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Sociopolitical Drivers and Barriers to Development and Adoption of Biogas in Mokambo Peri-urban in Mufulira, Zambia: How Does Local Government Fail to Provide Renewable Energy?

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List of Acronyms

CBD	Central Business District
CDM	Clean Development Mechanism
CEC	Copperbelt Energy Corporation
CSO	Central Statistical Office
ICLD	International Center for Local Democracy
PFAN	Private Finance and Advisory Network
PPA	Public Private Partnership
REEP	Renewable Energy Efficiency Partnership
REFIT	Renewable Energy Feed In Tariff
RET	Renewable Energy Technology
SDG	Sustainable Development Goals
SIDA	Swedish International Development Agency
SME	Small Medium Enterprise
SREP	Scaling-up Renewable Energy Programmes
UN	United Nations
ZESCO	Zambia Electricity Supply Corporation

Abstract

Biogas has been acknowledged as one of the most important aspects for sustainable development. It is a renewable energy technology being promoted especially in developing countries for poverty reduction and climate change action. Despite concerted efforts to alleviate poverty, production and adoption of biogas remains very low in Zambia, and they prompt some questions: How do institutional, situational, infrastructural and dispositional barriers affect the production and adoption of biogas? How does the local government fail to provide renewable energy? In search for answers, this study focuses on Mokambo peri-urban area in Mufulira district. The transformations to sustainability, transition arena, and adaptation and mitigation theories have been employed as theoretical framework. Using qualitative method and case study as a strategy, I engaged beneficiaries and non-beneficiaries of biogas project to explore the sociopolitical drivers and barriers to the development and adoption of biogas technology. Among the driving factors of biogas production include the protection of environment and climate change mitigation, poverty reduction, and agricultural production. The findings show that the sociopolitical barriers to the production and adoption of biogas include inadequate policies and strategies on modern energy, lack of community awareness on Renewable Energy Technologies (RET). Others are lack of titled land, intersectional inequality and resistance to change. Further, findings reveal that the local government does not provide any alternative sources of energy in the peri-urban area due to lack of funds, staff capacity and expertise. This paper concludes with recommendations and possible future research on biogas technology.

Keywords: biogas, renewable energy technologies, biodigester, adoption, barriers

Word count: 20,000

CHAPTER ONE: INTRODUCTION

1. Introduction

This chapter gives a synoptic outlook of the research study on biogas in Mokambo Peri-urban area in Zambia. It starts by giving a background to the study, country profile, and description of the study area. In addition, the chapter outlines the statement of the problem, the aim of the study, the objective, research questions, and significance of the study, delimitations and limitations of the study. The chapter ends by highlighting the overall organization of the entire study. This thesis is about the development and adoption of biogas in Zambia. Biogas is a combustible mixture of gases produced by the breakdown of organic matter in the absence of oxygen, mainly consisting of methane and carbon dioxide (Jørgensen, 2009). The country has basic regulatory framework which allows independent energy producers to operate off-grid to increase access to energy. However, access to renewable energy like biogas in the country is minimal. Using qualitative method, and case study as a strategy, I intend to explore the sociopolitical drivers and barriers to the development and adoption of biogas in Mokambo peri-urban area in Mufulira district. The local government has an increasingly important role to play in shaping modern energy such as biogas. This study will investigate how the local government fails to provide alternative energy in Mokambo peri-urban area.

1.1 Background

Poverty reduction is a key component in sustainable development debate. This is due to the persistence of extreme poverty around the world. The characteristics of poverty differ according to the geographical location. Africa accounts for the highest number of global poverty. The degree and severity of poverty in the continent is the most significant on the planet. The 10 countries with the largest

populations of severely poor are the Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Tanzania, Zambia and Zimbabwe (Turner et al, 2015). It is clear from the mentioned countries that Africa remains the last frontier of world's efforts to end poverty. The Sustainable Development Goal number 1, aims at ending poverty in all its forms everywhere by the year 2030 (UN, 2019). In a bid to reduce poverty, different interventions have been proposed, and some are being implemented to make this dream a reality. The main emphasis has been placed on economic growth in production, distribution and trade, as well as consumption of goods and services. Despite these concerted efforts to alleviate poverty, access to renewable energy like biogas which is key to poverty reduction has not been given much attention, particularly in peri-urban areas where the majority energy poor population exists.

Sub-Saharan Africa is the lowest electrified region in the world, with rural electrification levels below 5% (Karekezi and Kithyoma, 2002). With the majority of the region's poor people resides in dispersedly rural areas, conventional grid electrification is regarded to be too expensive. Gender studies in sub-Saharan Africa reveal that women suffer inadequate access to clean energy options than men (Karekezi, Mapato and Teferra, 2002). This is attributed to gender inequality and uneven distribution of resources. Gender equality and women empowerment are critical elements to ending energy poverty. The linkage of energy to women's work and well-being is proof of women's role as users of energy sources. On the one hand, gender issues in energy have attracted much needed attention at micro-level in terms of technological interventions such as biogas. On the other hand, they are yet to be tackled essentially at macro policies level in most countries in the region (Karekezi and Kithyoma, 2002).

The high cost of transmission and distribution of grid electricity to dispersed homesteads creates a potential market for decentralized energy technologies that

can fit the nature of sub-Saharan Africa's peri-urban population. The region is assumed to be good for the deployment of renewable energy technologies that are not only cost effective but also eco-friendly. In line with environmental matters, the climate change policy is often associated with energy policies. Therefore, synergetic solutions must be to address local pressing issues of poverty and environmental degradation while pursuing probable gains such as provision of clean energy (Jerneck and Olsson, 2012). Renewable energy is usually favored as the most appropriate energy source for rural and peri-urban areas in Africa.

Renewable energy generated from biomass, solar, hydro power, wind and geothermal resources provides immense prospects towards poverty reduction (UNDP, 2001). This is because technological advancements have paved the way for the conversion of these renewable resources into electricity, a valuable resource required to churn the wheels of improving people's livelihood (Eltrop, 2013). Unfortunately, the majority of the people still lack access to clean and modern energy for social and economic development in developing countries (WHO et al, 2018). Universal access to clean and modern energy is integral to SDG7 and critical for several other SDGs, particularly on good health and well-being, gender equality, climate action (SDG13), and eradicating poverty. Access to sustainable energy enhances the process of expanding the real freedoms that people enjoy (Sen, 2001). In this study, I have put Zambia's renewable energy sector into perspective. I have specifically chosen 'biogas' because it is believed that poverty can be eliminated with the intervention of sustainable energy, thus by embarking on clean, affordable and modern technological solutions in rural, peri-urban and urban areas.

1.2 Country Profile

Zambia is a land locked country located in Southern Africa and covers an area of 752, 614 square kilometers, making it the 39th largest country in the world (CSO,

2018). The country has a total population of 17.4 million (Worldometer, 2020). There are 49.52% males and 50.48% females (Ibid). The country has a youthful population and the distribution tend to be broader at the lower levels from ages 0 to 4 and gradually thins out with higher age groups up to the peak of 80 years and above (Ibid). From this population, women and children are the most affected with poverty. Zambia has fourteen ecosystems classified into four types, namely grassland vegetation, thickets, woodlands, and forests (SREP-Ministry of Energy, 2018). The country's rich endowment of resources provides the foundation for poverty reduction initiatives and the growth of sustainable energy in rural, peri-urban and urban areas.

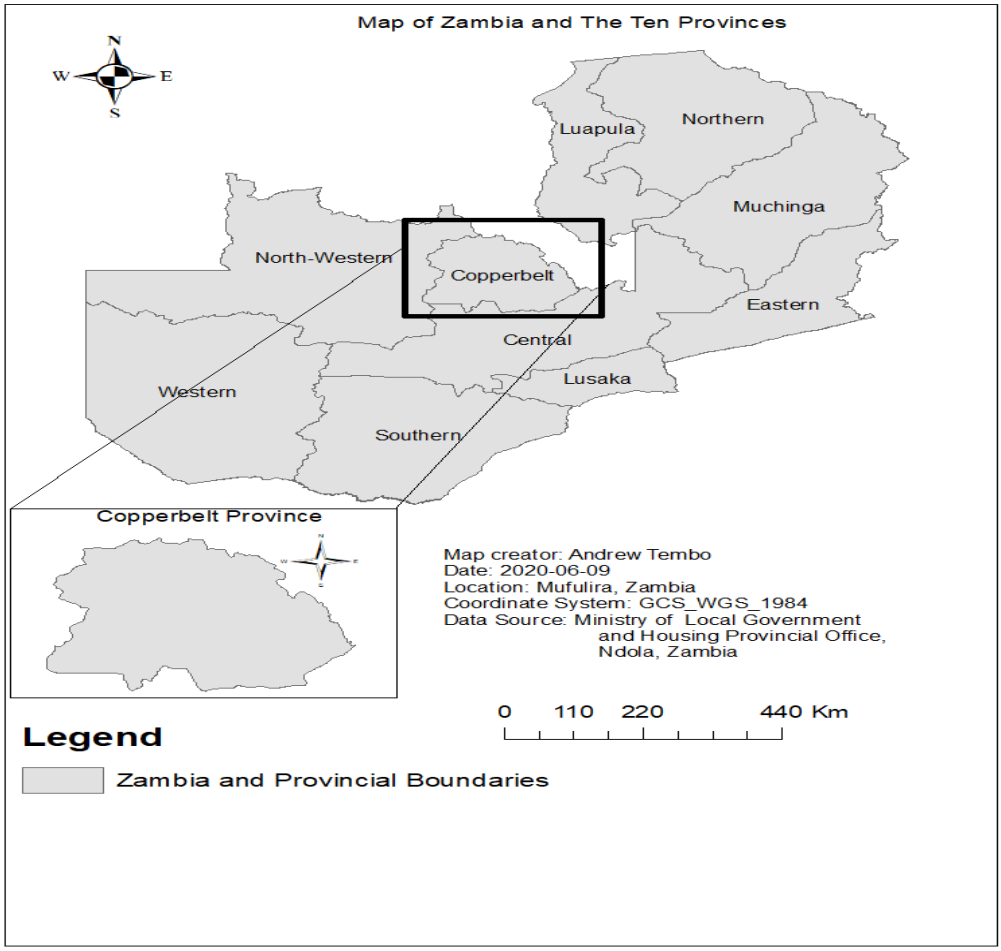

Figure 1: *Map of Zambia.* ***Source:*** *Ministry of Local Government and Housing*

1.2.1 Energy Situation

The country's energy consumption is mainly fuelwood, which accounts for over 70% of total national energy consumption (SREP-Ministry of Energy, 2018). The electrification rate remains low with only 31.2% of the population connected to the grid and with low energy consumption per capita of around 700 kWh/capita (Ibid). Being a landlocked country, electricity supply has been a challenge due to lack of direct access to the open sea for energy generation services. As a result, trade in power supply between Zambia and neighboring countries has incurred high transaction and transportation costs. The country's vision on energy is to achieve universal access to clean, reliable and affordable energy at the lowest total economic, financial, social and environmental cost. The goal is to increase renewable energy sources and reduce share of woodfuel to 40% (SREP-Ministry of Energy, 2018).

1.2.2 Energy Policy

Zambia is blessed with renewable energy resources like Biomass, Solar, Hydro, Geothermal, and Wind, among others. Despite the availability of such resources, the production of renewable energy technologies remains low due to various hindrances such as lack of clear regulatory framework and investment especially in biomass power development. Furthermore, renewable energy is compounded by lack of planning, and insufficient ideas on off-grid energy solutions, non-cost reflective tariffs, and inability to pay for electricity especially in rural and peri-urban areas (SREP-Ministry of Energy, 2018).

In 2008, the Zambian government drafted a national energy policy framework to diversify the energy mix through the use of renewable energy technologies (SREP-Ministry of Energy, 2018). The government incorporated the private sector investment and promoted conditions that ensure availability of adequate

supply of energy from different sources, in line with the national development goals. In addition, the Renewable Energy Feed in Tariff (REFIT) strategy was formulated to harness the renewable energy sector's potential. This was meant to enhance economic growth and improve the welfare of the people by implementing small and medium-sized renewable energy technology projects in rural and per-urban areas (Ibid).

In the recent past, Zambia's economy has been experiencing negative growth. The economic growth has remained subdued at 3.8% due to weak performances in many sectors (SREP-Ministry of Energy, 2018). The national poverty and inequality has remained stubbornly high compared to other countries in sub-Saharan Africa. One of the affected regions is the Copperbelt province, where district authorities have faced challenges to reduce poverty due to lack of access to alternative energy sources especially in peri-urban areas. Mufulira, the focus of this study is among the districts with the energy poverty population.

1.3 Description of Mufulira District

The population of Mufulira district stands at 196, 401 with an average annual population growth rate of 1.2% (CSO, 2018). There are 98, 192 males and 98, 209 females (Ibid). The district is well known to be wooded with savannah type of vegetation and abundant forest land. Generally, the fertile soil support natural forests with potential for agriculture and biomass. In the past few years, the forests have depleted due to unsustainable exploitation of the woodlands which have affected the rain pattern with increased dry spells and droughts (Mudenda et al., 2018). The district serves as a passage for the Kafue River which is the second largest river in the country, with the potential for hydro power and renewable energy generation. Despite the impressive resource endowment, energy poverty in peri-urban areas remains widespread (Ibid, p. 3).

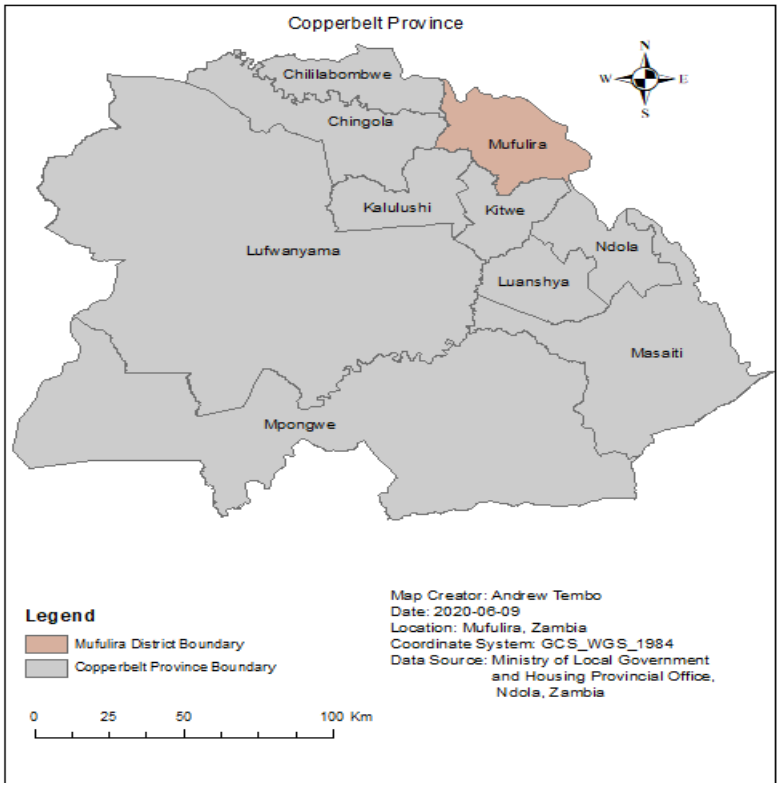

Figure 2: *Copperbelt province showing Mufulira district.* ***Source:*** *Ministry of Local Government*

1.3.1 Location of the Study Area in Mufulira District

The study was carried out in Mokambo Peri-urban area in Kantanshi constituency of Mufulira district. This peri-urban is in Minambe ward, in the North-east of the district. It is located 18 kilometers away from the Central Business District (CBD). According to 2010 statistics, the total population in the ward was 3, 695, of which 1, 784 were males and 1, 911 were females (CSO, 2010). This peri-urban has a mixture of tribes and languages. The common language spoken is Bemba. This community has been chosen as the site for this study because the area is one of the peri-urban set-ups in the district where renewable energy project for poverty reduction was initiated and implemented by Heifer International, SNV-Netherlands and Swedish International Development Agency (SIDA).

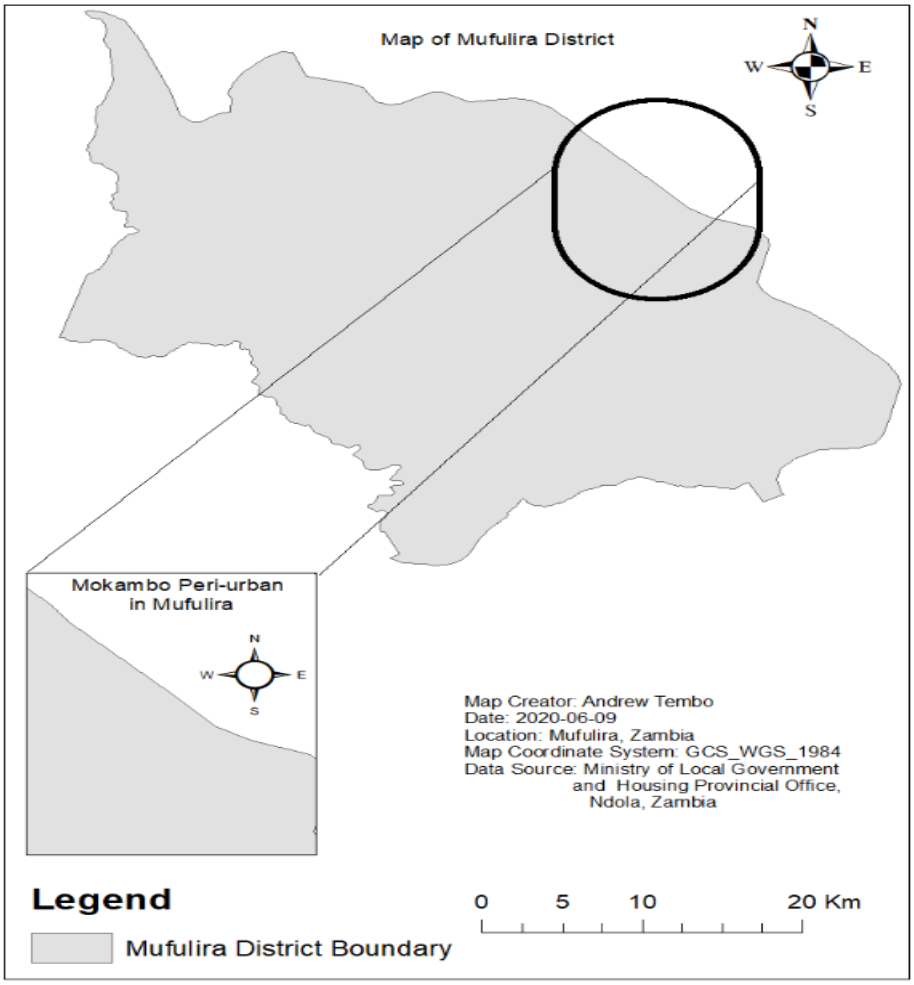

Figure 3: *Location of study area.* ***Source:*** *Ministry of Local Government, Ndola, Zambia*

1.3.2 Characteristics of the Study Area

The main socio-economic characteristic in the area is agriculture, with subsistence farming as the major activity supporting the livelihoods. The crops grown are maize (staple food), sorghum, cassava, groundnuts, vegetables, finger millet and sweet potatoes. The livestock such as goats, pigs and chicken are reared as source of protein. In addition, households keep cattle for milk production. Suffice to mention that there is high unemployment rate in area.

Informal employment such as trading in charcoal, mealie meal, sugar and toiletries is common (Macwani, 2003).

Mokambo peri-urban has one health center (clinic), one basic school and one community school. Access to primary health care and education is extremely difficult in the area. Most of the people are illiterate, and they walk 7.95 kilometers to access basic facilities (Mwikisa, 2002). Access to safe drinking water is a tussle for many households. The community relies on shallow wells for drinking water and domestic use. The sanitation conditions are not fit for human welfare. The majority of the people use pit latrines made of poles, mud and some pit latrines are covered with sacks and plastic materials. Others use the nearby bush to answer the call of nature.

1.4 Statement of the Problem

Zambia suffers from extreme energy poverty despite its abundant energy resources. Access to alternative energy sources are a major challenge in rural and peri-urban areas (Energy Africa-Zambia, 2018). The household's ability to acquire cleaner energy-carriers is an essential component of improving the wellbeing of underprivileged individuals and communities**.** Therefore, lack of access to clean and affordable energy prevents improved agricultural production and increased Small-scale Medium Enterprises (SME) in per-urban areas. Helping the poor to shift, and adopt modern energy systems is not only good for the environment, but can also solve their energy poverty (Energy Africa- Zambia, 2018).

The load-shedding of power has increased the demand for firewood and charcoal for cooking and lighting in peri-urban and urban areas. This is due to the fact that, over the past two decades the population has grown rapidly, thereby increasing the demand on the use of wood forests by the energy poor communities. Wood is

being harvested unsustainably and used inefficiently (OECD and IEA, 2006), resulting in the faster rates of forest depletion than regeneration. Zambia's estimated deforestation rate is between 250,000 and 300,000 hectares per annum, which is one of the highest rates of deforestation in the world (Energy Africa-Zambia, 2018). The country's energy generations entirely rely on the Kariba dam hydropower system which has been affected by poor rainfall. The over exploitation of the forests have affected the rainfall pattern in Mufulira district. For instance, in 2017/2018 and 2018/2019, the rainy season was characterized by extreme weather conditions and prolonged dry-spells (Chapoto, Chisanga and Kabisa, 2019). As result, there was a reduction of water levels in the Kariba dam that led to shortage of electricity supply, and increased load shedding of power for over 12 hours per day in the district.

To cushion the energy deficit and reduce poverty, the government emphasized on the importance of increasing the energy mix through promotion of off-grid electricity generation, and enhances alternative energy sources (SREP-Ministry of Energy, 2018). In response to the government's call for energy diversification, the Swedish embassy in Zambia initiated a project of installing and operating off-grid power connections to a share of over 1 million rural and peri-urban Zambians around the country (SIDA, REEP and PFAN, 2015). It is anticipated that when the project ends in 2021, about 1.6 million Zambians would have gained access to affordable and sustainable electricity for the first time (Ibid). In 2009, the government implemented the national decentralization policy to improve service delivery. This policy empowers the local government through councils to coordinate development on localized decision-making (Blum, Bandiera and Ashraf, 2016). However, the role of local government in the renewable energy sector is peripheral.

Mokambo peri-urban in Mufulira is connected to the national grid, but only few households have access to electricity. With high poverty levels in the community, many households are not connected, and are considered to be the energy poor. As a result, they are cutting down trees for fuelwood and producing charcoal for sale. Due to cutting down of trees the energy poor are viewed to be environmentally unsound, inefficient and practice unsustainable modes of energy production and consumption (IEA, 2011). The perception is that the existing energy sources in the community are expensive, harmful to the environment, and the climate (Ibid). In order to reduce poverty and increase food security in the area, the government introduced food security pack programme, targeting the vulnerable households. The food security pack has fared quite well in the community by targeting the poor farmers, but access to energy for cooking, heating and sustainable livelihoods remain a challenge.

Furthermore, in an effort to increase food security in the community, Heifer International (a non-governmental organization) provided farming inputs to households to boost the agricultural production. In addition, the organization gave cattle to some households for daily farming. Heifer International in collaboration with SNV Netherlands and Swedish International Development Agency (SIDA) implemented the small-scale development of biogas digesters commonly known as biodigester as an alternative source of energy in Mokambo. Biodigester is a structure constructed underground, made up with cement, brick/stone, and sand and fitted with pipes and appliances to decompose organic material and produce a renewable energy called biogas (Ghimire, 2016, p. 5). Despite attempts to promote the development of Renewable Energy Technologies (RET) such as biogas digesters, the production and its adoptability remain fairly low (Mudenda et al., 2018).

In addition, solid waste management by the local authority (Mufulira Municipal Council) is done through landfills with uncontrolled incineration, without generating energy for distribution and consumption. It is against this background that I intend to undertake a study of biogas digesters in Mokambo peri-urban area. I want to understand the social, economic and political drivers and barriers to the development and adoption of biogas in the peri-urban areas. I have chosen a peri-urban area for two reasons. First, many households lack access to energy, and people have migrated from rural to peri-urban areas in search of a better living (USAID, 2018). Second, very little is known about how peri-urban populations perceive biogas technology.

1.5 Aim of the Study

The aim of the study is to explore the sociopolitical drivers and barriers to the development and adoption of biogas. Further, to understand how the local government fails to provide alternative energy in Mokambo Peri-urban.

1.6 Objective of the Study

The objective of the study is to establish the social, economic and political drivers and barriers to the development and adoption of biogas. Further, to determine the factors affecting the local government to provide renewable energy in peri-urban areas.

1.7 Research Questions

The study is guided by the following research questions:

1. How do institutional, situational, infrastructural and dispositional barriers affect the development and adoption of biogas in Mokambo Peri-Urban area in Mufulira district?

2. How does the local government fail to provide renewable energy in Mokambo Peri-Urban area?

1.8 Significance of the Study

It is envisaged that the results of this study will contribute to the body of knowledge in the energy policy regulation and energy poverty reduction strategies. The findings will help policy makers and implementers of poverty reduction programmes to refocus their attention towards the energy poor, especially in peri-urban areas. The required information will be provided for effective policy design and implementation in Zambia, and other institutions in the world dealing with sustainable energy initiatives as alternative energy sources for human development. Additionally, very little is known about biogas in Zambia, and no known research has been done to assess the role of the local authority (Mufulira Municipal Council) in the renewable energy sector.

Furthermore, this study will inspire other researchers to expand and explore more on the drivers and barriers to the development and adoption of biogas. Moreover, it will bring up suggestions on how the local government can play a greater role in the provision of alternative energy in peri-urban areas. Through the promotion of sustainable energy in peri-urban areas, the prospects of poverty reductions and climate change mitigations would increase**.** Further, it will enhance education and training of personnel for successful implementation of any planned modern energy sources.

1.9 Delimitations of the Study

Delimitations are simply the choices that a researcher sets in order to control the study (Heppner and Heppner, 2004). In as much as renewable energy technology systems are designed for both the poor and rich people, this study is delimited to

the energy poverty only, in the peri-urban area because their access to energy is lower compared to urban areas. The participants include individuals of households who benefited from bio-digesters project and those who did not benefit. In addition, the Zambia Electricity Supply Corporation (ZESCO), Copperbelt Energy Corporation (CEC), NGOs, and the local government (Mufulira Municipal Council) and ward councilors are included as participants. The study has been restricted to Mokambo peri-urban area only, in Mufulira District.

1.10 Limitations of the Study

This study would have produced better results if many provinces, districts, and peri-urban areas were represented and included in the sample. The study targeted literate, semi-literate and illiterate respondents. First limitation is that, the illiterate participants needed to have the interview guide translated into the local language. As a result, much time was lost because the researcher took longer than anticipated. Second limitation was the hurdle of accessing some respondents during the day. This is because the study was conducted during rainy season when people were busy with farming activities. This led to delays in conducting interviews. To mitigate this, I had to engage the local focal point person of biogas project to ensure that the respondents are found in their homes. The third limitation was the insecurity in the community, which led to the removal of random sampling procedure as explained in chapter four under participant selection procedure section.

1.11Disposition

This study has seven chapters. Chapter one gives the introductory remarks and the background information to the study. It covers the statement of the problem, significance of the study, the aim and objective, delimitation and limitations of

the study. Chapter two examines relevant literature which is studied in an attempt to gain more insight into the research's interest area. The theoretical framework is discussed in Chapter three, with transformations to sustainability, transition arena, and adaptation and mitigation theories to help me to analyze the findings of the study. The research methodology is discussed in chapter four. The intricacies to do with research design, study population, sampling procedures, data collection and ethical considerations are discussed herein. Chapter five presents the research findings from the participants. Data analysis and discussions are done in chapter six. The analysis and discussions spun around connecting the results to the research questions, previous literature and theories employed in the study. Chapter seven draws on conclusion. This chapter ends by focusing on the implication of the findings, recommendations, and reflection on the study, and lastly suggestions for future research.

CHAPTER TWO: LITERATURE REVIEW

2. Introduction

This chapter reviews pertinent literature of the research study. In doing so, closely related concepts to biogas like Modern Energy, Renewable Energy Technologies (RET) and Alternative Energy will be articulated interchangeably as discussed by other researchers. Furthermore, the sociopolitical drivers and barriers to the development and adoption of biogas within and outside Zambia will be outlined to substantiate the assertion of this study. In addition, literature on local government's failure to provide alternative energy, and how it can play a proactive role in renewable energy will be reviewed.

2.1 Biogas- Renewable Energy Technology

Renewable energy technologies do not only provide energy, heat and transport fuel, but also offers the opportunity to reduce poverty, preserve the environment and facilitate prospects of development. Ošlaj and Muršec (2010) found that in Europe and other industrialized regions, the main reason for the production of renewable energy technologies is to protect the environment, minimize the threats posed by global climate change and the need to improve security and diversity of energy supply. In developing countries biogas promises a new hope for renewable primary energy supply in regions without conventional energy, and provides an opportunity for poverty reduction (Ošlaj and Muršec, 2010, p. 109). Although the study by Ošlaj and Muršec (2010) has contributed to the literature by highlighting the benefits of modern energy like improving security, the type of security being referred to, is not known. Again, despite this contribution production and adoption of biogas technology in peri-urban areas is very low (Mudenda et al, 2018). The production and adoption of biogas requires good understanding of cultural, social, economic and political barriers to the technology.

Other previous studies have shown that implementation of domestic biogas technology has unfolded in countries where national governments have been involved in the subsidy, planning, design, construction, operation and maintenance of biogas plants to enhance poverty alleviation initiatives (World Bioenergy Association, 2020). In 2011, China and India produced 2.8 million and 150,000 biogas plants respectively (Ibid). In developing countries, the SNV-Netherlands supported national programs on domestic biogas that aimed at establishing commercially viable technology in which local companies marketed and installed biogas plants for energy poverty households. The countries which were supported by SNV like Vietnam, Bangladesh, Cambodia, Indonesia, Senegal, Burkina Faso, Ethiopia, Tanzania, Kenya and Cameroon had installed more than 475,000 plants by the first half of 2012 (World Bioenergy Association, 2020). Although SNV-Netherlands supported the development of biogas digesters, most developing countries lack fiscal policy and strategy to implement modern energy technologies (Zhang et al, 2014).

In Zambia, SNV and SIDA constructed bio-digesters, locally known as ZamDigester to supplement conventional fuel sources in the country. An estimated 341, 000 units of biogas digesters are functioning in the country (Kaunda, Morel and Mtawali, 2013, p. 12). In addition, between 2008 and 2015, the Water and Sanitation Council of Zambia and its co-operating partners installed more than 60 biogas digesters measured $4m^3$- $80m^3$ with funding from donors (Shane, Gheewala and Kasali, 2015). Despite the quantification by these mentioned researchers on the installation of biogas digesters, the impact of the technology to the beneficiaries is not clearly outlined, but merely indicating international and national statistics about biogas.

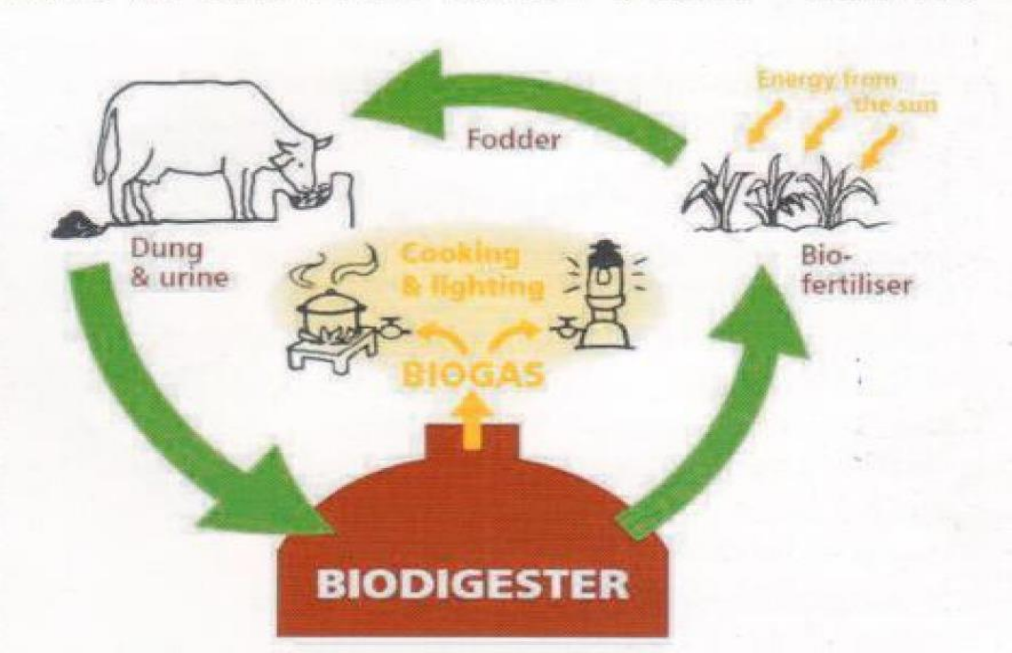

Figure 4**: Family-sized biodigester.* ***Source*: *Ghimire, 2016

2.2 Drivers of Biogas Development

2.2.1 Climate Change Mitigation

Climate change mitigation is the main driver for shifting to biogas systems. Zambia has experienced adverse effects of climate change such as extreme weather conditions. It is expected that the trend will continue in the near future, thereby impacting negatively on the economy and people's livelihood. The envisaged climate change mitigation measures include the development of biogas technology (SREP-Ministry of Energy, 2018). Moreover, the depletion of biomass fuels and soil quality, threats of solid wastes, the protection of environment and sustainable sanitation, and the increased agricultural residues justifies the need to go for biogas technology (Mulinda, Hu and Pan, 2013, p. 508).

2.2.2 Economic Benefits and Sustainable development

Another study on the production of biogas in Africa by Mulinda et al (2013) found that biogas initiated and implemented by the government reduces demand for firewood and increase the chances of environmental protection, which is an essential component in sustainable development. In Zambia, a study by Shane, Gheewala and Kasali (2015) found that the country has biogas potential of 76PJ per annum from animal manure and crop residues. This is sufficient to increase agricultural production through the use of bio-slurry and other economic benefits to more than 3 million households (Ibid). While both studies have contributed to the literature by articulating the importance of biogas, the type of economic benefits and the most identified beneficiaries of biogas technology are not unknown.

2.2.3 Health Benefits and Poverty Reduction

Health benefits are among the social drivers of biogas production. The Institute for Health Metrics and Evaluation estimated that there were 10,675 premature deaths in Zambia in 2016, attributed to household air pollution (Energy Africa-Zambia, 2018). Therefore, access to biogas could reduce premature deaths from household air pollution by 500 per annum by 2030 (Ibid). The impact can significantly be reduced by the introduction of biogas as an alternative energy. The health benefits disproportionately benefit women and girls by using improved cook-stoves and lighting, and increased school attendance respectively. Smith (2011) argues that biogas is closely associated with poverty alleviation.

2.3 Sociopolitical Barriers to Production and Adoption of Biogas

There are elements in the literature review that I have identified as key barriers to the successful production and adoption of biogas. These are institutional, situational, infrastructure and technical expertise, and dispositional barriers.

These elements apply prior to and/or throughout the production and deployment of renewable energy technologies.

2.3.1 Institutional Barriers

The construction of biogas digesters in peri-urban areas requires mobilization and planning capabilities. A study by Okello et al (2013) on institutional engagement, found that regions that have strong institutional support to bioenergy programmes have succeeded in promoting modern technologies. However, the study by Okello et al (2013) falls short of complete revelation of the successes of biogas to the energy poor. Another study by Roopnarain and Adeleke (2017) on energy policy, found that in regions where renewable energy policies are in place, there is often lack of coherent strategies and coordination to enhance and promote biogas technology. For instance, a 300 kW MSW energy plant (Taka Gas Project in Dar es Salaam, Tanzania) that underwent vigorous planning and was supposed to generate 7.08 MWh/d of electricity did not take off due to poor planning. Mfune and Boon (2008) in a study on renewable energy technology in Zambia, found that there is inadequate policy provision, lack of awareness, lack of monitoring and lack of collaboration among relevant organizations like research institutions and business houses. Although the study by Roopnarain and Adeleke (2017) and Mfune and Boon (2008) discovered lack of policy provision and coordination as barriers to renewable energy technologies, the two studies did not outline the root causes of lack of implementation strategies and coordination.

Mugodo, Magama and Dhavu (2017) and Rupf et al (2015) found that obstacles to the uptake of biogas include lack of awareness and cognizance on the viability of the technology as a sustainable energy and waste management method. They found that most of the people are not aware about the opportunities provided by biogas as a dual fuel production and waste management technology. However, the two studies have not outlined the root causes of lack of awareness. Highlighting

on factors affecting the dissemination of information in the area would have given a more clear understanding of the outcome of the study.

2.3.2 Situational Barriers

Situational barriers refer to people's situations and the extent to which resources such as finances and titled land enables an individual to access renewable energy technology (Seetharaman et al, 2019; Smith 2004). The financial constraint is far more common barrier to non-participation in biogas programmes in Zambia due to high poverty levels which is over 76 percent (Central Statistical Office, 2010). A study by Mfune and Boon (2008) found that renewable energy technologies in Zambia are very expensive that an average household cannot afford. A similar study by Kemausuor, Adaramola and Morken (2018) found that biogas plants are expensive, and small-scale livestock farmers find it difficult to finance its production. Parawira (2009) found that a biogas digester requires high investments, operational and maintenance cost.

Additionally, Pueyo (2018) found that public services in sub-Saharan Africa are not creditworthy, and too risks to engaging with the countries on Power Purchase Agreement (PPA). Financial lending institutions are afraid of investing in biogas technology, fearing to lose their money. An investigation done by Pueyo (2018) did not consider a consultative approach of broad spectrum of stakeholders about renewable energy. Although Kemausuor, Adaramola and Morken (2018) and Parawira (2009) identified financial constraint as a barrier, additional insights regarding people's inability to finance biogas production would have added strength to the findings. Further, a research study done by Yousuf et al (2016) discovered that barriers to biogas technology arise due to the disorderly efforts initiated by developers and agencies. The study done by Yousuf et al (2016) did not fully explore the reasons behind the disorderly work of bioenergy programmes by the decision-makers and agencies.

2.3.3 Infrastructural and Technical Expertise Barriers

One of the critical infrastructural barriers is the poor grid network in most countries which poses a challenge to existing power plants (GIZ, 2018). An investigation by Kesselring (2017) found that grid network infrastructure is not robust enough in Zambia and it affects the capability to grant grid access to renewable energy power plants. A study carried out by Tucho et al (2016) reported that inadequate transportation infrastructure in rural and peri-urban areas increases the disruption of feedstock supply chains. However, the two studies have not fully outlined the possible course of action towards establishing a robust grid infrastructure. On the technical expertise perceptive, the extent to which the beneficiaries of biogas understand the technology is important. Suberu, et al (2013) found that modern technology systems are more complex, requiring skills and technical expertise in designing, construction and management. Indeed, biogas needs technical knowledge and skills. Unfortunately, in Zambia skills are scarce and inadequate leading to technical problems such as poor designs and construction of biogas digesters (Shane, Gheewala and Kasali, 2015).

Mudenda et al (2018) studied the capacities and barriers affecting successful deployment of renewable energy technologies in Zambia. They found that lack of government's support of sustainable energy through well-focused energy policy and strategy on grid network, underserved populations, underexploited renewable energy sector and heavy reliance on a service-challenged hydro-power utility hinders the successful deployment of modern technologies. The study conducted by Mudenda et al (2018) contributes to the knowledge on barriers to renewable energy technologies. However, the study has not elaborated on the undeserved population and the actual type of renewable energy technology, and the reasons behind the failure to explore the alternative energy.

2.3.4 Dispositional Barriers

The dispositional barriers are associated with an individual's feelings, thoughts and self-perception. The studies done by Sebitosi and Pillay (2005) and MacKeracher, Suart and Potter (2006) found that populations especially in rural and urban areas have low self-esteem and negative attitudes towards their situation. They consider themselves to be poor, illiterate and too busy for sustainable transition. Some people have traditional beliefs that their communities are isolated and therefore, nothing new can change in their lives (Shane, Gheewala and Kasali, 2015). The study done by Nyembe (2011) revealed that some communities in Zambia are resistant to change towards development. As a result, they lack self-confidence to learn, develop and adopt modern energy technologies. However, the findings by the four researchers could be argued on the context of subjectivism. More knowledge on what makes people busy and fail to participate in sustainable transition, and resist to change would have consolidated their studies.

2.4 Factors Affecting Local Government to Provide Renewable Energy

Municipalities are known to have an upper hand in supporting sustainable future for rural, peri-urban and urban areas. Among the functions and mandates of the local government include planning for energy transition in peri-urban areas (Borchers, 2015). Modern energy technology efficiency like biogas can benefit peri-urban population by engaging the local government which has better knowledge and connections to local communities. Unfortunately, the local government in sub-Saharan Africa has no capacity to provide sustainable energy. Borchers (2015) investigated the role of local government in sustainable energy. He found that in municipalities, there are staff capacity barriers and financial resource challenges that inhibit the provision of alternative energy. Furthermore, Borchers and his colleagues found that within municipalities, there were

institutional location uncertainties and political ambivalence (Borchers, Brown and Ndlovu, 2015). Although the researchers found that municipalities lack staff capacity, the two studies provided little information on the lack of capacity building in local government institutions.

2.5 Engaging Local Government in Renewable Energy

The local government has a critical role to play in renewable energy transitions, yet the ability within local authorities to undertake this task is severely inadequate. It is possible for local government to play a greater role in modern energy because municipalities are often better placed to plan and respond to energy needs in locally appropriate ways (Borchers, Brown and Ndlovu, 2015). To find the means of engaging the local government to contribute to renewable energy, Couture and Leidreiter (2014) found that contributing to renewable energy is a political decision and ethical imperative, and requires a variety of stakeholders' participation. However, this study could be argued on the basis of insufficient suggestions on the possible ways for local government to contribute towards renewable energy in peri-urban areas.

2.6 Summary

The reviewed literature indicates that renewable energy enhances economic growth, protects and preserves the environment, and improves people's everyday lives. It is certain that biogas has the potential for poverty reduction and sustainable development. Nonetheless, critical knowledge about potential benefits of using biogas in peri-urban is void. The barriers to the production and adoption of biogas in peri-urban areas include weak policies and increased prices of renewable energy technologies. However, the barriers to the production and adoption of biogas technology are not clearly articulated in some literature. Further, the reviewed literature shows there is inadequate research on the

challenges faced by the local government to provide alternative energy. Even though some driving forces and barriers to biogas have been explored, it is important to re-examine these aspects to ascertain how biogas can be enhanced in peri-urban areas. In addition, the inability by the local government to provide modern energy in peri-urban areas needs to be investigated. The barriers and any other knowledge deficit that may arise in the research process are what this study strive to address.

CHAPTER THREE: THEORETICAL FRAMEWORK

3. Introduction

This chapter endeavors to theorize the principle essence of the study. Even though this study has emphasis on empirical research, it is guided by three theories namely; transformations to sustainability, transition arena, and adaptation and mitigation theories as propagated by Scoones (2016), Kemp and Loorbach (2006), and Jerneck (2018) respectively. The choices of these three aspects are purely based on the core objective of this study. The transformations to sustainability theory provide a holistic and integrated view of the processes by which people achieve or fail to achieve sustainable energy. Furthermore, the theory explores the politics of resources and the dominance of scarcity storylines on research, policies and practices. Moreover, the theory touches on the politics of transformations and the way these play out in union with technology-led, market-led, state-led, and citizen-led processes (Scoones, 2016).

Transition arena has been employed in this study for social learning in the peri-urban area to understand the participation process, production and adoption of biogas technology. The transition arena has pathways and aspects which are relevant to this inquiry. It plays a vital role in the strategic level of modern energy technologies, including the advancement of long-term goals. It promotes networking, exchange of knowledge and understanding among the actors (Kemp and Loorbach, 2006). As a concept, transition arena provides the basis for debate on renewable energy in communities.

The adaptation and mitigation theory has been employed to guide in explaining gender inequality, and how climate change policies are linked to the current development ideas (Jerneck, 2018). Inequality is one of the obstacles to the development and adoption of biogas technology. Adaptation and mitigation ideas give insights on how to get out of poverty, including energy poverty.

Furthermore, it guides institutions on how gender can be addressed in terms of access to, use of and control over Renewable Energy Technologies (RET) in the current era of climate change.

3.1 Transformations to Sustainability

The term sustainability has become a boundary concept combining science and policy and diverse actors with different agendas (Scoones, 2007). However, determining what sustainability and poverty reduction mean, technically and governmentally remains problematic even with the terms' increasing stance in public and policy debate. Currently, there are sustainable economies, assets, trades, survival means, and farming, and undoubtedly development. The boundary work for poverty reduction and sustainability which evolve typical understanding, firmly in epistemic communities with collective efforts has become an immerse pursuit (Scoones, 2016).

A key point to sustainability is the focus on transformation processes that could reduce poverty and enhance development. Despite an increasingly understanding of the concept of sustainability, integrating environmental issues, socioeconomic ideas, now inferred in terms of green economies is a challenge (Avis, 2018). There has been low production, adoption and /or transformation to modern technologies especially in developing countries due to traditional, organizational, and political challenges that arise (Schmitz and Scoones, 2015). This study theorizes on four transformations namely; technology-led, market-led, state-led and citizen-led transformations. These will help to understand the social and political drivers and barriers to the production and adoption of biogas technology in Mokambo peri-urban area.

3.1.1 Technology-Led Transformations

The notion that new technological systems are the solution to today's challenges is a familiar one and part of the modernist development discourse. World Bank (2012) states that poverty which seem to have persisted in developing countries despite several interventions, can be eradicated with sustainable interventions, that is through modern technology. Although such perspectives have been extensively denounced for their naivety about the assurances of new technologies and the possible draconian politics involved, there has been some advocacy for critical social science to engage with the discussion (Robbins and Moore, 2015; cited in Scoones 2016, p. 299).

In diversity, alternative technology-absorbed views emphasize on small-scale, suitable technology with bottom up approach, and grassroots participation. For example, the prospects of energy efficient leapfrog with affordable, small-scale sustainable technologies like biogas digesters tied to community energy systems is highly pronounced (Scoones, 2016). The difficult task is to build on the capability among technology providers, agents, lending institutions and repairers for an action towards off-grid rural and per-urban electricity supply (Ockwell and Byrne, 2015; cited in Scoones, 2016).

Technology-led transformations which are socially embedded and located in communities are more likely to be supported. With such initiatives, various livelihoods can be scaled-up, indicating a social and technological view that has different economic value with new dimensions. A key argument for renewable energy in peri-urban areas is that, for technology to be developed and adopted by people, the process of technological systems must be transparent and democratic (Scoones, 2016). The transformations to sustainability should take into consideration politics and encourage local-level market-led transformation niches

that can challenge a wider incumbent regime as part of political system (Smith and Raven, 2012).

3.1.2 Market-Led Transformations

Market-led solutions aim to ensure right prices, protect and secure production, and adoption of renewable energy technologies. The new market discourse coined as green economy may in turn reinforce existing extractive, exploitative neoliberal capitalist trade (Kenis and Lievens, 2015), and fail to deliver renewable energy technologies. Some proponents argue that the green economy is just a duplicate of the present neoliberal economy, and does not address the political interests that brought up set-back to sustainability (Levidow, 2014; cited in Scoones, 2016). As developing countries shifts to green economy and integrating private sector investment for alternative energy solutions, it is important to understand how this initiative would be accomplished. There is need to determine who would be the winners and the losers especially in peri-urban areas where the majority energy poverty population resides. To be precise, public and private investments in biogas technologies is vital for poverty reduction in peri-urban areas. However, the interests of the private investors in renewable energy must be investigated to avoid maximization of profits at the expense of the energy poor. Market-led actions should be in line with state-led transformations to ensure the production and adoption of biogas technology.

3.1.3 State-Led Transformations

Some commentators have argued that sustainability and energy resources are classic dilemmas and are not always flexible to market solutions. Certain problems often require states to intervene, as part of a response to development. The modern technology approach needs a big role by the state to advance technology-led and market-led transformations through regular financing and

guidance (Mol, 2003; cited in Scoones, 2016). Lessons are drawn from developmental states in East Asia where narratives about market-led development have reflected on rapid transformations in economies, enhanced growth and improvement of livelihoods (Scoones, 2016). The fundamental state-led reallocation of resources, state harmonization, and financing of industrial development in a lenient and cautious way helped to improve the welfare of the people (Scoones, 2016).

The renewable energy sector in peri-urban areas reveals the role of the state in the transformations to sustainability. For example, China has shown strong state-led support for renewable energy innovation, design, and manufacture, and has relentlessly become the global leader in energy technologies (Hochstetler and Kostka, 2015; cited in Scoones, 2016). Similarly, Germany replaced its nuclear capacity with renewables through huge state-funded private investment (Scoones, 2016). Therefore, the role of the state in the development and deployment of biogas energy in peri-urban areas is of the greatest importance. The state and the market are inseparable, and they are a basis of meeting renewable energy technology objectives. In addition to state-led transition, Gupta (2013) points out that transition techniques require more independent, responsible, and citizen-led processes that can enhance the development and adoption of the technology.

3.1.4 Citizen-Led Transformations

A citizen-led transformation refers to the mobilization, collaboration, and capacity building for sustainable transformations (Gupta, 2013). These processes take several patterns and intersect with the state-led and market-led transformations to promote modern technologies at grassroots level**.** The grassroots initiatives through mobilizations by social movements normally provide new organizational structures for local stewardship of modern energy technologies. In certain instances, some movements have failed to link energy to

expanded rights, acceptance and livelihood encounters to allow a large mobilization in communities with real political influence (Scoones, 2016). Despite the failures, there are important prospects in environmental and climate change justice campaigns by feminist environmental promoters who have firmly promoted livelihoods with alternative renewable energy technologies.

Citizen-led environmental justice campaigns create collaborative action on sustainability and development, and facilitate fundamental transformations to biogas technology. Furthermore, citizen-led actions also happen outside arranged activities. As a result, the production and adoption of renewable technologies becomes day-to-day livelihood practices. Moreover, the utilization of local knowledge and practices are very important for building path ways to renewable energy innovations (Scoones, 2016). In the transformation to modern technology processes, politics are involved. Renewable Energy Technologies (RET) are central to poverty reduction in peri-urban areas but their relevance and significance depend on extensive politics, whether embedded in the technology-led, market-led, state-led or citizen-led processes (Scoones, 2016). The citizen-led efforts can initiate a biogas technology, but it must be backed-up by technology-led, state-led, and market-led transformations.

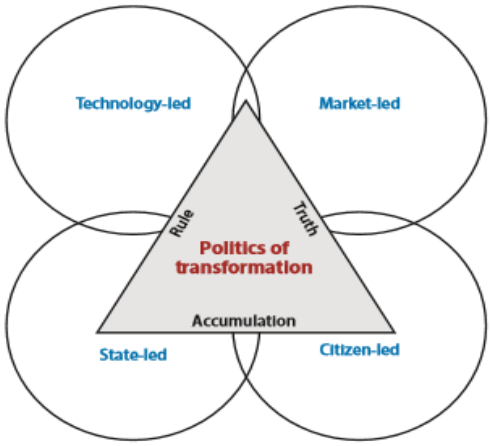

***Figure 5**: Transformations and politics of sustainability*. ***Source:** Scoones, 2016*

3.2 Transition arena

Sustainability transitions require new policy pathways through transition arena which can significantly contribute to the development and adoption of modern technologies in peri-urban areas. Transition arena is an important instrument for interaction and knowledge exchange among stakeholders (Kemp and Loorbach, 2006). It enhances learning among the participants, so that the actors involved adjust their own problem definitions and perceptions because of a better understanding of the nature of the problem and the perspectives held by other actors (Kemp and Loorbach, 2006). In this study, Transition Arena (TA) is employed as a process in engaging with institutions and beneficiaries of biogas technology in Mokambo peri-urban area. It helps to understand the creativity and integration of goals and plans for the biogas technology, and how the participants are involved in the process.

3.3 Adaptation and mitigation

In peri-urban areas, poverty is one of the main stressors surrounding environmental degradation and climate change. Biogas as an alternative source of energy in households has been ignored, despite the threat of climate change. Taking into consideration the adverse effects of climate change on the poor people, turning to biogas would provide a better solution to vulnerable communities. Shifting to other sources of energy with the essence of just combating carbon emissions may not be appropriate enough, but turning to progressive and durable renewable energy such as biogas (Jerneck and Olsson, 2013), might offer some long-lasting solutions for the people in peri-urban areas. It is important to note that the transfer of modern technology takes several ways, and encompasses gender equality, control of environmental resources, and socialization. If gender influences the utilization of social and environmental resources, then it would also induce the proportions of adapting to climate change

(Jerneck, 2018). Therefore, adaptation and mitigation in the lens of gender equality plays a vital role in addressing poverty, climate change and adoption of biogas technology.

3.4 Summary

To sum up, putting the study into perspective, modern technology supported by transformations to sustainability (Scoones, 2016), and Transition arena (Kemp and Loorbach, 2006), and adaptation and mitigation (Jerneck, 2018) serves as a theoretical framework of this study. The choice of the three theories is based on the objective of the study. Transformations to sustainability theory hinges on politics of transformations and the way these play in combination with technology-led, market-led, state-led, and citizen-led processes. The Transition Arena (TA) is employed to engage with institutions and beneficiaries of biogas technology in Mokambo peri-urban area, and how the participants such as constructors of biogas digesters are involved in the processes. Adaptation and mitigation concept has been applied to guide on gender inequality and how it can be addressed in terms of access to, use of and control over renewable energy technologies.

CHAPTER FOUR: RESEARCH METHODOLOGY AND DESIGN

4. Introduction

Research, particularly social research relies on analytical assumptions with systematic investigations using valid research approaches to acquire knowledge about a phenomenon (Creswell and Poth 2017). This chapter provides philosophical assumptions and the methodology which has been applied in the study. It describes among other issues the research paradigm, research design, the study population, sampling and participants' selection procedures, processes employed for data collection and analysis. The researchers' position and ethical considerations are also explained.

4.1 Research paradigm

This research is designed under the interpretive paradigm with emphasis on qualitative interpretative of social phenomena within its context (Collis and Hussey, 2014). The acclamation given to ontological and epistemological belief guides the insinuation which reflects on research models that should have preference over the type of strategy (Blaikie and Priest, 2017). Setting up my study within a paradigmatic structure enabled me to consider my responsibility on what makes up a reality (ontology) and a suitable way of understanding reality (epistemology), which later allows research to be relevant (Perren and Ram, 2004). The interpretive paradigm is suitable to assist with this study because it is based on general monism ontology which contends that observation is an assumption and value laden, and therefore, social global inquiry cannot be separated from the actions taking place in the world (Jackson, 2011). On epistemological point of view, those who embrace this philosophical aspect, maintain that knowledge is socially constructed from people's attributes to nature and their surroundings (Blaikie and Priest, 2017). The principle essence is to help

in the understanding of the world through the lenses of biogas as a sustainable energy source in Mokambo peri-urban area. The analysis is done within the frame of beneficiaries and non-beneficiaries of biogas technology.

4.1.1 Research design

The research design refers to the way in which the researcher establishes a road map to conduct the research (Faryadi, 2019, p. 770). To be precise, this is a strategy which involves making decisions about every aspect of the research in a much grounded way in relation to the research questions and the changing context (Mason, 2018, p. 30). In this study the design has been applied to frame the research, and show how all the parts of the project are integrated to respond to the central research questions. The qualitative research method had been employed. My preference of qualitative than quantitative method was based on the premise that by listening to people's experiences, views and perceptions on biogas, meaningful and accurate information could be obtained. Qualitative method deals with contextualization, interpretation, understanding and perspectives of participants (Faryadi, 2019, p. 769). This method allowed me to have open-ended discussions with the beneficiaries and non-beneficiaries of biogas through interviews. Like any other method, qualitative method has some weaknesses. One of the weaknesses is that it tends to be subjective (Ibid). However, it was my responsibility to be as objective as possible in the study.

Creswell and Poth (2017) argue that Grounded theory, Phenomenology, Ethnography, Narratives and Case study are the five qualitative approaches to scientific investigation. Based on Creswell and Poth (2017) argument, I applied a case study as research strategy. A case study is an empirical inquiry of the phenomenon in-depth and within its real life and context particularly when the borderlines between events and context are not clearly evident (Yin, 2009, p. 2). The case study was appropriate for my research because the geographical nature

of Mokambo peri-urban area offers good prospects of understanding the dynamics surrounding biogas technology. Additionally, this strategy helped me to delve into the intricacies underlying the sociopolitical drivers and barriers to the development and adoption of biogas. Further, it helped me to understand the factors behind local government's failure to provide alternative energy in the area.

The case study extensively makes use of several sources of data which increases the authenticity of the research (Yin, 2009). I formulated an interview guide with open-ended questions for the respondents. This strategy allowed me to be more flexible in the process of the study. The primary and secondary sources were used as well as participant observation to collect data. I had to triangulate the primary and secondary data which include reports, articles and the manual on biogas in Zambia to give more concrete evidence on the technology. The advantage of the case study is that it deals with real life issues and examines views directly related to the situation (Flyvbjerg, 2006). The disadvantage is that the researcher might not follow systematic processes and/or may get skewed views that could influence the direction and outcome of the study (Yin, 2009).

4.2 Study population

A study population is a collection of individuals, objects or members who are the main focus of a scientific inquiry (Faryadi, 2019, p. 771). The target population of this study includes the local community, the local government officials, and ward councilors. Others include Non-Governmental Organizations (NGOs), and parastatal and private institutions which are in the field of electricity supply and implementation of renewable energy projects within Mufulira district and around the country.

4.2.1 Gaining Access to Area of Study and Participants

Prior to the start of fieldwork I contacted the project coordinator for Liberty House Community Outreach Missions in Mokambo peri-urban. I had a brief discussion with him and two civic leaders about the purpose of my study. I clearly stated that the study was the fulfillment of the master's degree programme. I discussed with them the methods through which data would be collected. The discussions took more than an hour. The NGOs and energy supply corporations were contacted through official written communication, with full details about the study. In addition, follow ups were made through emails and phone calls.

4.2.2 Selection of Participants and Procedure

Selection refers to carefully choosing the most suitable ways of coming up with the sample, and gain access to relevant data sources that are potentially generative in relation to a wider universe (Mason, 2018, p. 53). Basically, there are two sampling techniques which researchers usually employ in their studies. These are probability or representative sampling, and non-probability or judgmental sampling (Saunders et al, 2011). A probability sample is a sample which has been selected randomly. A non-probability sample is a sample which has not been selected using a probability random selection criterion (Bryman and Bell, 2007).

For this study, the respondents were selected using a combination of purposive and snowball non-probability sampling technique. Purposive sampling is based on the researcher's preference to select cases which can answer the questions and satisfy the objectives of the research (Faryadi, 2019, p. 772). The purposive sampling allowed me to engage the research respondents who have experience and knowledge in renewable energy technologies. The advantage of purposive sampling is that it is time effective sampling procedure. The disadvantage is high levels of bias because it is based on the researcher's opinion (Faryadi, 2019). A

snowball sampling procedure was also utilized. The snowball sampling is when the researcher makes an initial contact with a participant relevant to the research, who in turn makes contact with others (Faryadi, 2019, p. 773). The advantage of snowball sampling is it is cost effective sampling method. The disadvantage is, it relies on the subjective judgment of the informants (Johnson, 2014). Only two sampling techniques were adopted. Of course, this was against the earlier plan of including the simple random probability technique. The reason why random sampling technique was removed from the three earlier planned sampling procedures is due to:

- **Security concerns**: A group of criminals had spread the country, gassing citizens in their houses at night, and Mufulira district was not spared. Due to increased incidences of chemical spraying, any strange person seen walking in the community could be suspected to be a gasser. Communities started killing any unknown person in their communities (mob justice), and more than 43 innocent citizens lost their lives. Whenever I wanted to enter the community for data collection I had to notify the police. It was scary, and not possible to follow any randomly selected person.

4.3 Data Collection

Data collection is a process of gathering information, and establish meaning to the phenomenon so that one can have answers to the research questions (Faryadi, 2019, p. 773). In this study, three methods of data collection were utilized and these include interviews, document reviews and participant observation.

4.3.1 Interviews

Interviews are common methods of collecting data (Faryadi, 2019, p. 775). In this study, 25 people were selected for interviews. The interviewees were 1 Senior Manager in the renewable energy department from Zambia Electricity Supply

Corporation (parastatal company) and 1 Senior Manager- under the department of renewable energy from the Copperbelt Energy Corporation (private institution). These Energy Supply Corporations were targeted for being major suppliers of power in the country. Two directors (1 for department of Public Health and 1 for department of Engineering Services) from Mufulira Municipal Council were selected. These were selected based on their responsibilities for solid waste management and technical services around the district. Others include 3 NGOs and 2 ward councilors. These are involved in poverty reduction and climate action initiatives. In addition, 8 beneficiaries and 8 non-beneficiaries of biogas digesters project in Mokambo peri-urban were selected in the sample. The participants were selected based on their knowledge and familiarity with biogas technology in Mokambo peri-urban area.

The data was collected using the interview guide. The interview guide was formulated in relation with the research questions. The semi-structured interviews were conducted. Face-to-face interviews with the respondents were applied to bring out primary data (Faryadi, 2019, p. 773). The interviews were carried out at the offices of participants, and homes of the beneficiaries and non-beneficiaries of biogas digesters project. The native language of the participants is Bemba, making it possible for me to carry on with interviews because I understand and speak the language. For participants in institutions, English language was utilized. The interviews were done in the range of 15 to 60 minutes. All the interviews were recorded using my phone after getting consent from the respondents, with the aim of transcribing. The semi-structured interviews were useful because they allowed me to capture data on a number of questions. The advantage of employing semi-structured interviews is that it enables flexibility and freedom of expression during the interview (Faryadi, 2019, p. 775). The disadvantage is that it is time consuming to sit down with respondents and conduct open-ended interviews (Ibid).

4.3.2 Documents Review

The secondary data refers to existing information in the form of specific subjects (Faryadi, 2019, p. 776). Published materials were utilized. I came across the published manual on the productive use of biogas and bio-slurry. Other secondary sources include internet searches and previous research works. Prior (2003) argues that it is important to abandon the search for meanings in texts and instead redirect attention to what is being referenced in documents. Some of these were grey literature such as the Zambia's Seventh National Development Plan (SNDP) which is a blue-print for development up to 2021, and a national energy policy document on the investment plan for renewable energy in Zambia. The advantage of secondary data is that a researcher can easily interpret the information and present it based on their styles. The disadvantage is that the validity and reliability of the source and the information might be questionable (Ibid). The maximum caution was placed on the validity and reliability of these published materials and previous researches to ensure the credibility, authenticity, representativeness and sense (Faryadi, 2019, p. 776).

4.3.3 Participant Observation

In order to get an in-depth understanding and appreciate biogas technology, I utilized participant observation (Burawoy, 1991). The households with biogas digesters were visited. The sites visit of digesters were being done immediately after the interview, and each visit would take 20 to 30 minutes. Viewing biogas digesters and face to face discussion with the beneficiaries and builders of the digesters allowed more information to be revealed. Through participant observation I gained an understanding of the layout of the biogas digesters fitted with pipes and appliances to decompose organic materials. Further, I learnt how cow dung and water are mixed before electricity is generated. The generated energy is meant for cooking and lighting, whereas the digested slurry is used in

agricultural fields, vegetable gardens and orchards. The method of observation was employed to strengthen my understanding of more unaware aspects of biogas in use.

4.4 Researcher Positionality

Realizing my position in the research helped to consider how the study process unfolded. From the beginning of this study, thus all the way back to the idea of the research topic, formulation of research questions and fieldwork, my view as a Zambian originating from the Eastern part of the country, and researching on alternative energy remains at the forefront of my priorities for human development. The expression of biogas beneficiaries that people from outside the area come to talk to them but never come back was an eye opener for me to position myself as a student who has visited the area for academic purpose. Even if I had introduced myself at the initial stage of the study, I constantly maintained my position to build and increase the trust of respondents to enable them give their honest perceptions on biogas. My position in the study fitted well with the participants without contrast. I have admitted that the research was framed by my position as Zambian student. Knowing my position in this research has helped me to change the way of understanding events on personal perceptions, and associate the scientific claims to the course of knowledge production without the researcher's beliefs (Jackson, 2011).

4.5 Ethical Considerations

Research ethics relate to how well the data and knowledge illuminates certain kinds of issues, and the extent to which they can bolster the validity of your arguments (Mason, 2018, p. 96). It is argued that researchers whose main targets are people or elements should reflect on their actions before, during and after their research, and pay special attention to ethical issues related to the research

(Kombo and Tromp, 2009, p. 106). This study was carried out in a manner that upheld the rights and respect of the respondents, and their safety was not compromised. Before commencement of field work, authority was obtained from the civic leaders. The Participant Information Sheets (PIS) and Consent Forms (CF) were availed to the respondents.

The consent form informed the respondents, about who the researcher is, the aim of the study, the use of the collected information, and the research potential benefits to the future of biogas as an alternative energy. The participants were assured that they would not be identified by name and their responses would be treated with utmost confidentiality (O'Relly, 2009, p. 62). Furthermore, the participants were told that they are free to refuse or withdraw from participating in the study at any time. In addition, the interviewees were informed that the interview would take the range of 15 minutes to 1 hour. Further, the participants were informed on where the final copy of the research study could be accessed.

4.6 Data Analysis

The data has been analyzed qualitatively. With qualitative data analysis I refer to thematic analysis in form of identifying and interpreting people's views and situations (Faryadi, 2019, p. 776). First I repeatedly listened to the recorded responses from the phone, and identify common themes and relationships between them. Second I transcribed the recorded interviews manually to give meaning to the data. Third, I categorized the data based on the themes. This was done by focusing my analysis on three categories namely drivers to biogas development, sociopolitical barriers to production and adoption of biogas, and the factors affecting the local government to provide alternative energy.

Saldana (2013) points out that the responses need to be sorted out and the data should be placed in the right categories and themes. For instance, when

considering various sociopolitical barriers to the development and adoption of biogas, relevant responses from all the participants were referred as ‘common barriers’. The theme of key barriers is highlighted and all ideas under this category were arranged for presentation. The data is presented by using illustrative quotes and in line with the participants’ views. This approach of data analysis has been employed to enable me have a meaningful conclusion. It is important to mention that data analysis has been done manually for two reasons. The first reason is that I am not conversant with data analytical tools such as Nvivo for qualitative data analysis. The second reason is that I have serious challenges with internet in my country. It is very difficult to access internet services in Zambia.

CHAPTER FIVE: PRESENTATION OF FINDINGS

5. Introduction

As the case study provided me with in-depth knowledge of the phenomenon, the findings covered many different aspects and are of a broad variety which will be described in this chapter. In the chapter thereafter, the findings will be analyzed in connection to overarching themes. These findings are the expressions of the 25 respondents. The findings have been presented according to the categories under which the participants responded. Suffice to mention that all similar responses from each of the three categories have been integrated and presented under specific themes. For example, all the findings on drivers to biogas production have been presented in the same group. Similarly, all the responses on sociopolitical barriers to the development and adoption of biogas have been grouped together and presented under the same theme. The same approach has been used on the responses for the local government. It is worth noting that lack of funds is appearing as a sociopolitical barrier, as well as a hindrance to local government's participation in alternative energy. Therefore, the financial challenge has been presented separately because the categories, under which it falls, differ in style and content.

5.1 Drivers of Biogas Development

i. Environmental Protection and Climate Change

The pace of development in the world with the use of sophisticated machinery has accelerated the threat to the environment. This has made governments particularly in the Global South to panic and look for solutions. In response to the threats, the Zambian government has developed environmental management measures that would protect the environment (SREP-Ministry of Energy, 2018). The desire to protect the environment has forced communities to embark on biogas digesters as

source of energy instead of fuelwood. This is in line with the responses from the participants as indicated below:

"The environmental protection has driven the development of biogas. In the energy sector, the government through ZESCO-Limited has encouraged the production of Renewable Energy Technologies to generate clean energy. The government through its liberalized energy policy has contributed to the development of biogas production by encouraging the private sector to invests in alternative energy to protect the environment and enhance sustainable development" (Interview 23). Similar views were expressed by interviewee 22.

The cutting down of trees for firewood and charcoal production has contributed to climate change. Communities have been communicating and mobilizing themselves to educate each other on climate conditions which they feel it has drastically changed. Therefore, the threat of climate change has led to the peri-urban community to turn to alternative energy such as biogas. This was expressed in the quoted interview:

"We have been communicating to one another concerning the environment. Personally, I have learnt that destroying the forest contributes to climate change, and is not good for my health and food security. Therefore, turning to biogas digester apart from firewood is the best solution to mitigate climate change" (Interview 5).

ii. View on Economic and Sustainable Development

The blueprint of sustainable development has become widely accepted in today's political discourse. The politicization of sustainability among key pillars of development such as economy and society has enabled the shift to intergenerational thinking. This has given the way for the innovation of biogas technology. In this vein, the private sector has taken keen interest in promoting

sustainable development through alternative energy to support the overall call for sustainability, as revealed by the respondent below:

"Even though Copperbelt Energy Corporation's main focus is to supply power to the mining industry, the corporation has taken a deliberate step towards alternative sources of energy like solar panels. The company has not ventured into biogas per say, but plans are in place to explore biogas and wind energy. I think what has been driving the development of biogas is the enthusiasm for sustainable development, and of course, the rate of industrial growth which has raised high demand for energy" (Interview 16).

iii. Poverty Reduction

It is argued that access to renewable energy is a solution to poverty reduction. The households' ability to acquire modern energy is important to improve the welfare of individuals and communities in peri-urban areas. In an effort to alleviate social problems, institutions have been advocating for biogas as a source of energy for households as they engage in various income generating activities. This is in line with the expression by the participant below:

"ZESCO limited is a vertically integrated institution and wholly state-owned utility company. The main objective is to distribute power to all areas to enable households venture into business activities to improve their living standards. As a power supply company, we are aware that energy is important especially in peri-urban areas for poverty reduction. Right now the corporation has a programme with Rural Electrification Authority to ensure that people in peri-urban areas have access to energy to help them reduce poverty" (Interview 23).

iv. International Aid

Most developing countries depend on the assistance from international agencies for their development agendas. Zambia has embraced organizations which are involved in renewable energy technologies to help the energy poor. The financial assistance from the international agencies drives the development of biogas. The assistance is provided on the premise that households without reliable source of energy can take advantage of the presence of the donors. This was expressed by the respondent as stated below:

"Provision of cattle to households by Heifer International and the presence of SNV and SIDA in Mokambo facilitated the construction of biogas digesters. Biogas needs cow dung, and money to purchase required materials. It is difficult to find such resources in this community, but outside organizations have helped me to construct a biogas digester on my yard" (Interview 1). The similar response was given by interviewee 4.

v. Agricultural Production

The potential increase of agricultural production is one of the economic factors to develop biogas technology. Biogas digesters produce high quality organic fertilizers known as 'bio-slurry' which farmers apply in their farms. The bio-slurry contains nutrients such as nitrogen, phosphorous and potassium essential for crops, and provides nutrients to the soil more than chemical fertilizers (Ghimire, 2016). It is for this reason that farmers go for biogas digesters in order to have access to biogas slurry as fertilizer for their crops. This was stated by the respondent as quoted below:

"Agriculture being the main economic livelihood for the peri-urban community has facilitated the construction of biogas digesters on farm lands. Farmers would want to use the biogas slurry as fertilizer to increase the yield and fish farming.

This is one of the motivating factors for putting up a biogas digester. As DECOP organization, we sensitize these farmers on sustainable agriculture, and promote biogas as alternative sources of energy" (Interview 15). Similar response was given by interviewee 14.

5.2 Sociopolitical Barriers to Production and Adoption of Biogas

i. Lack of Focused Policy and Strategy

The findings show that one of the biggest obstacles to biogas production and adoption in Mokambo peri-urban is lack of focused energy policy and strategy. There is no fiscal policy and strategy to invest in biogas technology (Shane, Gheewala and Kasali, 2015). Additionally, there is no institutional engagement, and this has led to lack of coordination and stakeholder involvement in the energy sector. The renewable energy sector has not been given much needed attention by the politicians. Institutions are not willing to invest in renewable energy for fear to lose their capital. Again, corruption tendencies in the implementation of development projects are high. These are expression of the participant as quoted below:

"Biogas is good to improve peri-urban communities. There is no one who can refuse to have electricity in the house. The problem is lack of political-will to enforce policy implementation of alternative energy. There is no keen interest in biogas technology. We are relying too much on hydropower system which has failed to meet the demand of power supply. The problem is with us politicians who want self-gain through corrupt practices at the expense of the poor. Even some financial lending institutions have no confidence in renewable energy sector (Interview 2). Similar responses that institutions are hesitant to invest in renewable energy fearing to lose their finances were also expressed by interviewee 16 and 23.

ii. Technical Barriers

The ability to use modern technology requires full knowledge of the equipment. Unfortunately, high illiterate rates in the peri-urban area have contributed to inability to operate biogas digesters. There is limited technical capacity/expertise in Mokambo peri-urban to design, install, operate, and maintain biogas digesters, as the respondent puts it:

"Technical knowhow is a challenge to successful production and adoption of biogas. There is lack of training on how to operate biogas digesters in the community. Renewable energy technologies require some technical knowledge on the part of the user. Unfortunately, such knowledge and skills are very low in this community" (Interview 20).

iii. Lack of Awareness

Access to information is important for members of the community to make informed decisions. For an innovation like biogas to be developed and adopted in communities, sensitization is key to its success. Regrettably, many people in Mokambo peri-urban are unaware of the biogas technology. This is attributed to the low level of awareness on the benefits of biogas, and unprogressive traditional beliefs held by households (Shane, Gheewala and Kasali, 2015). The majority of the community members lack education and critical information on the importance of biogas. This is a huge barrier to the successful production and adoption of biogas in the area. This statement is in line with the expression of the respondent as quoted below:

"One of the major barriers is lack of awareness in the community. Although the energy sector has been liberalized, the use of biogas would partly depend on how well-informed about the technology the potential household-user is. Unfortunately, there is lack of community awareness on biogas which has

contributed to some resistance to change" (Interview, 10). Interviewee 23 also brought up the same sentiments.

iv. Gender Inequality

The reproductive and productive work of women is often not valued. Women face challenges to access and gain control over resources. Resources are unevenly distributed, and women are more marginalized than men in almost all sectors of the economy. In this study, the majority of the respondents were women who own biogas digesters. Despite having such a technology their contribution to sustainability is ignored. Sectors which are crowded by women, technological progress and ideas are usually overlooked. This is echoed by a participant as indicated below:

"Biogas is good for household welfare, but the playground is not fair for women. Men have more advantage than women in terms of access to resources. Women are always neglected and regarded as not fit enough to par-take such innovations" (Interview, 25).

Another respondent said that she was not very much recognized among the men. She explained that *"I was chosen to attend a 12 days training in construction of biogas digesters in Kabwe town. There were 30 men and 4 women in the workshop. Being a woman, the organizers were asking if l would be able to construct the biogas digester after the training. I told them 'yes' I would, and here I am, I have constructed a biogas which I use for cooking" (Interview 17).*

v. Financial Constraints

Renewable Energy Technologies (RET) are capital intensive, requiring significant upfront costs. With most households in Mokambo peri-urban not electrified, connecting to the national grid is absolutely necessary, but very expensive. Poor

people face challenges associated with the high initial capital cost of acquiring RETs, especially when compared with the low cost of charcoal. High cost of biogas construction is a barrier which the respondent pointed out as quoted below:

"Most of the people are poor in this area. The same poor households are asked to pay upfront payment cost towards the construction of biogas digesters. This is commercialization of development through capitalism and neoliberal instincts. The poor are being exploited. Of course, I have biogas on my farm, and I paid K3, 500 (350 USD) upfront payment for materials, which is very expense for an ordinary peri-urban community member. Only very few households can manage" (Interview 6). Interviewee 21 had expressed the same thoughts.

vi. Inadequate Feedstock Supply

Heifer International provided the small-scale farmers with farming inputs and livestock to ensure food security. The organization supported biogas digesters project because it has the potential for poverty reduction. When digesters are constructed, the owners need to feed them regularly with the right amount of animal manure, and water. The availability of manure is vital to ensure continuous operation of the digester. However, there is lack of enough feedstock which is a barrier to biogas production. This is expressed by the respondent below:

"*Only few households have biogas digesters because of lack of cattle to access cow dung. To build a biogas digester, one should have animals like cattle or pigs to give you manure needed to feed the digester and generate energy. Without animals, you cannot think of building a bio-digester" (Interview 3).* On the same subject, other respondents expressed same views as quoted below:

"I would like to have a biogas digester at my home, but l do not have cattle to access dung for the digester. Only few households benefited animals brought by Heifer International" (Interviewees 9, 11, 12, 18 and 19).

vii. Lack of Monitoring Mechanism

The installed biogas digesters require monitoring to ensure efficient and effective operation. Unfortunately, due to lack of monitoring mechanisms in Mokambo, biogas digesters are not functioning. The biogas digesters have failed to function because of lack of monitoring by the team tasked with the responsibility. This statement is line with the respondent's expression below:

"Biogas project in Mokambo has not achieved the intended objective due to lack of monitoring of the constructed digesters. For example, SNV and SIDA installed a biogas digester at my backyard, but no one has taken up the responsibility to monitor the operation of the installed plant. Not even the local authority, including the sponsors of the project has come to check on the operation of the biogas digester" (Interviews 6).

viii. Lack of Titled Land

Furthermore, the study revealed that the other barrier to biogas production is lack of ownership to land. Most of the people in the peri-urban area do not own land. Land is in the hands of the council. It is difficult for the poor to acquire land from the local authority. This is in line with the response as quoted below:

"Land ownership is cardinal to any form of development. Without land you cannot think of constructing permanent structure. Many people in Mokambo have no land titles, and they are squatters. In most cases, squatters on state and customary land do not think of constructing biogas digesters because of their insecurity" (Interview 13). Similar response was expressed by interviewee 7.

5.3 Factors Affecting Local Government to Provide Alternative Energy

i Lack of Strategic Planning

The municipal council has the responsibility of providing social services to peri-urban areas. Among the services include solid waste management for various purposes including energy generation. However, the local authority in Mufulira district does not separate and process solid waste to generate energy for consumption. The Mufulira Municipal Council has no specific plans in place to generate energy from the solid waste. This was expressed by the respondent as quoted below:

"The department of public health in the council is responsible for solid waste management in the district to prevent diseases in communities. Waste is collected and disposed of in designated sites by land filling. There are no specific plans or strategies in place to use waste to generate electricity. The council does not provide any alternative energy to peri-urban areas. The council provides public health education and water supply by drilling boreholes in rural and peri-urban areas" (Interview 8).

ii. Lack of Funds

In Zambia, the national energy policy clearly points out biogas and other forms of renewable energy, but pays more attention to hydropower system. Although the 7th National Development Plan has a well stipulated renewable energy policy, the local authority does not provide renewable energy technologies in Mokambo peri-urban area. This is in line with the respondent expression:

"Despite having the Renewable Energy Feed in Tariff policy in the 7th National Development Plan, the local government is not providing alternative energy in Mokambo peri-urban. I would like to see alternative energy in this peri-urban but

it is impossible because of lack of financial resources. The funds being raised by the council are not enough to invest in biogas technology or other renewable energy projects" (Interviews 2).

iii. Staff Capacity and Expertise

Capacity building entails an organization having sufficient number of staff who possess the necessary knowledge and skills for technical and management systems. Unfortunately, Mufulira Municipal Council has inadequate staff. Furthermore, the existing staff has limited knowledgeable about renewable energy technologies. These are the views of the respondent as quoted below:

"My department only provides solar street lighting in urban areas. The challenge is that the council do not have enough staff to undertake biogas projects. Moreover, we lack knowledge on renewable energy technologies. I think we need expertise in the field of alternative energy" (Interview 24).

CHAPTER SIX: ANALYSIS AND DISCUSSION

6. Introduction

In this study, I was interested in exploring the sociopolitical drivers and barriers to the development and adoption of biogas. In addition, I wanted to understand the factors hindering the local government to provide alternative energy in Mokambo peri-urban area. Twenty-five people were interviewed, and the responses were categorized. The findings are analyzed and discussed in relation to the research questions, previous literature, and the theories employed in the study as outlined in chapter three.

6.1 Drivers to biogas development

The study was set up to explore the barriers to the development and adoption of biogas in Mokambo peri-urban area. First I wanted to establish the factors driving the development of biogas. Findings revealed that there are basically five drivers, and these are environmental protection and climate change, view on economic benefits and sustainable development, health benefits and poverty reduction, international aid, and agricultural production.

i. Environmental protection and climate change

The environmental protection and the threat of climate change as main drivers of biogas development in the community became prominent among the responses. This finding of the study is in line with Ošlaj and Muršec (2010) study on renewable energy. In their study, they found that environmental preservation, improvement of security and energy diversity supply drives the development of biogas. However, my findings show that there are no security improvements, and the energy supply in Mokambo peri-urban area is erratic. Additionally, my study compliments the claims by SRE-Ministry of Energy (2018) that climate change mitigation measures facilitate the production of biogas in the community. Locally,

people get in touch and educate each other about the importance of preserving the environment. Education about climate change is a factor which increases sustainable transformations and the lack of it, is a big barrier. I discovered that people in the community communicate to each other about climate change, which leads to stronger efforts to look for alternative sources of energy, and community-led development.

Community-led development is associated with citizen-led transformations. The transformations to sustainability theory suggest citizen-led transformation as one of the four main ways of transformations. Citizen-led transformation refers to mobilization, networking, and capacity building for sustainability transformations (Gupta, 2013). It presents itself in the community predominantly through oral communication within and between individuals and communities. The communication between individuals in the community on environmental degradation, and more specifically in relation to biogas digesters has been extensive in the field *(interview 5, 22, 23).* However, I found lack of concrete citizen-led, to action that goes beyond communication. For example, biogas digesters project as alternative energy was borne out of donor (SNV and SIDA) and Heifer International led initiative. From my findings, I conclude that this initiative is a hybrid neoliberalism and not genuinely citizen-led.

The intersectionality between technology-led, state-led and citizen-led transformations as discussed by Scoones (2016) becomes apparent when tracing the origins of the knowledge on environmental degradation and biogas technology to government information given out to the community. The state has failed to use its political influence to mobilize communities for environmental matters and livelihood initiatives that can encourage a shift to renewable energy like biogas. In reality, renewable energy technologies are key to many transformations, but their significance and value depends on more sizeable politics (Scoones, 2016).

ii. View on Economic benefits and Sustainable development

The investigations of this study are in line with Mulinda, Hu and Pan (2013) and Shane, Gheewala and Kasali (2015) claims that the views on economic benefits and sustainable development facilitate the innovation of biogas technology led by government institutions. However, my findings revealed that private institutions are more involved in the initiation and implementation of biogas technology than the government. The private sector has taken advantage of the energy deficit on the market to make profit. It is the market-led transformation that is exploiting the fortunes of the biogas technology. Complimenting on Shane, Gheewala and Kasali (2015) study, my findings show that more women benefit, and the economic benefits include increased productivity, efficiency and risk reduction.

Scoones (2016) argues that critical thinking about sustainable development encourages political goals on the economy, society and technology. The transformation to sustainability theorizes market-led solutions as a remedy aiming to ensure the right prices, protection, and sustainability. In practice, the commercialization of economic growth and sustainable development has resulted into extractive and exploitative tendencies towards the energy poor, and fails to bring sustainability due to neoliberal capitalist connections. Biogas as an alternative source of energy in Mokambo peri-urban area has not thrived due to lack of the state intervention.

iii. Health Benefits and Poverty Reduction

The study by Energy Africa- Zambia (2018) established that bioenergy could reduce pre-mature deaths by 500 per annum by 2030. Additionally, Smith (2011) found that biogas technology is closely linked to poverty alleviation. The findings of the study uphold the claims by Energy Africa Zambia (2018) and Smith (2011) because I found that impoverishment has led to the production of biogas in Mokambo peri-urban area, and there is a strong link between access to modern

energy and poverty reduction. Further, the participants mentioned of reduced workload, particularly on the part of the women for not walking long distances to collect firewood, and other health benefits by using improved cook-stoves. However, these highly pronounced benefits by the respondents who own biogas digesters were not physically seen on the ground because the bio-digesters are not functioning. High poverty levels are visible in the community, because biogas is not easily accessible, affordable, reliable and usable at household level.

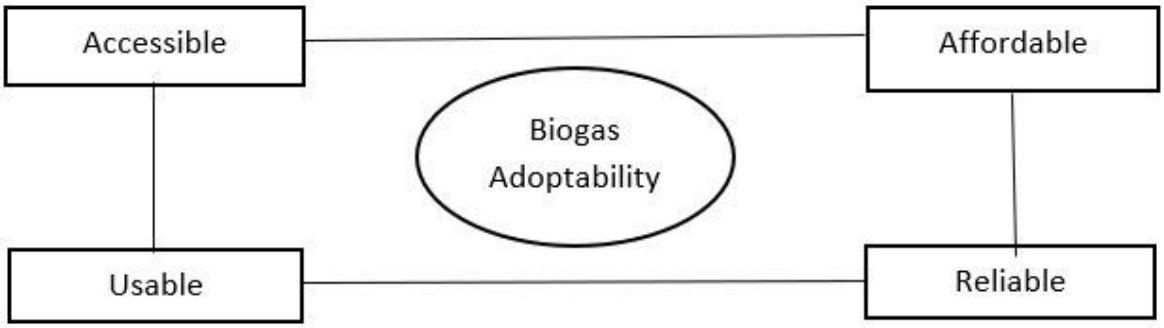

Figure 6*: Illustration aspects of biogas adoptability* ***Source:*** *Authors' own articulation*

iv. International Aid

The investigations revealed that assistance from international organizations played a critical role in the development of biogas in the community. The respondents who are the beneficiaries of biogas mentioned that receiving cattle from Heifer International and material support from donor agencies (SNV and SIDA) enabled some households to construct biogas digesters. My findings are in line with Mulinda, Hu and Pan (2013) study, that networks of various stakeholders have been engaged to support the development of biogas. This represents technology-led transformation as articulated by Scoones. Organizations supporting technology-led transformations are socially embedded and located in communities and end up with different technological solutions (Scoones, 2016).

At the initial stage of the project in Mokambo peri-urban, the agencies provided biogas materials to households to construct bio- digesters as demonstration. The rest of the households were not provided with the building materials. This resulted into very few households having constructed biogas digesters.

v. Agricultural Production

My findings of the study reveal that community education on the benefits of increased agricultural production enables the people to go for biogas technology. These findings confirm what Mulinda, Hu and Pan (2013) found in their study when they examined the effects of biogas on agriculture. The respondents mentioned that biogas digesters produce not only electricity, but also bio-slurry which is used as organic fertilizer *(Interview 6 and 17)*. The focus is on the use of biogas to maximize the benefits of bio-slurry when it is applied in the farms and gardens. My findings expands this claim by pointing out that besides applying bio-slurry in farms as organic fertilizer, bio-slurry is also used to feed fish in ponds. Based on the findings, I argue that biogas is important for human development and improvement of the living conditions of people in the peri-urban area. Therefore, maximizing on cultural, social, economic, political, and environmental benefits from the digested products enhances technology-led development and livelihoods (Scoones, 2016).

6.2 Sociopolitical Barriers to Biogas Production and Adoption

The research question about sociopolitical barriers is formulated to establish the factors affecting the production and adoption of biogas in Mokambo peri-urban area. The findings show four main barriers, with each barrier having an element attached to it. These are institutional, situational, infrastructure and technical, and dispositional barriers.

6.2.1 Institutional Barriers

i. Policy and strategy

In Zambia, the policy and strategy on biogas is not precise and clear. Despite the fact that energy is pivotal for the nation's advancement, energy policy matters and discussions have paid little attention to biogas. Biogas technology transition needs good fiscal policy which attracts incentives both to the energy poor and the potential investors (Shane, Gheewala and Kasali, 2015). The energy policy and strategy which is in the Seventh National Development Plan is not well framed to enable relevant institutions to implement it. The promotion of biogas is clearly mentioned in the national energy policy but it does not go into details to clarify how it would be done. The findings of my study are in line with Roopnarain and Adeleke (2017) and Mfune and Boon (2008) investigations, that production and adoption of biogas technology have been unsuccessful because of weak policies and lack of integrated approach for renewable energy. However, the two studies do not point out actual reasons underlying the lack of policy implementation and coordination. My finding points to corruption, and inadequate technical staff leads to the widening gap between the stated energy policy goals and attainment of the planned goals.

Technology-led and state-led transformations provide the leeway on how to deal with biogas development and adoption. Drawing from different analyses of sociotechnical change, renewable energy management requires particular institutional and policy levers for effecting change towards bioenergy (Scoones, 2016). The overall success in biogas development takes into account political processes. Moreover, the political-will has a huge influence in the development of renewable energy technologies through bottom-up approach with a wide consultative view in peri-urban areas.

ii. Lack of awareness

Through this study I found that there is lack of sensitization on biogas in the peri-urban area. Many people are not aware of the benefits of biogas technology. These findings confirm the claims by Mugodo, Magama and Dhavu (2017) and Rupf et al (2015) that in sub-Saharan Africa, policy makers and business houses have no adequate information on the potential benefits of biogas. My findings resonates and expands this claim further by revealing that high illiteracy levels in the community, and lack of electricity and exposure to both print and electronic media have increased the problem of not accessing and passing on information about biogas technology.

Mokambo peri-urban is behind in terms of modern communication channels that befits human standards. People lack awareness and information that can assist them to make informed decision on the production of biogas technology. Scoones (2016) states that sustainability thinking calls for different traditions and politics of resources to explore the policy and practices. Therefore, transition to biogas requires potential beneficiaries receiving accurate information. The process to information awareness involves diverse knowledge and multiple practices to implement it.

iii. Lack of management and monitoring of installed biogas digesters

My findings show that the installed biogas digesters in Mokambo peri-urban are not functioning because of lack of management, and monitoring. Of all the 8 biogas digesters which I visited, no installed bio-digester is functioning. It is difficult to determine whether or not these 8 biogas units are among what Kaunda, Morel and Mtawali (2013) claims to be functioning in Zambia. My findings are in line with Mfune and Boon (2008) discovery that biogas plants are not well managed. Since the digesters were constructed in 2014, no monitoring team either from the central government or the private sector, including SNV and SIDA has

monitored how the biogas digesters are operating. The Zambian government and its partners have not taken monitoring of the installed bio-digesters as an important aspect in strengthening modern technologies. However, the study done by Mfune and Boon (2008) could not ascertain the causes of ineffective management and lack of monitoring. My findings show that there is absence of continuity allegiance to energy policy, and lack of clear definition of responsibilities, and coordination. This is a drawback and defeats the whole purpose of promoting biogas technology. Scoones (2016) maintains that sustainability and advancement outcomes are important aspects, and they pave the way for monitoring and evaluating change.

6.2.2 Situational Barriers

i. Financial constraints

Lack of enough financial support to invest in biogas production, transmission, maintenance and distribution is one of the challenges facing the Zambia's renewable energy sector. The results of this study are in line with Kemausuor, Adaramola and Morken (2018) and Parawira (2009) investigations that biogas plants are expensive to operate and maintain. The production and adoption of biogas technology has remained behind in Mokambo peri-urban due to high installation and maintenance costs. My study show that $4m^3$ and $6m^3$ of biogas digester requires K1, 500 (US$150) and K3, 500 (US$350) respectively as installation costs *(Interview 6, and 22).* This amount of money is too high to raise for peri-urban population that depend on farming for livelihood. Additionally, my findings upholds the assertion by Mfune and Boon, (2008) that the prices of renewable energy technologies are much higher than what an average Zambian household could afford. The findings of my study expand this claim by revealing that among the most affected social groups that cannot afford are the peri-urban communities.

The first two biogas digesters in Mokambo were constructed as demonstrations. Thereafter, the sponsors of the project started asking for upfront investment payments from the people. Many households in the peri-urban area did not manage to construct biogas digesters. The failure by the households to pay the initial capital costs prompted the sponsors (SNV and SIDA) of biogas to request potential beneficiaries to contribute in kind by providing bricks and digging digester pits. The required materials and expenses were to be provided by the sponsors. Very few households were assisted. These findings confirm what Yousuf et al (2016) found in their study that the barriers to biogas technology arise due to the disorganized efforts introduced by the developers and agencies. However, my findings extend this claim by revealing that the sponsor's interest took center stage than the welfare of the people. Only fourteen households in Mokambo peri-urban managed to construct biogas digesters *(Interview 1).* The majority of the farmers failed to construct digesters, thereby rendering the development and adoption of biogas in the peri-urban technically impossible.

Further, my findings are in line with the Central Statistical Office (2010) conclusion that 76% of high poverty levels in Zambia's rural areas and 26 % in urban areas contributes to lack of bioenergy development. In line with the Central Statistical Office (2010) assertion, my findings expand this claim that the inability to develop and adopt biogas technology in Mokambo peri-urban area is due to lack of adequate household empowerment. People have no income, and the stance taken by the initiators of biogas project to ask the poor households to pay high upfront investment cost for biogas digesters leaves much to be desired.

Pueyo (2018) established that public services in sub-Saharan Africa are not credit worth. As a result financial institutions perceive the renewable energy sector as a risk business, making it difficult for investors to access financial support. My study in addition to Pueyo (2018) assertions, found that inadequate information about biogas is the main reason why financial institutions fear to invest in

renewable energy. The alternative energy debate falls under the politics of sustainability and development. Therefore, the technology-led, market-led, state-led and citizen-led transformations as outlined by Scoones (2016) come into perspective. These aspects play key role in ensuring that stakeholders understand the development of modern technology.

ii. Inadequate feedstock supply

With the abundant feedstock, biogas production can address the energy challenges in Zambia (Shane, Gheewala and Kasali, 2015). My findings on feedstock contradict with Shane, Gheewala and Kasali (2015) study that animal manure is enough for biogas production in Zambia. In this study, the findings show that feedstock is not enough to feed the biogas digesters because people do not have enough animals. For example, Heifer International provided one cow to each household, and only one hundred and fifty households benefited out of over one thousand households *(Interview 1).* It is from one provided animal per household that each household is expected to access cow dung to feed biogas digesters. It takes more than 5 days for a cow to produce a 20kg of dung to be mixed with water in order to generate energy *(Interview 1, 2 and 17).* This is practically impossible to sustain a biogas digester in the peri-urban area if feedstock is not enough. This brings the idea of Scoones (2016) that in the transformations to sustainability concept, state-led intervention becomes very important for effective implementation of programmes and projects of sustainable energy.

iii. Lack of land tenure

In peri-urban areas, land ownership plays key role with regard to what and/or how a person can make use of the land. People with titled land have the autonomy and can decide on what to do with their land, which may not be the same with people without land. Peasant farmers who have lease agreements or land titles have

improved their investments and are more productive than the landless farmers (Smith, 2004). It is easy for households with titled land to construct biogas digesters as opposed to those without land. My finding resonates with Smith (2004) study on land tenure. My investigations reveal that land is an obstacle to the production and adoption of biogas in the community. The poor people needs titled land to be able to put up biogas plants, but this is not easily accessible to them. My findings uphold the assertion by Scoones (2016) notion on transformations to sustainability ideas that issues to do with land revolve around access and rights in a highly altered manner, and sometimes violence and greedy over resources occurs. He further points out that local people in the context of the so-called land ownership raise questions concerning tenure rights, and land administration systems. He therefore, emphasized on mutual understanding between stakeholders and the need to develop institutions that address this process (Ibid, p. 298).

6.2.3 Infrastructure and technical barriers

i. Infrastructure

In sub-Saharan Africa, poor grid network is one of the critical infrastructural barriers to sustainable energy. Kesselring (2017) and Tucho et al (2016) established that grid network infrastructure is not good enough in Zambia, and entire sub-Saharan region. It affects access to renewable energy power plants and transportation of supplies in rural and peri-urban areas. However, the two studies could not ascertain the bottom-line leading to poor grid network and transport infrastructure. Based on the findings, I argue that the first preference of urban development than rural and peri-urban areas development by policy makers is the major reason for poor infrastructure. Moreover, the dependence on hydro-power systems has affected the development of other sources of energy.

ii. Inadequate technical expertise

The lack of knowledge on biogas digesters by constructors, coupled with poor quality of construction materials has affected the implementation of renewable energy technologies in Zambia. The builders are not well enlightened and have no technical knowledge to construct and maintain biogas digesters. In Mokambo peri-urban, participants revealed that poor workmanship of biogas digesters has led the digesters to have leakages *(interview 1, 3, and 20).* This has contributed to non-operation of the bio-digesters. These findings are in line with the assertions by Suberu et al (2013) and Shane, Gheewala and Kasali (2015) that the use of scarce, economic and sub-standard materials in the installation of digesters accompanied by the lack of human skills affects the operation of biogas. My findings attest to the two studies, and expand these claims that biogas digesters in Mokambo peri-urban area are of poor design, and not operating due to inadequate knowledge and skills by the constructors.

The team which built biogas digesters did not receive adequate training to acquire knowledge and skills on biogas digesters. From my field experience, this is attributed to the country's inability to effectively adopt biotechnology policy, substandard scientific technology base, and minimal basic research in institutions of learning. Scoones (2016) reasoned that transformations to sustainability gives way to renewable energy sources if the broad arrangement of power involving states and corporations are fundamentally associated with knowledge, and expertise. The findings of my study compliment the claim by Scoones (2016), and confirm that biogas technology is not prospering in the peri-area area due to lack of knowledge and technical skills. It is evident from the findings that knowledge and technical expertise determines the design, quality and life-span of the biogas technology.

Further, the community especially farmers are more concerned with lack of technical know-how exhibited by biogas constructors, which can lead to reliable networks to look for more local participants to be engaged as builders. My findings uphold Kemp and Loorback (2006) transition arena ideas, that a network of innovators and strategic thinkers from different backgrounds will come together to discuss the transition in a strategic way. My study concurs with this claim because a network may include actors such as local authorities and people with practical knowledge about biogas technology. However, the findings of the study differ with Kemp and Loorback (2006) suggestion that frontrunners should go beyond their working areas to look for capable people. Base on the findings, I argue that the energy poor are aware of their needs, and capable of identifying competent biogas constructors by virtue of their standing and networks in peri-urban communities. Enlightening the people on the need to participate in the development and adoption of biogas technology will be difficult to achieve, if local knowledge and citizen-led transition is not incorporated.

6.2.4 Dispositional barriers

i. Intersectional (gender) inequality

Intersectional inequality is associated with social identities such as sex, gender, class, race, and ethnicity. In addition, gender is among the inequalities working at the center of poverty, deterioration of the environment, climate change and technological issues (Jerneck and Olsson, 2012). The findings of this study uphold the claims by Sebitosi and Pillay (2005) and MacKeracher, Saurt and Potter (2006) studies that women are uneducated, vulnerable, discriminated, lack opportunities and capacity, and end up getting low deal of everything including renewable energy shares. However, this study contradicts with Sebitosi and pillay (2005) and MacKeracher, Saurt and Potter (2006) results that women get low deal of renewable energy. The findings of my study show that more women than men

own biogas digesters. Seven of the eight visited people who own biogas digesters in Mokambo peri-urban are women.

The question could be; why women? From the field notes and through interaction with the participants, I found out two reasons that bring women into the spotlight of bio-energy. First, women and children are the poorest social group compared to men in the area (CSO, 2010). Due to societal and cultural perceptions, women have less access to resources to enable them stand on their own. Therefore, targeting the females in the biogas digesters project was one of the possible and alternative means of empowering the women and enhancing gender equality *(Interview 25)*. Second, there is a perception that women are more caring for the environment and addressing adverse effects of climate change. My findings of the study confirm Jerneck (2018) reasoning on adaptation and mitigation that climate change policies are associated with energy policies which can enable people to diversify their livelihoods, and strengthen gender equality.

In Mokambo peri-urban area people understand the modern technology and its potential benefits differently, making it crucial to embrace. For instance, women and men perceive technological uptake differently because of gender regimes. Considering the current division of gender between production and reproductive labour, the provision of biogas digesters constitute a synergy between several SDGs from poverty eradication to increased gender equality and reduced emissions. Further, my investigations upholds Jerneck (2018) views, and argue that livelihoods can be enhanced through the development and adoption of clean energy such as biogas, of which women in Mokambo peri-urban have taken keen interest in the technology. An eminent technological shift to biogas digesters can offer nine of the seventeen SDGs by reducing environmental degradation, health hazards to women and girls, and enhancing access to clean energy.

ii. Resistance to change

Resistance to change from the use of primitive modes of energy to modern energy like biogas can be associated with cultural beliefs and traditions in peri-urban areas. In Zambia, the traditional and cultural beliefs that women should not enter a kraal (Shane, Gheewala and Kasali, 2015), to collect dung contributes to the resistance to the development and adoption of biogas. My findings contradict with this claim. This study's results show that women are free to enter the kraal and collect cow dung for biogas digesters, contrary to Shane, Gheewala and Kasali (2015) study. The lack of sufficient knowledge and confidence in biogas technology is the main cause for resistance. For example, on the Copperbelt province of Zambia, people in peri-urban areas continue to cut down trees for charcoal production and firewood because it is affordable (Nyembe, 2011).

The findings of this study maintain the claim by Nyembe (2011) that some people resist to adopt and embrace new technology if they see it to be unaffordable. This is because people's behavior and attitudes are difficult to change, and repugnant to their own advancement. My findings uphold Scoones (2016) assertion that with state-led actions and robust approach of disseminating information, people would understand the benefits of biogas technology and accept change.

6.3 Factors Affecting Local Government to Provide Alternative Energy

With the research question two, I wanted to understand how the local government fail to provide alternative energy in Mokambo peri-urban area. The results show that there is no plan to provide renewable energy technologies in the peri-urban area *(interview 8 and 24).* The findings of my study established two hindrances contributing to the local authority's failure to provide alternative energy. First is lack of financial support to embark on alternative energy in peri-urban areas. The local authority depends on its narrow cash revenue collection base which cannot sustain the full operations of modern energy projects. The central government

provides equalization fund once in a while. The same equalization fund is not enough to support renewable energy projects such as biogas.

The second hindrance is staff capacity and expertise. The local authority has insufficient staff to handle the renewable energy sector effectively. Additionally, there are no staffs that are trained in Renewable Energy Technologies (RET) to respond to the cross-cutting issues like alternative energy. The personnel at the council has no knowledge and skills in the operations of biogas. These findings are line with Borchers (2015) assertion that non-provision of alternative energy by the local government is due to lack of financial resources and staff capacity. My findings expand this claim and reveal that unexplored renewable energy options by the local authority have affected the development of biogas.

6.3.1 Engaging Local Government in Alternative Energy

Renewable energy has been recognized as a key component in enhancing economic development. Therefore, the local government can play an active role in peri-urban areas' renewable energy. The findings of my study uphold Couture and Leidreiter (2014) claim that local government's contribution to renewable energy is a political decision and ethical imperative. My findings expand this claim that the energy policy implementation strategy and assigning of responsibilities to specific departments would enable the local government play a proactive role. Further, my study upholds Scoones (2016) transformations to sustainability views that development and adoption of modern technology requires state-led transformations to facilitate public investment and policy incentives to marshal quite long term goals and private finances, either at an initial or later stage of technology implementation.

6.4 Summary of the Analysis and Discussions

The findings were categorized to ascertain the sociopolitical drivers and barriers to the production and adoption of biogas. Further, it was meant to understand how the role of local government to provide alternative energy is hindered by lack of funds, and staff capacity and expertise as follows:

- Drivers of biogas development
- Sociopolitical barriers to biogas production and adoption
- Factors affecting the local government to provide alternative energy

6.4.1 Connection of Results to Research Questions

The modern energy has been praised as essential for enhancing green growth and attainment of sustainable development. This study has been guided by two research questions. The first question focused on the institutional, situational, infrastructure and expertise, and dispositional barriers to the development and adoption of biogas. The second research question looked at how the local government fail to provide alternative energy. The views of beneficiaries and non-beneficiaries of biogas, including those in public and private institutions were explored.

With the help of the research questions, the findings of this study points to environmental protection and climate change mitigation, the view on economic benefits and sustainable development, health benefits and poverty reduction, international aid, and agricultural production as the drivers of biogas production. Further, my findings show that lack of clear energy policy and strategy, lack of awareness, inadequate monitoring, financial challenges, inadequate feedstock, lack of titled land, inadequate training and expertise, gender inequality and resistance to change are key sociopolitical barriers to the production and adoption of biogas in Mokambo peri-urban area. The local authority does not provide

renewable energy technologies in the peri-urban area due to lack of funds, and staff capacity and expertise.

6.4.2 Connection of Results to Literature Review

The findings of my study uphold the claim by Ošlaj and Muršec (2010) that environmental protection and the climate change mitigation measures enhances the production of biogas. In addition, the findings of this study are in line with Mulinda, Hu and Pan (2013) and Shane, Gheewala and Kasali (2015) claims that the views on economic benefits and sustainable development facilitates the innovation of biogas technology led by government institutions. However, the findings contradict with Mulinda, Hu and Pan (2013) and Shane, Gheewala and Kasali (2015) claims that governments initiate and implement biogas technology projects. My findings show that biogas technology is initiated and implemented by the private sector. Furthermore, these findings are in line with Mfune and Boon (2008) and Borchers (2015) studies that poor policy implementation, lack of funds and lack of interest in alternative energy affects the development and adoption of clean energy. My findings expand this claim and reveal that corruption in public institutions and lack of initiatives to explore modern energy has negatively affected the production of biogas technology.

6.4.3 Connection of Results to Theory and Conceptual Framework

In this study, my findings concur with the transformations to sustainability theory (Scoones, 2016), that renewable energy technologies require public investments, and policy stimulus to induce long term private support, whether in the early stage of development or later in the implementation. In addition, my study compliments Kemp and Loorbach (2006) ideas, that modern technological solutions through participation might be an answer to Mokambo peri-urban energy problems. However, biogas is not a final solution to energy poverty. People are aware of

their needs, and capable of identifying the strengths and weakness through democratic process. Further, the findings of my study uphold the assertion by Jerneck (2018) that adaptation and mitigation are among the two essential guides to climate change, poverty reduction, and that technology development and adoption might not be successful if gender equality is not incorporated.

CHAPTER SEVEN: CONCLUSION, RECOMMENDATION AND REFLECTION

7. Introduction

In this chapter, conclusions, recommendations and reflections are drawn based on the research findings, analysis and discussion. The conclusions are presented with regard to the objective that was set and the research questions of the study, followed by the recommendations, reflections, and the possible future research.

7.1 Conclusions

The study has explored how the institutional, situational, infrastructural and technical expertise, and dispositional barriers have affected the development and adoption of biogas in Mokambo Peri-urban area. In addition, the study has examined how the role of local government to provide renewable energy in the peri-urban area is affected by lack of funds, staff capacity and expertise. Using the qualitative method with the guidance of transformations to sustainability, transition arena, and adaptation and mitigation theories, the study has provided insights into social, economic and political drivers and barriers to biogas production and adoption. Based on the findings the driving forces are; the desire to protect the environment and climate change mitigation, economic benefits and sustainable development, health benefits and poverty reduction, international aid, and agricultural production.

The barriers to the development and adoption of biogas include inadequate policies and strategies on modern energy, lack of community awareness on Renewable Energy Technologies (RET), lack of maintenance and monitoring of installed biogas digesters, high upfront payment costs, and inadequate feedstock supplies. Others are lack of titled land, intersectional inequality and resistance to change. The local authority (Mufulira Municipal Council) fails to provide

alternative energy because of lack of funds, staff capacity and expertise. This study is of great significance because it will enable policy makers and implementers of sustainable energy programmes to refocus their priorities. The study has added to the literature that lack of clear and precise energy policy implementation and strategy, lack of knowledge, and inadequate Research and Development on renewable energy technologies affects the production and adoption of biogas. From my findings, I conclude that the development and adoption of biogas technology needs quadruple (thus technology-led, market-led, state-led and citizen-led) transformations, social learning, and adaptation and mitigation in the energy sector, and wider system changes.

7.2 Implications of Findings for Practice

This study has presented the sociopolitical drivers and barriers to the development and adoption of biogas technology. The participants' expressions lay a base of knowledge for policy makers on how the community can be helped to overcome the barriers surrounding the biogas technology. It is clear from the study that the intervention of the state, financial aid and community awareness on the benefits of biogas are crucial to the production and adoption of biogas. From the findings, it is evident that Zambia's policy-makers struggle to address bio-energy challenges to improve people's living standards because of poor implementation strategies. This has created inconsistencies in the production of biogas technology in the peri-urban areas. The energy policy should be in synch with other measures that mitigate climate change and reduce poverty. The identified barriers to the production and adoption of biogas cannot be addressed overnight, but will require continued dialogue among stakeholders. It is from the analysis of this study that I make the following recommendations:

7.3 Recommendations

When I analyze and interpret my findings I see that there are more barriers to biogas. Therefore, close collaboration, capacity building and increased financial support from both public and private institutions for the development of biogas technology in peri-urban areas is paramount. Based on the findings, two propositions to overcome the barriers to the development and adoption of biogas are identified. The first one concerns the overall National Energy Policy in Zambia, and the second one concerns the local government to play a proactive role in alternative energy in peri-urban areas.

7.3.1 National energy policy

Even though the Zambian government intends to improve rural and peri-urban areas electrification levels from the current 4.4% to 8% by 2021 with investment plan of 100 megawatts (MW) of renewable energy-based electricity generation (SREP-Ministry of Energy, 2018), the target is unlikely to be achieved due to lack of an integrated strategy. The integrated strategy refers to an approach that sets as key to renewable energy goals, break down responsibilities for implementation to the most relevant departments, and request for regular monitoring to ascertain the progress made (Shane, Gheewala and Kasali, 2015). Unfortunately, the Ministry of Energy has no structures at provincial and district levels. There is no single department of energy and /or office in all the 10 provinces and 116 districts around the country, apart from the ministry headquarters in the capital city, Lusaka.

First, it is recommended that the government should introduce departments of renewable energy at provincial and district levels in the country. Second, the development and adoption of biogas should be supported by a well stipulated energy policy and regulatory framework, with allegiance to implement it. Third, there must be increased financial allocation to biogas and other renewable energy

sources. Fourth, there should be continuous Research and Development in alternative energy. The public and private universities should be adequately funded to carry out research on renewable energy. Fifth, it is necessary to employ close collaboration among researchers, implementers and the communities whenever biogas and other renewable energy projects are brought forth. Sixth, the government should provide supportive mechanisms like subsidies to biogas production.

7.3.2 Engaging local government in alternative energy

To proactively engage the local government in sustainable energy requires specific capacity building (Borchers 2015). It is therefore, imperative for the Zambian government to train local government staff in renewable energy technologies. Further, a clear guidance on the actual role of the local authority in sustainable energy should be outlined. Further, the local authorities must be positioned to use initiatives and lead modern energy implementation actions with fundamentally locally based support. In addition, the government should allocate substantial amounts of money to councils specifically for alternative energy. This approach will help the local authorities to; (i) implement national energy policy at district levels, (ii) increase the knowledge about Renewable Energy Technologies (RET) with a focus on poverty reduction, environmental and climate change mitigation measures.

7.4 Reflection

Looking back on the whole process of this study, I reflect upon the experiences gained. One of the intriguing lessons is that knowledge is nuance. Starting from creating the research topic, formulating research questions, interviewing respondents and transcribing, I continuously gained knowledge and skills. Carrying out qualitative research for the first time, I found it to be very interesting. The applied methodology was informative. Fieldwork made me to

realize that situations occur out of one's control. It was an awesome experience of a distinctive mind. Finding ways in which biogas technology can improve people's well-being, one would consider employing a qualitative inquiry.

7.5 Future research

This study has shown that the drivers and barriers to the development and adoption of biogas in peri-urban areas in Zambia up until now have been inadequately studied. Further investigations are required to strengthen the validity and reliability of this study. Therefore, the following future researches have been suggested:

- A quantitative study to determine the production and acceptability of biogas in Zambia.
- Assessing the potential for other feedstock like pig manure for the bio-digesters to generate energy.
- Examining the proactive role of local government in institutionalizing sustainable energy into local actions.

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APPENDICES

Appendix 1: Interview guide for Institutions providing energy (ZESCO and CEC)

Institution information

i. Please tell me about your institution?
ii. What are the specific goals of your institution?
iii. How would you achieve these goals?
iv. How does your institution understand poverty reduction and sustainable renewable energy?

Context

My study focuses on poverty reduction and renewable energy technologies. I have learnt that your institution supplies energy to all parts of the country.

i. In general, what is your institution doing towards poverty reduction in communities?
ii. How do you aim at reducing poverty in communities?
iii. The majority of the people in peri-urban areas are regarded or considered to be 'energy poor'. How are you addressing the problem of energy poverty in peri-urban areas?
iv. Owing to the fact that your institution is more responsible for energy; is your organization able to advocate for energy for the poor? If yes, how? If no, why?
v. Do you provide Renewable Energy Technologies as alternative sources of energy in peri-urban areas? If yes, how? If no, why?
vi. What drives the development of biogas technology?

vii. What are the barriers to the development and adoption of biogas technology?

viii. Heifer International and SNV-Zambia have implemented a biogas digesters project for energy poor households, as an alternative source of energy in Mokambo peri-urban in Mufulira district. Has your institution played any party in this initiative? If 'yes' what has been your major role? If 'no' why?

ix. Your institution provides energy in many areas. How has been the relationship with the local councils and NGOs dealing with sustainable energy technologies?

x. What do you say about the response of the people towards alternative renewable energy technologies provided by the institution?

xi. How would you evaluate alternative renewable energy technologies provided by your institution?

xii. With regard to provisions of alternative sources of energy, is there anything else you would like to tell me?

Appendix 2: Interview guide for beneficiaries and non-beneficiaries of biogas

Context

I have learnt with keen interest, of biogas digesters project implemented in this area by Heifer International and SNV-Zambia office, spearheaded by Liberty House Community Outreach Missions which has been in effect for more than five years now.

i. How did you learn about the biogas digesters energy technology?
ii. How did it start? Were you sensitized before the biogas technology was implemented?
iii. What prompted Heifer International and SNV-Zambia office to choose Mokambo peri-urban for biogas technology?
iv. What drives the development of biogas technology in this area?
v. Would you consider yourself as poor? In either case, tell me why?
vi. Are you one of the persons who has benefited from biogas energy? If yes, how does it work? If 'no', why?
vii. Has the introduction of biogas digesters by Heifer International and partners improved or worsened your living conditions? In either case, why do you think so?
viii. Records show that only few households have benefited from biogas energy. What are the barriers to the development and adoption of biogas technology?
ix. In general, how do people in this area perceive biogas energy? Was there any initial form of resistance to biogas? If yes, why?
x. Apart from Heifer International and partners, are there any other stakeholders working in this area on alternative energy sources? If yes, who are those?

xi. With regard to alternative sources of energy, how is local government featuring in the provision of alternative renewable energy technologies in this area?

xii. In reference to drivers and barriers of biogas development and adoption, is there anything else you would like to share with me?

Appendix 3: Interview guide for Non-Governmental Organizations

Institution information

i. Please tell me about your institution?
ii. What are the specific goals of your institution?
iii. How would you achieve these goals?
iv. How does your institution understand poverty reduction and renewable energy technologies?

Context

I heard that your institution is working in collaboration with Heifer International and SNV-Zambia on poverty reduction initiatives. One of your initiatives is biogas digesters project, as an alternative sustainable source of energy in Mokambo Peri-urban area.

i. Why and how did you come up with this project?
ii. What do you intend to achieve with this project?
iii. Why do you think Mokambo peri-urban was the right site for the project?
iv. What is your main role in this project?
v. According to 2010 Census of Population and Housing, Mokambo was considered to be poor. Do you think poverty can be reduced through provision of alternative energy technologies like biogas digesters? If 'yes', How?
vi. What drives the development of biogas?
vii. What can you say about the barriers to the development of biogas technology in Mokambo?
viii. The project started in 2014, it is now close to six years, and the records show that few households are using biogas energy. Is there anything

you can share with me about the adoption of biogas technology by the local community?

ix. How was the perception of biogas technologies as alternative source of energy in the community? If ‘good’, how? If ‘bad’, why?

x. Apart from Heifer International and SNV Zambia office, which other organizations are involved in this initiative?

xi. Under the national decentralization policy, the Ministry of Local Government has been given the sole responsibility to implement sustainable energy projects for poverty reduction. Do you work with local government (particularly Mufulira Municipal Council?) If yes, what is the role of local government in the provision of alternative renewable energy technologies? If No, why?

xii. In reference to the drivers and barriers of biogas development and adoption, is there anything else you would like to share with me?

Appendix 4: Interview guide for Local Government (Mufulira Municipal Council) Officials

Organization information

i. Please tell me about your institution?
ii. What are the specific goals of your institution?
iii. How would you achieve these goals?
iv. How does your institution understand poverty reduction and renewable energy?

Context

My keen interest is in poverty reduction and alternative renewable energy technologies. The decentralization policy in Zambia clarifies the principal mandates of local government in the delivery chain of public services to the local demands in rural, peri-urban and urban areas.

i. In general, what is your institution doing towards poverty reduction in communities?
ii. How do you aim at reducing poverty in communities?
iii. The majority of the people in rural and peri-urban areas are regarded or considered to be 'energy poor'. What policies and strategies are in place to address the problem of energy poverty in peri-urban areas?
iv. Have you been successful in your strategies to address energy poverty in peri-urban areas? If yes, how? If no, why?
v. Owing to the fact that the Municipal council is more or less responsible for garbage collection and waste management; what is the Municipality's alternative strategy towards the use of waste to generate energy?
vi. Do you provide Renewable Energy Technologies as alternative sources of energy in communities? If yes, how? If no, why?

vii. Heifer International and SNV-Zambia in collaboration with Liberty House Community Outreach Missions have implemented a biogas digesters project for energy poor households, as an alternative source of energy in Mokambo peri-urban. Has your institution played any party in this initiative? If 'yes' what has been your major role? If 'no' why?

viii. The local council has the sole mandate of public services delivery in rural, peri-urban and urban areas in partnership with key stakeholders. What would you say about your relationship with ZESCO, and NGOs dealing with sustainable energy technologies?

ix. What has been the reception of the local people towards alternative renewable energy technologies provided by the local authority?

x. How would you evaluate alternative renewable energy technology provisions by the local authority?

xi. With regard to provisions of alternative sources of energy, is there anything else you would like to tell me?

Appendix 5: Participant Information Sheet

Thesis Title:	Sociopolitical drivers and barriers to development and adoption of biogas in Mokambo Peri-urban in Mufulira, Zambia: How does local government fail to provide renewable energy?
Aim of the study:	To explore the drivers and barriers to the development and adoption of biogas, and understand how the local government fail to provide alternative energy in peri-urban areas.
Research questions:	1. How do institutional, situational, infrastructure and technical expertise, and dispositional barriers affect the provision of renewable energy in Mokambo Peri-Urban area? **2.** How does the local government fail to provide renewable energy in Mokambo Peri-Urban area?

Appendix 6: Consent Form

FACULTY OF SOCIAL SCIENCES

CONSENT FORM

Research Title:

Sociopolitical Drivers and Barriers to Development and Adoption of Biogas in Mokambo Peri-urban in Mufulira, Zambia: How Does the Local Government fail to Provide Alternative Energy?

Student Name: Andrew Tembo

I have been given information about research title and discussed the research project with Andrew Tembo who is conducting this research as part of a Masters' degree, supervised by Dr. Yahia Mahmoud in the department of Human Geography at Lund University.

I have been advised of the burden associated with this research, which include taking a little of my time, and have had an opportunity to ask Andrew any questions I may have about the research and my participation.

I understand that my participation in this research is voluntary, I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect my treatment in any way /my relationship with the Department of Human Geography or my relationship with Lund University.

If I have any enquiries about the research, I can contact Dr. Mahmoud on +46 462228406, or if I have any concerns or complaints regarding the way the research is or has been conducted, I can contact Katherine Anderson Ahlstedt, Programme Coordinator, Graduate School of Lund University on +46 462220000 or email: master@sam.lu.se

By signing below I am indicating my consent to (please tick):

Having one recorded interview for 15 minutes to 1 hour with the researcher asking me about poverty reduction initiatives and alternative energy technology systems;

I understand that information from me will be used for a thesis and I consent for it to be used in this manner.

Signed ..... Date ...../...../.....

Name .....

List of Interviewees

Interview No.	Status	Date of Interview
1.	Beneficiary of biogas project	2 March 2020
2.	Ward Councilor	2 March 2020
3.	Beneficiary of biogas project	3 March 2020
4.	Beneficiary of biogas project	3 March 2020
5.	Beneficiary of biogas project	4 March 2020
6.	Beneficiary of biogas project	4 March 2020
7.	Non-beneficiary of biogas project	4 March 2020

8.	Mufulira Municipal Council	6 March 2020
9.	Non-beneficiary of biogas project	6 March 2020
10.	Non-beneficiary of biogas project	6 March 2020
11.	Non-beneficiary of biogas project	6 March 2020
12.	Non-beneficiary of biogas project	6 March 2020
13.	Ward Councilor	6 March 2020
14.	Non-Governmental Organization	13 March 2020
15.	Non-Governmental Organization	15 March 2020
16.	Copperbelt Energy Corporation	16 March 2020
17.	Beneficiary of biogas project	17 March 2020
18.	Non-beneficiary of biogas project	17 March 2020
19.	No-beneficiary of biogas project	17 March 2020
20.	Beneficiary of biogas project	20 March 2020
21.	Non-beneficiary of biogas project	20 March 2020
22.	Beneficiary of biogas project	20 March 2020
23.	ZESCO Limited	23 March 2020
24.	Mufulira Municipal Council	27 March 2020
25.	Non-Governmental Organization	30 March 2020