given by the study key informants when asked if the energy used and consumption patterns among Chalimbana ward households have environmental implications are as shown in table 17.

Table 17: Environmental implications of energy used and consumption patterns among Chalimbana ward household according to the key informants

KII NO.	Do you feel the energy used and consumption patterns among Chalimbana ward household have any environmental implications and give a reason?
1	“Yes, the high use of charcoal among the households is responsible for the high deforestation rates in Chongwe”
2	“The use of charcoal and firewood to meet household energy needs causes deforestation which alternatively is responsible for climate change and other adverse environmental impacts.”
3	Use of firewood in homes of Chalimbana causes emission of harmful gasses which are responsible for climate change. The high dependence on firewood and charcoal also causes deforestation which in turn also negatively affects the environment by disturbing the rain cycle, it causes soil erosion and climate change
4	“Yes, usage of charcoal and firewood affects the rainfall patterns.”
5	High electricity energy demand in households and other sectors in the country as witnessed previous years caused ZESCO to load shed its customers because it did not have the capacity to meet the required demand. The energy deficits in this period were aligned to climate change as the company is highly dependent on Hydro Electricity Power (HEP). Therefore, if we do utilize energy wisely and invest into renewable energy, we may face another energy deficit. This is because energy generation is dependent on the environmental resources which should be used sustainably to curb or mitigate any negative environmental impacts that result from energy use
6	“The use of charcoal and firewood among Chalimbana households is responsible for climate change due to the cutting down of trees and emission of GHGs. The practice of cutting down trees also causes land degradation through soil erosion.”
7	The use of charcoal and firewood to meet household energy needs causes climate change
8	Cutting down of trees for firewood and charcoal causes deforestation
9	Cutting down trees for charcoal and firewood affects the rainfall patterns
10	“I am not sure”

Source: Field data

CHAPTER SIX: DISCUSSION OF FINDINGS

6.1 Introduction

This chapter presents a discussion of findings. The discussion is made with reference to the study objectives and available literature on the study topic.

6.2 Household Energy Technologies Used in Chalimbana Ward

Household Energy sources and forms in Chalimbana ward

Zambia's energy sources include electricity, petroleum, coal, biomass, and renewable energy such as solar (Makashini *et al*, 2014). In this study, energy sources and household energy appliances were used to determine the energy technologies used among Chalimbana ward households. The study found that more than 90% of the households in Chalimbana ward were not connected to the national ZESCO electricity grid. Some of the households depended on energy from petroleum products, solar, cell batteries and biomass residues. However, most of the households in the ward depended on traditional biomass (Charcoal and firewood) which accounts for more than 50% for their energy needs. These study findings are coherent with the study by Mudenda *et al* (2018) who note that Zambia is undersupplied with renewable energy with the majority of households still reliant on traditional biomass from charcoal and firewood. This traditional biomass energy accounts for more than 70% of total local energy requirements (MoE, 2019 and IEA, 2020).

According to Surendra (2011), renewable energy technological services are unaffordable to the majority of the poor in rural and peri-urban areas of developing countries. Chalimbana ward being a rural area has households inclined to high use of charcoal and firewood with a few accessing renewable energy provided through ZESCO electricity or home generated solar energy. The high dependence of biomass energy according to the study key informants is mainly because it is affordable and easily accessed by households of Chalimbana ward. Baltruszewicz *et al*. (2021) supplements these findings by noting that the reliance on inefficient biomass energy is necessitated in the low-income earning households of Zambia because it comes free (as collected firewood), or is inexpensive compared to other household energy sources.

Energy Used According to Household Purpose in Chalimbana ward

Charcoal, firewood, biomass residues and ZESCO electricity are the only forms of energy are used for cooking in Chalimbana ward according to the study participants. Yet again, biomass in form of firewood and charcoal accounts for the largest share (80%) of energy that was used of cooking in this area. These findings are similar to findings obtained in other parts of Zambia from available literature done by CSO (2016) who note that since the 1960s to date, the three main cooking fuels in Zambia are firewood, charcoal and electricity.

The study findings show that an efficient biomass cooking energy technology is also used among Chalimbana ward households. This cooking technology involves burning of biomass residues or pellets using Improved Cooking Stoves (ICS) shown in figure 13. The stoves are used for cooking needs as they believed to be more energy efficient than use of traditional charcoal or traditional firewood stoves. The stoves use biomass residues obtained from agriculture fields and the general environment. Historically, use of ICS has been tested and disseminated in Zambia since the 1970s. In 2010, the combination of sawdust pellets and micro gasifying cook stoves was however first successfully marketed. Several organisations since then have been trying to market this technology to low-income households, claiming environmental, health and financial benefits upon adoption (Peša, 2017).



Figure 13: Improved biomass cooking stove used among Chalimbana households

Source: Field data

Despite cooking, lighting is another household need that was used to define the energy technologies used among the households of Chalimbana ward. At a national level, Malama *et al* (2015) notes that the key sources of energy used for lighting in Zambia include electricity, candles, diesel, open fires, solar panels, and torches. In Chalimbana ward, it was found that energy sources used for lighting purposes includes solar, ZESCO electricity, cell batteries and petroleum products in form of kerosene, diesel and candles. Among these, solar energy is the most used. This is owed to lack of ZESCO electricity connection among most of the households. Furthermore, the high use of solar lighting appliances in the Chalimbana ward is also be attributed to its affordability and efficiency when compared to other energy sources such as cell batteries and petroleum products.

Though not categorised as basic household needs like cooking and lighting, the study findings also reveal that entertainment, laundry, cleaning temperature control and communication purposes were also used to determine the energy technologies used among Chalimbana households. In these regards, it was found majority of the households with appliances that save the previously listed purposes are connected to ZESCO followed by those with home generated solar panels. This indicator entails that majority of the households in Chalimbana do not have entertainment, laundry, cleaning and temperature control energy technologies.

6.3 Energy Consumption Patterns Among Households of Chalimbana

Household Expenditure on Energy Consumption in Chalimbana ward

The energy consumptions patterns among households of Chalimbana ward for this study was measured with reference to the amount spent in Zambian kwacha on each energy source. In this regard, the study findings show that households with ZESCO electricity averagely spend more on energy followed by those using Charcoal. However, average expenditure on Charcoal energy when calculated with reference to all the 175 household is the highest when compared to other energy forms used in Chalimbana ward. Limited access to electricity accompanied by other social economic factors, are among the main factors influencing high charcoal energy consumption in Chalimbana ward. Similar to these findings, Dlamini *et al.* (2016) notes the inadequate and erratic supply of electric power in Zambia makes charcoal the main energy source among households.

Factors influencing Expenditure on Household Energy Consumption

According to available literature, a number of factors influence household energy consumption patterns. Notably, Zaharia *et al.* (2019) argues that there is a causal link between energy consumption and economic growth as an increment in the later will have an influence in energy demand. In this study, the tested hypothesis is through multiple linear regression analysis concludes that at least one of the social economic factors influences average monthly amount spent on household energy consumption in Chalimbana ward. The positive coefficients for household head monthly income (+0.001543), household head years in formal education (+0.947), number of household members (+0.033) and number of rooms in the house (+6.81) all indicate that an enhancement in each of these social economic factor results to increased average monthly expenditure (*i.e in Zambian kwacha*) on household energy consumption in Chalimbana ward. They are hence all significant factors in influencing household average monthly expenditure on energy consumption, with number of rooms been the most significant factor.

The study findings from the regression analysis are consistent with Mutua and Kimuyu (2015) who revealed that variables such as the household head's gender and occupational and educational attainment, as well as household location and size, are key determinants of not only the propensity to conserve energy but also levels of actual energy savings. Similarly, the study findings show that gender and marital status have an influence on household energy consumption expenditure in Chalimbana ward. Here, the coefficient for Male (-6.73) indicates that shift from a female headed household to a male headed household will decrease expenditure on household energy consumption by ZMW-6.73. Accordingly, the coefficient Not Married (+0.91) indicates that a shift from a household with a head that is married to one that is not married will increase expenditure on household energy by ZMW +0.91. The influence of these factors may arguably also be aligned to other existing social economic factors among Chalimbana ward households.

Chalimbana ward Household Energy Conservation Methods

The study findings show that 'not using many household energy appliances at the same time', 'switching off or putting off unused household energy appliances or sources' and 'substituting one energy source for another depending on the energy requirement purpose' are some of the methods used to conserve energy among households of Chalimbana ward. Among these,

switch off or put off method is the most commonly as it is used by more than half of the study participants. These findings confirm and validate the social practice theory by showing routinized type of practices for energy conservation among households of Chalimbana ward (Higginson *et al.* (2014).

The major reason for striving to conserve energy in any form among households of Chalimbana ward is to reduce household expenditure on energy. This as such questions if the practice of energy conservation would be upheld if the economic situation of Chalimbana ward households is positively enhanced. It also questions if energy conservation in the study area is being used as a tool for promoting steady energy supply at household level while meeting the global concerns over energy induced environmental issues as noted by Quedrago (2017). This is because only less than 2% of the study participants mentioned protecting the environment as a reason for conserving household energy.

Household Energy Efficient Appliances

The study findings on available energy efficient appliances in households connected with ZESCO electricity show that stoves and pressing irons are perceived as the most common high energy consumers in Chalimbana ward. Other perceived energy consumer household appliances include water geyser, electrical kettle, house heater and fridge. On the other hand, saving lights, TV, fridge, radio, computer, phones and electrical kettles are perceived to be energy efficient according to the study participants. Having fridges and electrical kettles on both side of energy efficient and high energy consumer appliances brings in the need to understand the energy literacy levels among householders of Chalimbana ward. Used here, an energy literate person can be someone who knows the energy consumption of their domestic appliances, knows with what actions they can save energy in their home, knows how to make economic energy efficient decisions or knows about the relation between energy use and climate change (Van den Broek, 2019).

Based on the given description given for energy literacy, it can be argued that the energy literacy level of Chalimbana ward assessed through what they consider as non-effective and efficient household energy appliances remains inconclusive. This is because an individual can be energy literate according to one definition of energy literacy, but not according to a different conceptualisation of energy literacy (Van den Broek and Walker, 2019). However, availability of energy efficient appliances such as energy saving lights in the household of Chalimbana also shows efforts to consume less energy. Accordingly, the availability of high

energy consumer appliances in the household also signifies presence of high energy consumption patterns in selected households of Chalimbana.

6.4 Perceived Environmental Implications of Consumed Household Energy

According to Zhao *et al.* (2012), energy is the essential material basis for economic and social development. However, energy consumption if not sustainably utilised leads to a serious threat of climate change, environmental pollution and human health. According to the study participants, household biomass energy from firewood and charcoal is perceived cause air pollution, weather alterations, deforestation, habitat loss and soil erosion. WHO (2018), supports these perception by noting that air pollution resulting from burning biomass in form of charcoal and firewood causes risk to households' health by creating levels of air pollution greater than those allowed by international ambient air quality standards.

Zidago and Wang (2016) notes that burning of charcoal and firewood causes air pollution by emitting gases such as Carbon Monoxide (CO), Carbon dioxide (CO₂), nitrogen oxides (NO_x expressed as NO₂), Methane CH₄ and particulate matter, with pollution levels dependent upon the biomass type, combustion processes, and the scale of biomass burning activity. Similarly, the study found that air pollution from energy sources is also dependent on the combustion technology used among other factors. This is because the study shows that when compared to charcoal and firewood, use of Improved Cooking Stoves (ICS) to burn biomass residues is perceived to cause lesser air pollution according to the study participants.

Petroleum products used for household energy according to the study participants equally cause air pollution. According to Marquès *et al.* (2020), air pollution from petroleum products are responsible induced anthropogenic climate change, human respiratory illness and Ozone layer depletion. Therefore, the use of petroleum products for household energy needs in Chalimbana can be validated to have adverse environmental implications.

ZESCO electricity assessed from the source, infrastructure points or at the time of constructing electricity energy generation plants is believed to cause habitat loss or modification in various localised areas according to the study findings. ZESCO energy was also mentioned to be responsible for loss of aquatic life according to the study respondents. However, this may differ depending on the type of energy source been used by ZESCO. With reference to Hydro Electricity Power Plant (HEP), Zelenakova *et al.* (2018) argues that

negative environmental impacts of HEP would only be possible if impact mitigation measures are not effectively implemented.

In a similar view to the study findings which show that charcoal and firewood energy is perceived to be responsible for habitat loss, Dlamini *et al.* (2016) notes that the act of cutting down trees to meet the household energy needs provided through charcoal and firewood causes losses of niches for various ecological species. Furthermore, deforestation driven by the demand for charcoal and firewood is also responsible for weather alterations, soil erosion and land use change according to the study findings. Deforestation is interlinked to these effects as the practice of unsustainable cutting of trees has a contagious effect on the environment (Kasaro *et al.*, 2019). It is therefore important that the households of Chalimbana ward switch to use of renewable energy such as solar energy. Solar energy according to few of the study participants is only believed to be responsible for exposure to hazardous waste because of the electronic waste generated for solar energy devices or components. However, through effective waste management practices such as recycling, this challenge would be curbed. Exposure to hazardous material through household energy use in Chalimbana ward is mainly caused by cell batteries according to the study participants.

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter presents conclusions and recommendations based on the findings of this study. The conclusions are given with reference to each of the study objectives and thereafter a general conclusion of study is given.

7.2 Conclusion

Most households in Chalimbana ward depend on traditional biomass energy (Charcoal and firewood). Other energy sources and forms used among these households include ZESCO electricity, petroleum products, solar, cell batteries and biomass agriculture residues. Despite affordability, the high reliance on traditional biomass in Chalimbana ward is also because the area is undersupplied with renewable energy. However, energy used in this area is also dependent on the required household purpose.

Furthermore, it should be noted that Chalimbana ward households connected with ZESCO electricity followed by those using Charcoal spend the most on energy consumption. Expenditure on household energy consumption in the study area is influenced by social economic factors such as family size, house size and education. In order to conserve energy, the households in this area use a variety of conservation methods of which the most used involves switching or putting off unused household energy appliances or sources.

With regards to the perceived environmental implications of household energy consumption, household energy if not sustainably utilised as is the case in Chalimbana ward causes air pollution, habitat loss, land use change, exposure to hazardous waste among other environmental atrocities. The environmental effects of household energy sources or forms used among Chalimbana ward households vary and depend on consumption patterns among other factors.

Based on the study finding on its three objectives, it can therefore be concluded that households in Chalimbana ward do practice energy conservation. However, this is not done at a substantive level that can yield benefits of household energy conservation. Household energy conservation in Chalimbana ward is mostly done to meet economical needs for predominant low-income earning households in the area. It is not done for yielding sustainable environmental, economic and social benefits that come with household energy conservation.

7.3 Recommendations

Based on the findings of this study, the following are the recommendations:

- i. There is need for more households in Chalimbana ward to be connected with electricity from ZESCO or the Rural Electrification Authority (REA). This will ensure that they have access to clean renewable energy and therefore curb the inefficacy use of unclean traditional biomass energy in form of Charcoal and firewood.
- ii. The Government for the Republic of Zambia (GRZ) through the Ministry of Energy, Ministry of Green Economy and Environment (MGEE) as well as other NGOs should implement programs that will teach households of Chalimbana ward on how to develop and install household biogas energy technology systems. This will enhance the energy mix among Chalimbana ward households and therefore play a positive role in energy conservation and use of clean household energy technologies. .
- iii. The Government of The Republic of Zambia (GRZ) through ZESCO should develop and install modernised smart energy conservation technologies in households connected with ZESCO electricity energy Chalimbana ward. These technologies should be used to automatically switch off certain household appliances when inefficient energy consumption is observed.
- iv. Private firms and NGOs should continue to develop and distribute (*at a cost or for free*) modernised Improved Cooking Stoves (ICS) among the households of Chalimbana ward. These ICS should however be enhanced with high energy efficiency technology that will promote energy conservation and mitigate the adverse environmental implication resulting from inefficient household energy use.
- v. The Governmental for The Republic of Zambia (GRZ) through the Ministry of Energy (MoE), Ministry of Local Government and Rural Development (MLGRD), and Ministry of Green Economy and Environment as well as in partnership with other NGOs should setup and implement robust programs that will educate the community of Chalimbana ward on how to conserve energy and its importance.

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APPENDIX ONE: QUESTIONNAIRE

Questionnaire No.....
(For official use only)

SECTION A: GENERAL PROFILE

1. Sex of Household Head

- a) Male ()
 b) Female ()

2. Household head marital status

- a) Single ()
 b) Married ()
 c) Divorced ()
 d) Separated ()
 e) Windowed ()

3. Household head occupation ?.....

4. Household average income per month?.....

5. Household family size number?.....

6. Indicate below Age distribution of household members

AGE OF HOUSEHOLD HEAD	NO. OF HOUSEHOLD MEMBERS WITHIN THE AGE GROUP EXCEPT THE HOUSEHOLD HEAD				
	0-7 Years	8-17 Years	18-35 Years	35-55 Years	Above 55 Years

7. Indicate below the distribution for level of education for household members

HOUSEHOLD HEAD LEVEL OF EDUCATION	No. HOUSEHOLD MEMBERS WITH THE LEVEL OF EDUCATION BELOW EXCEPT THE HOUSEHOLD HEAD		
	Primary school level	Secondary school level	Tertiary school level Above 55 Years

8. Number of rooms in the house?.....

9. Village location name?

SECTION B: HOUSEHOLD ENERGY TECHNOLOGIES

10. Do you use any of the listed forms of energy in table 1 and specific the amount spent or quantity used for each selected form? In the last row of the table specify why the selected energy form is used.

N.B: Answer Yes or No on energy use (second row). In the second column you specify the amount or quantity used. You may also indicate “not sure or I do not know” if you do not know the answer.

	HOUSEHOLD ENERGY FORM OR TECHONOLOGY							
	ZESCO	Solar	Charcoal	Firewood	Biogas	Petroleum Products	Other specify	
Energy use (<i>Yes or no</i>)								
Average amount								

11. Do you use the forms of energy for the purposes listed table below and give reason?

N.B: Tick on were applicable

Energy Use or Purpose	HOUSEHOLD ENERGY FORM OR TECHONOLOGY							
	ZESCO	Solar	Charcoal	Firewood	Biogas	Charcoal Pellets	Petroleum products	Other Specify
Cooking								
Lighting								
Entertainment (<i>E.g TV</i>)								
Irrigation								
Lundry (<i>e.g ironing</i>)								
Refrigeration								
House Cleaning								
House temperature control (<i>e.g Air con</i>)								
Communication devices power supply								
<i>List other purposes</i>								

SECTION C: ENERGY CONSUMPTION & CONSERVATION PRACTICES

12. If you use electricity, name any present household energy appliances you feel are energy savers or energy efficient according to make and give a reason for this answer?

.....
.....
.....

13. If you use electricity, which present household energy appliances do you feel consume more energy and give a reason for this answer?

.....
.....
.....

14. What are some of the measures you put in place to consume less energy in in any of its types (*e.g charcoal, firewood or electricity*) the house?

.....
.....
.....

15. What are some of the reasons you have for ensuring that the house consumes less energy?

.....
.....
.....

16. What are some of the challenges you face in striving to ensure that the house consumes less energy in in any of its types (*e.g charcoal, firewood or electricity*)?

.....
.....
.....

SECTION C: IMPLICATIONS OF ENERGY CONSUMPTION ON THE ENVIRONMENT

17. In your own opinion, do you feel household energy consumption patterns have any environmental implications?

Provide the answers according to the categories in the table below.

Energy Use or Purpose	HOUSEHOLD ENERGY FORM OR TECHNOLOGY							
	ZESCO	Solar	Charcoal	Firewood	Biogas	Charcoal Pellets	Petroleum products	Other Specify
Indicate “Yes, No or I do not know” in each column to provide your opinion for question 11								
Explain reason for answer								

APPENDIX TWO: INTERVIEW GUIDE FOR EMPLOYEES OF ENERGY INSTITUTIONS IN CHALIMBANA WARD

Respondent Profile

- i. Sex of respondent
- ii. What is the name of the energy institution you work?.....
- iii. What is your position at the institution?.....
- iv. For how long you have been working in this area?.....

Household Energy Technologies

- v. From your observation, what are the most common sources of household energy in Chalimbana and reason for use?
.....

Household Energy Consumption and Conservation in Chalimbana

- vi. In a period of month and with focus on the type energy you provide, what do feel is the average energy consumption rate per household in Chalimbana?
.....
- vii. Do you feel that the households in Chalimbana are using the energy you provide sustainably and give a reason?
.....
- viii. From your own experience, are the households in Chalimbana practicing any energy conservation methods, if any name them?
.....
- ix. Which factors do you feel influence energy conservation among households of Chalimbana?
.....
- x. Are there any strategies you have put in place as an institution to promote household energy conservation in Chalimbana?
.....

Environmental implications of household energy consumption

- xi. Do you feel the energy consumption patterns among Chalimbana household have any environmental implications and give a reason?
.....

APPENDIX THREE: INTERVIEW GUIDE FOR EMPLOYEES OF CHONGWE MUNICIPAL COUNCIL

Respondent Profile

- i. Sex of respondent
- ii. What is your position at the institution?.....
- iii. For how long you have been working in this area?.....

Household Energy Technologies

- iv. From your observation, what are the most common sources or technologies of household energy in Chalimbana?
.....
- v. what do you feel are the reason behind using the previously named energy sources by Chalimbana households?
.....

Household Energy Consumption and Conservation in Chalimbana

- vi. Do you feel that the households in Chalimbana are using the energy you provide sustainably and give a reason?
.....
- vii. From your own experience, are the households in Chalimbana practicing any energy conservation methods, if any name them?
.....
- viii. Which factors do you feel influence energy conservation among households of Chalimbana?
.....
- ix. Are there any strategies you have put in place as an institution to promote household energy conservation in Chalimbana?
.....

Environmental implications of household energy consumption

- x. Do you feel the energy consumption patterns among Chalimbana household have any environmental implications and give a reason?
.....

**APPENDIX FOUR: INTERVIEW GUIDE FOR CHALIMBANA WARD LOCAL LEADERS
(HEADMEN AND AREA WARD COUNCILLOR)**

Respondent Profile

- i. Sex of respondent
- ii. What is your position?.....
- iii. For how long you have been leader in this area?.....

Household Energy Technologies

- iv. From your observation, what are the most common sources or technologies of household energy in Chalimbana?
.....
- v. what do you feel are the reason behind using the previously named energy sources by Chalimbana households?
.....

Household Energy Consumption and Conservation in Chalimbana

- vi. Do you feel that the households in Chalimbana are using the energy you provide sustainably and give a reason?
.....
- vii. From your own experience, are the households in Chalimbana practicing any energy conservation methods, if any name them?
.....
- viii. Which factors do you feel influence energy conservation among households of Chalimbana?
.....
- ix. Are there any strategies you have put in place as a leader to promote household energy conservation in Chalimbana?
.....

Environmental implications of household energy consumption

- x. Do you feel the energy consumption patterns among Chalimbana household have any environmental implications and give a reason?
.....

APPENDIX FIVE: UNZA STUDY ETHICAL APPROVAL



THE UNIVERSITY OF ZAMBIA DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road Campus | P.O. Box 32379 | Lusaka10101 | Tel: +260-211-290 258/291 777
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APPROVAL OF STUDY

10th March, 2022

REF NO. NASREC-2022-FEB-001

Alfred Chewetu
The University of Zambia
School of Natural Sciences
P.O. Box 32379
LUSAKA

Dear Mr. Chewetu,

RE: "HOUSEHOLD ENERGY CONSERVATION PRACTICES IN CHALIMBANA WARD, CHONGWE"

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	Ordinary Review	Approval No.
Approval and Expiry Date	Approval Date: 10 th March, 2022	Approval No. NASREC-2022-FEB-001 Expiry Date: 9 th March, 2023
Protocol Version and Date	Version - Nil.	9 th March, 2023
Information Sheet, Consent Forms and Dates	<ul style="list-style-type: none">English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to NASREC within 5 days.
- All protocol modifications must be approved by NASREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to NASREC within 5 working days.
- All recruitment materials must be approved by NASREC prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. NASREC will only approve a study for a period of 12 months.
- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to NASREC.
- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by NASREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled "late submissions" and will incur a penalty fee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.
- Every 6 (six) months a progress report form supplied by The University of Zambia Natural and Applied Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.
- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO), both NASREC
- and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.
- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.
- Filing a closing report (rather than just letting your approval lapse) is important as it assists NASREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.
- A reprint of this letter shall be done at a fee.
- All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address

or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented. Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of NASREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,



Dr. E. M. Mwanaumo

**CHAIRPERSON
THE UNIVERSITY OF ZAMBIA NATURAL AND APPLIED SCIENCES RESEARCH
ETHICS COMMITTEE - IRB**

CC: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies

APPENDIX SIX: LOCATION MAP FOR STUDY AREA

CHALIMBANA WARD LOCATION MAP

