SOLAR ENERGY AS AN ALTERNATIVE ENERGY SOURCE FOR LIGHTING: THE CASE OF GEORGE, LUSAKA

By

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A dissertation submitted to the University of Zambia in partial fulfillment of the requirements for the degree of Master of Science in Spatial Planning

The University of Zambia

Lusaka

2021

DECLARATION

I, **COSMAS KAAMBO**, do hereby declare that this dissertation is my own work to the best of my knowledge and that it has never been produced or submitted for any degree, diploma or other qualification at the University of Zambia or at any other university for academic purposes. I further declare that all other works of people used in this research have been dully acknowledged.

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CERTIFICATE OF APPROVAL

This dissertation of **COSMAS KAAMBO** is approved as fulfilling part of the requirements for the award of the degree of Master of Science in Spatial Planning by the University of Zambia.

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ABSTRACT

Some informal settlement dwellers use candles and kerosene for lighting. However, kerosene and candles are hazardous to health and property. Burning candles and kerosene in indoor emits toxic carbon monoxide (CO), nitrogen oxide (NOx) and sulfur dioxide (SO_2). The aim of the study was to investigate factors that influence adoption of solar energy for lighting in George Settlement. The objectives of the study were to determine the extent of adoption of solar energy, to ascertain factors that lead to using solar energy and to investigate barriers to adoption of solar energy. A sample of 50 respondents from George Settlement was conveniently selected. A structured questionnaire was used to obtain information. Five key informants from government institutions were purposively selected. An interview guide was used to obtain information.

Results indicate that adoption rate of solar energy among respondents is very low (18 percent). This is due to; low income (average K750), high cost of solar devices and insufficient policy support. Variables of solar energy that promote adoption include: having relative advantage (98 percent) over candles and electricity, being; environmentally friendly (94 percent), compatible (92 percent), easy to use (90 percent), pre-testing (88 percent) and observable (72 percent). The major barriers to adoption of solar energy are low income among residents (90 percent), high cost of solar devices (88 percent), insufficient policy support (78 percent) and poor quality of solar devices (36 percent).

The study concludes that adoption of solar energy as an alternative for lighting among respondents is very low. Factors that influence adoption are solar energy being; compatible, environmentally friendly, pre-tested, observable, and easy to use and having relative advantage. Major barriers to adoption are: low income, high cost of solar devices, poor quality of solar energy devices and insufficient policy support. It is recommended that ZDA should consider off-grid solar for job creation.

Key Words: *George Settlement**;** solar energy; adoption of solar; barriers to adoption*

DEDICATION

I dedicate this work to my mother Agness Munsanda Kaambo, my children, Keith, Hillary, Philip, Edith and Mary. My dedication also goes to my brothers Golden, Samuel, William, David and my sister Mary. Not forgetting my nephews and nieces Clevious, Evaristo, Christopher, Olivia and Happiness respectively. Thank you for your encouragement and for sacrificing the time I should have spent with you but spent working on this dissertation.

ACKNOWLEDGEMENTS

This dissertation benefited a great deal from contributions of many people without whose support, it would not have been possible to complete. I would like to particularly, thank my supervisor Dr. Douty Chibamba for the expert guidance which has enabled me to produce this work. I thank him for the professional guidance and criticism. I am indebted to lecturers and members of staff from Geography Department at the University of Zambia (UNZA) for the assistance and guidance rendered to me during the course of my study.

My sincere gratitude also goes to the research assistants Ms Eneless Mbewe and Ms Anna Banda of George Settlement and research participants who include: members of the community in George Settlement and members of staff at REA, The Ministry of Energy and ZESCO. I thank them for being open and for giving me the information at the needed time. Special thanks go to my family, even the extended family. Putting everyone's name would result in a voluminous document but you know you are special to me. My children, Keith, Hillary, Philip, Edith and Mary thank you for your love, care, support, understanding and patience during the course of this work. I always looked forward to your "thunderous welcome" whenever I came back home from school. I love you dearly. Mum, I am eternally grateful for all those encouraging words, love and prayers. My brothers; Golden, Samuel, William, David and Sister Mary, thank you for your love and support. I am also indebted to my nephews; Evaristo, Christopher and Clevious and my nieces, Olivia and Happiness for all their encouragements, and kindness. Thank you for your love and support. To the DEBS Chibombo District and the Headteacher, Chabona Primary School (Mr Mutubya), thank you very much for giving me permission to come and pursue my studies.

Most importantly I thank God Almighty for his unfailing love, mercies, patience and kindness towards me. You are wonderful. In you I live and have my being. Thank you for the gift of life**.**

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ABBREVIATIONS AND ACRONYMS

CO …… Carbon Monoxide

CSO…….. Central Statistics Office

GDP……. Gross Domestic Product

GRZ……. Government of the Republic of Zambia

NO…… Nitric Oxide

NO_2…… Nitrogen Oxide

NO_x…… Nitrogen Oxide

PV……. Photovoltaic

REA ……. Rural Electrification Authority

RETs……. Renewable Energy Technologies

SDGs……. Sustainable Development Goals

SHSs……. Solar Home Systems

SIDA……. Swedish International Development Agency

SMEs…… Small Medium and Enterprises

SO_2…… Sulfur Dioxide

UNDP…… United Nation Development Programme

WHO ……..... World Health Organisation

ZDA …….. Zambia Development Agency

ZESCO ……. Zambia Electricity Supply Corporation

CHAPTER ONE: INTRODUCTION

1.0 Background

Informal settlements have challenges of accessing electricity (Simon, 2015). Because of these problems, informal settlement dwellers resort to using seemingly cheaper alternative sources of energy such as candles and kerosene for lighting. However, kerosene and candles are hazardous to both health and property. Figueroa (2016) noted that in Kibera, Kenya, 55 percent of households used kerosene for lighting and 42 percent used electricity for lighting. Similarly, Appies (2016) observed that in South Africa's informal settlements, 24 percent of households used kerosene, 20 percent used candles and 6 percent used solar light for lighting. Kerosene and candles are some of the causes of explosions and household air pollution (Lay et al., 2013).

Burning of kerosene emits pollutants such as fine particulates, carbon monoxide (CO), nitric oxide (NO) and sulfur dioxide (SO_2) (Lam et al., 2012). These pollutants have severe consequences on human health because they impair lung function and increase infection illnesses including tuberculosis, asthma and cancer risks. Kerosene is also responsible for poisonings, especially among children, as it is mistaken for water (Mills 2016).

Burning of candles in indoor environments releases a large number of toxic substances such as carbon monoxide (CO) and nitrogen oxide (NOx) (Lau et al., 1997). Besides, candles are a major source of house fires. For instance, in Monrovia, Liberia, there was an occurrence of an average of one-candle related "shack fire" every week Mills (2016). Despite shortcomings presented by the aforementioned fuels, adoption of solar energy among informal settlement dwellers still remains low (Shahsavari, and Akbari, 2018).

On the other hand, Amankwah-Amoah (2015) argues that many parts of Africa have some of the best solar energy resource in the world that can be used to facilitate economic growth for example, Nigeria, Kenya and Zambia. However, despite the huge potential for solar energy described in the forgoing, informal settlement households in Sub-Saharan Africa continue using fuel-based energy for lighting. Yet, these fuels have high costs for end-users, including economic costs, health or safety and environmental costs.

Some factors that influence adoption of solar energy include; availability of substitute sources of energy that may be seen as cheaper and availability of electricity in some of the households (Kaminski, 2011). Others are lack of communication on efficiency of solar, its sustainability and benefits of using solar devices for lighting. High cost of solar devices too hinder residents from purchasing them (Karakaya and Sriwannawit, 2015). Low income among residents is also a barrier to adoption of solar energy. Therefore, this research attempted to investigate factors that influence adoption of solar energy for lighting in George Settlement.

1.1 Problem statement

Informal settlements are characterized by limited access to electricity (Figueroa, 2016). Hence, residents of these settlements resort to using the seemingly cheaper but unclean forms of energy for lighting such as candles and kerosene. These forms of energy have serious implications on health and property. The smoke that comes from burning candles and kerosene contains carbon monoxide (CO), nitrogen oxide (NOx), fine particulates, nitric oxide (NO), and sulfur dioxide (SO_2) among other substances. These substances are harmful to human health in that they cause respiratory diseases such as tuberculosis, cancer and asthma (Lay et al., 2013).

Using kerosene and candles for lighting results in in-door air pollution, burn injuries and property damage. Kerosene also causes poisonings particularly to children who take it as they mistake it for water (Zweig and Pharoah, 2017). Imizomo Yethu in Cape Town, one of the informal settlements, experienced a major fire which was caused by burning of candles and kerosene on the 8th of February, 2004 (Harte et al., 2009). The fire caused significant damage to housing and infrastructure resulting in widespread homelessness and loss of personal possessions. Given all these problems caused by the aforementioned fuels, however, most low-income households in Zambia still use them. This study therefore, investigated factors that influence adoption of solar energy for lighting in George Settlement. Solar energy has several benefits not limited to zero carbon emission, safe from health and environmental damage and cheap once initial cost is met as the sun's radiation is free Aman et al. (2015).

1.2 Aim of the study

The aim of the study was to investigate factors that influence adoption of solar energy for lighting in George Settlement.

1.3 Objectives

The objectives of the study were:

i. To determine the extent of adoption of solar energy for lighting by households of George Settlement.
ii. To ascertain factors that lead to using solar energy for lighting in George Settlement.
iii. To investigate the barriers to adoption of solar energy for lighting in George Settlement.

1.4 **Research questions**

i. To what extent has solar energy been adopted?
ii. What factors lead to using solar energy for lighting in George Settlement?
iii. What are the barriers to adoption of solar energy for lighting in George Settlement?

1.5 Significance of the Study

The significance of this study is that its outcomes can assist planners to designate some areas specifically for grid solar projects in communities in order to promote solar energy adoption. Planners can propose to local government to have houses in some settlements designed with solar energy gadget. Planners can use the results of this study to encourage communities through sensitisation on energy needs that require them to switch to clean energy. In turn, this will promote attainment of Sustainable Development Goal number 7which states; ensure access to affordable, reliable, sustainable and modern energy for all. The study can serve as basis for further research on slum upgrading and energy security.

1.6 Organisation of the Study

This dissertation has six chapters. Chapter One provides the introductory chapter and highlights the background of the study, the problem statement, aim and objectives, the research questions and discusses the significance of the study. Chapter Two provides the

literature review and discusses the extent of adoption of solar energy for lighting in George Settlement, factors that influence adoption of solar energy for lighting in George Settlement and barriers to adoption of solar energy for lighting in George Settlement. Chapter Three discusses the description of the study area. Chapter Four provides the research design, the methods of data collection, data analysis and sampling procedure. Chapter Five provides the findings and discussions and Chapter Six highlights the conclusions and recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of literature on solar energy. The review of literature focuses on adoption of solar energy, factors that lead to using solar energy and barriers to adoption of solar energy.

2.1 Extent of adoption of solar energy

According to Wojuola and Atant (2017) rapid population growth has resulted in increasing demands for energy as well as growing environmental concerns. It has also revealed the constraints of conventional energy. They further argued that this has generated a global need for government policies that seriously consider Renewable Energy Technologies (RETs). The close relationship between renewable energy (RE) and sustainable development is prompting countries across the world to adopt RET in order to ensure sustainable development. It has been argued that doubling the current implementation of RE generation can reduce CO_2 emission to 349 g/KWh, which is less than the 498 g/KWh targeted for 2030 (deLlano-Paz et al., 2015). This will keep atmospheric CO_2 below 450 parts per million, which is required to prevent severe climate change. Air pollution, human-induced climate change, energy supply insecurity and cost increases are some of the problems associated with fossil fuel that have given rise to the implementation of (RETs) across the world. The close relationship between RE and sustainable development has prompted several governments worldwide to introduce laws that promote RE. There is thus, a steady growth in the use of renewables worldwide. By 2013, RE provided an estimated 19.1 percent of global energy consumption (Nejat et al., 2015). Of this total share, traditional biomass accounted for about nine percent hydropower, four percent renewable heat and transport biofuels provided about one percent. By 2014, renewables rose to an estimated 27.7 percent of the world's power generating capacity which was enough to supply an estimated 22.8 percent of global electricity. Hydropower capacity rose by five percent to approximately 1055 GW, while other renewables collectively grew from nearly 18 percent to an estimated total approaching 660 GW.

However, most African countries including Zambia have not prioritised RETs. This can be proved by considering how much money is allocated to RETs in the national budget. It is usually far less than expected and therefore, cannot allow proper implementation of renewable energy projects such as solar energy plants. This will make it difficult for Zambia and other African countries to meet Sustainable Development Goal 7 (SDG7). In most African countries, leaders lack political will and vision so as to exploit available natural resources to better the lives of the citizens. They would rather spend huge sums of money on political issues on the expense of developing solar energy projects or any other RETs.

According to Conway et al. (20190) in order to achieve SDG 7, innovative approaches will be required to deliver affordable, reliable, sustainable and modern energy to Africa's poor. As a partial contributor to this goal, Solar Home Systems (SHSs), are an increasingly an affordable and reliable option for the low-income, informal settlement urban households to initially access electricity (for at least lighting and media) in a manner that bypasses the legal financial and practical barriers that often block grid electrification. Nevertheless, Ohunakin et al. (2014), argue that the basic barrier to solar energy in Nigeria is high initial cost. This implies that, solar devices are unaffordable to low-income people. People with low-income would rather spend the little they earn on basic needs such as food items instead of buying solar devices and continue buying candles every day for lighting. They little realise that solar energy devices are cheaper than buying candles every day because solar devices, once bought, no other costs are involved since they only require charging the devices in the sun which is free.

In Nigeria, the National Energy Policy (NEP) was approved by the Nigerian government in 2003, with the overall thrust of optimal utilisation of the nation's energy resources, both conventional and renewable, for sustainable development, and with the active participation of the private sector (Sambo, 2009a). This was closely followed by the National Renewable Energy Master Plan (NREMP) in 2005. NREMP envisioned national sustainable development through the implementation of RET, with the expectation of a 10 percent RE penetration by 2020. Despite Nigeria's abundant RE resources, the country is still heavily reliant on fossil fuels. The challenges surrounding the implementation of RET are attributed to the low level of public awareness, prices, financing constraints and weak technology

dissemination strategies (Sambo, 2009b). Other factors include a lack of consumer confidence due to poor product quality, a lack of adequate policy, and a lack of skilled manpower. The economic, social, technical and political (including educational) barriers must be overcome for the proper integration of RE into the nation's energy mix.

According to UNDP and WHO (2009), despite the primacy of energy in people's lives, most sub-Saharan Africans live in energy poverty. Behera and Ali (2016) argue that about 80 percent of Sub-Saharan Africans primarily rely on solid fuels for meeting household energy needs. Lack of access to modern energy carriers and efficient and safe energy using devices is a cause of the prevailing "energy poverty" that traps households in a vicious cycle of deprivation (Polsky and Ly, 2012). A transition to safer energy carriers and devices could reduce the vulnerability of energy-poor households, leading to better human health and welfare.

Despite several authors such as Khalil et al. (2017) and Shahsavari and Akbari (2018) having well-articulated advantages of adopting solar energy, however, most of them never talked about the need to have small affordable solar devices such as pico solar or solar home systems (SHS) which are affordable to the low-income households. Small solar devices are the most suitable for low-income households like informal settlement dwellers because they are not very expensive.

According to Fakier et al. (2014); Tait and Winkler (2012) argue that many parts of Africa have some of the best solar energy resource in the world that can be used to facilitate economic growth, increase access to energy and alleviate poverty on the continent for example, Nigeria, Kenya and Zambia. Despite Africa having the resource mentioned above, many of its low-income inhabitants still use kerosene and solid fuels for lighting. In Cape Town, over 16 000 residential fires were reported by emergency services between 2009 and 2016, of which 7605 (47 percent) were in informal dwellings (Zweig and Pharoah, 2017). These fires are often attributed to accidents involving the usage of non-electric energy sources and devices.

According to Kachapulula-Mudenda et al. (2018), a diversified renewable energy sector is a prerequisite for the widespread adoption of RETs among Zambian households. Similarly, Knudsen (2002) carried out a study on use of alternative renewable sources of energy for lighting. The study revealed that despite candles having had been responsible for starting fires in informal settlements, some residents continued using them for lighting because they were relatively cheap and were easily accessible in local shops as compared to kerosene. Similarly, other residents reported that they were using kerosene for lighting though it was a source of structural fires and caused burns and poisonings among children. The rapidly increasing price of electricity forced residents to use kerosene and candles.

Ghaffar et al. (2008) observe that if consumers cannot identify the advantage of solar power over the current sources of power which is supplied readily and cheaply, it is unlikely that adoption will follow. Improving communication on the benefits of using solar energy for lighting will enhance its adoption by households. Solar is cheap because once the initial cost of buying a solar device is met, no other costs are paid as heat (radiation) from the sun is free. Solar energy is advantageous in that it does not pollute the environment. Further, solar energy does not cause health damage to humans or to animals and plants. According to Leach (1992) the energy ladder hypothesis assumes that a household's energy choice depends on a household's income level. As income rises, households move first, from using traditional fuels such as kerosene and then to modern fuels like solar energy.

Deambi (2011) argues that solar energy generated during the day needs expensive batteries for storage. This acts as a barrier to adoption of solar energy by low-income people as they cannot afford to buy expensive solar devices and storage batteries. On a contrary view, Deambi (2011) states that the cost of solar panels has constantly been declining over the years. He asserts that the fast declining cost of solar power as a result of improved technology was likely that by 2015, solar would be the cheapest type of electricity generated. However, this is not yet feasible in Zambia because we are not yet self-reliant as to produce our own solar devices to meet the demand of the population. In addition, there is lack of prioritization of renewable energy in the national budget by the Zambian Government. Some of the largest drivers or enablers of uptake of solar energy are environmental concerns, setting aside

enough money for solar energy, having knowledge and awareness of solar as well as having interest in exploring new technologies.

A low level of awareness about the benefits, functional characteristics and efficiency of renewable energy technologies available for use by households is another factor which prevents successful adoption of solar energy in Zambia (Kachapulula-Mudenda et al., 2018). Mbewe (2002) affirms that the policies, incentives and benefits associated with RETs in Zambia have not been effectively communicated to energy users to the extent that they would adopt solar energy. Usage of improved solar energy will partly depend on how well-informed a potential household decision-maker is when choosing modes of energy for domestic use. Therefore, when faced with inadequate information, users of old and less-efficient products may still hold notions about inadequacies associated with renewable energy technologies. Mbewe (2002) further revealed that the low levels of awareness are attributed to inappropriate modes of communication to access certain forms of media and local agencies' failure to accommodate household energy users with low levels of literacy (English is the official language in Zambia and the main language used during energy campaigns in the media). There is need to use local languages also when sensitising people about solar energy so that the message is understood clearly by everyone. Poor knowledge base and misconceptions about solar energy technologies are widespread among potential household users, thus, limiting the adoption and subsequent usage of RETs. Therefore, such people cannot adopt solar energy because of lack of knowledge about it.

2.1.1 Adoption theory

Kaminski (2011) theorised that the process of adoption commences with an individual driven by precedent conditions such as a felt need to adopt an innovative product or service. The individual will pass along an innovation decision process at a pace that is influenced by their own level of innovativeness and by the perceived characteristics of the innovation. The decision making process is aided by communication channels; either mass-media communications or by local channels such as word-of-mouth. The diffusion of innovations theory has been used to explain the adoption of various innovations; Kaminski used the process to evaluate the implementation of a diffusion project, and found that the adoption rate is positively related to the level of knowledge potential adopters demonstrate. Despite

some adopters rejecting the innovation due to its attributes, they remain open minded to later adoption. The extent of adoption of solar energy in this study is therefore, assessed by possession of solar devices. The study uses the number of households in the sample who own solar devices to determine the extent of adoption of solar energy.

2.1.2 Technology adoption model and processes

According to Calantone et al. (2006) prior conditions exist that have an effect on a potential user's decision to adopt a technology. The decision making process begins when an adopter (individual, organisation or stakeholder), first becomes aware of an innovation (knowledge) (Rao and Kishore, 2010). According to Rogers (2010) new ideas are spread from individual to individual over time. When ideas about an innovation spread, individuals make choices either to accept or to reject the innovation.

2.2 Factors that lead to using solar energy

For solar energy to be adopted by households, it needs to meet the needs of the households adequately and efficiently (Kachapulula-Mudenda et al., 2018). They argue that complicated technology is often received with resistance while simple technologies usually receive a claim for ease of adaptability and ability to positively influence livelihoods. For instance, outcomes of the solar home systems project they undertook in Eastern Province of Zambia indicated that households admitted to having an improved standard of living owing to the transition to solar energy technology. The improved quality of lighting enabled studying among school going children for longer hours and a broader level of domestic services. The study however, left a gap by indicating that solar improved the standard of living of the people. Solar alone cannot improve the standard of living of people. There are other aspects that should be considered in order to have improved standard of living. These include; incomes, adequate nutrition, transport to get to work, safety in the community and clean neighbourhoods.

According to Kaminski (2011) an individual's technology adoption behaviour such as solar technology is determined by his or her perceptions regarding relative advantage, compatibility, complexity and observability of an innovation. These constructs have

relationship with the studied variables. This relates to attitude towards use of solar technology.

Brix (2015) described the 90's as the years faced with great negativity of the solar PV industry caused by faulty solar panels that found their way into the Kenyan market. This greatly influenced to build up a perception of the local consumers that the solar panels "never work" as the panels terribly failed to meet the minimum expectations of the consumers. Brix (2015) attributes most of the quality problems associated with the 90's to lack of capability to detect or measure quality among the Kenyan authorities and thus, the authority had to rely on the foreign help to curb the proliferation of substandard solar modules at the market. Indeed, it took independent testing of panels in 1999 notes Patwardhan et al. (2012) to weed out the underperforming suppliers and brands.

Pode and Diouf (2011) carried out a research on perception of solar energy. They observed that while the technology has been with us for decades now, solar PV technology is still perceived as a new technology largely because of the low awareness of the application of the systems. This has been a big barrier to the penetration of the technology. There is also lack of analysis and knowledge of advantages of solar energy among households in informal settlements so as to determine as to which is better between solar energy and fuel based lighting. In this regard, the study attempted to evaluate the effect of the quality of the solar PV products on the uptake of the solar PV technology. Five variables were used to test the contribution of quality of products on the uptake of the solar PV technology. They included rated performance of the solar PV product, reliability of the solar PV product, aesthetics of the solar PV product, durability of the product as covered by warranty and the perceived quality as supported by brand equity. This reveals the widespread perception that solar PV technology is in a better position to cater for the ever-increasing energy needs in developing countries (Muntasser et al., 2000; Sayigh, 1999).

Past research shows that domestic solar systems are well-suited to an urban environment, are a proven and effective technology, and offer the opportunity for individuals to make a statement about their environmental beliefs (Faiers et al., 2007). They are also described as affordable, compatible with other technologies, able to reduce pollution and technically

reliable (Berger 2001). Timilsina et al. (2000) suggest that solar power is attractive at a national policy level because it can reduce national carbon emissions and contribute to the GDP through jobs and income in the manufacturing and engineering sectors and provide an export product. Solar energy can raise householders' awareness of energy consumption by means of a monitoring facility provided with the installation. This enhanced awareness of energy use can encourage further energy efficiency (Truffer et al., 2001). The perception of adopters has a large impact on the decision whether to adopt a new technology or not. This is because the way that adopters perceive the complexity of technology can impact on their decision (Karakaya and Sriwannawit, 2015).

The attributes most commonly considered by adopters of solar energy include: relative advantage, or the degree to which the innovation is perceived as being superior to the idea or product it replaces; perceived risk, the expected probability of economic or social loss resulting from innovation; complexity, the extent to which the innovation appears difficult to use and understand; compatibility, the degree to which the innovation is seen as consistent with the innovator's existing values, past experiences, and needs; pre-testing, the extent to which one can test an innovation to see if it works before adopting it; and observabiIity, the degree to which the results of an innovation are visible to others (Mekhilef et al., 2011).

It has been argued that the acceptance of RET by the public is associated with the people's beliefs, attitude and perceptions of such technology (Adibet al., 2015). Public attitudes need to change to make major developments in terms of the implementation of RET feasible. Public (social) acceptance shortens the time between the first discussions of new technical systems and their implementation. It is for these reasons that education on REs is regarded as essential for the successful implementation of RET and for public support.

The variables of solar energy that were assessed in this study include; relative advantage, complexity, compatibility, pre-testing, observability, environmentally friendly and easy to use. Generally renewable-energy technologies such as solar energy, windmills, biogas and geothermal are perceived as clean energy sources, which contribute to climate change mitigation.

2.3 Barriers to adoption of solar energy

Solar energy adoption is experiencing a lot of barriers in Africa and in other parts of the world despite the plenty of solar radiation available (Ohunakin et al., 2014). Four of such barriers namely; technical and environmental, financial and economic, social and policy barriers are discussed.

2.3.1 Technical and environmental barriers

In his study about barriers to adoption of solar in Nigeria, Ugulu (2016) observed that practical obstacles related to uptake of solar energy included incompetence, dishonest technicians, product quality and solar inefficiency. Where solar devices are poorly designed and installed, they lead to disappointment. Failure to match household energy demand can lead to lower than normal power yield resulting in dissatisfaction.

Consumers' lack of confidence in installers and untrustworthy technicians are identified as major barriers. The perceived quality of solar energy is an important determinant of adoption. Use of deception, changing product labels and providing solar adopting households with lower quality solar devices or fewer batteries than required is a common problem in developing countries as found in Ugulu's study. It is often done by installers and sellers of solar devices in order to maximize profit. Similar problems of poor performance of solar devices and consumers' lack of confidence in installers were reported in Namibia (Wamukonya, 2001) and in China (Karakaya and Sriwannawit, 2015).

Renewable energy technologies (RETs) in developing countries including Zambia are new. A lot of people have an insufficient understanding of these technologies. There is growing consensus among policy makers that efforts to disseminate RETs in Africa have fallen short of expectations (Lay et al., 2013). While it is recognised that RETs cannot solve all of Africa's energy problems, RETs are still seen as having a significant unexploited potential to enable African countries meet their growing energy requirements. Renewable energy is already the dominant source of energy for the household sub-sector. If properly harnessed, it can meet a significant proportion of energy demand from the industrial, agricultural, transport and commercial sub-sectors.

Despite recognition that they are important sources of energy for sub-Saharan Africa, RETs have attracted neither the requisite level of investment nor tangible policy commitment (Lam et al., 2012). The success of RETs in the region has been limited by a combination of factors which include: poor institutional framework and infrastructure; inadequate RET planning policies; lack of co-ordination and linkage in RETs programmes; pricing distortions which have placed renewable energy at a disadvantage; high initial capital costs; weak dissemination strategies; lack of skilled manpower; poor baseline information; and weak maintenance service and infrastructure.

The introduction of unfamiliar technologies such as RETs requires the development of technical skills. The importance of technical know-how in the increased utilisation of RETs has been recognised in the region, but in spite of efforts by governments, there is a continuing shortage of qualified personnel (Lay et al., 2013). Technical knowledge is important in order to build over the long term, a critical mass of professional African policy analysts, economic managers and engineers who will be able to manage all aspects of the RET development process and to ensure effective utilisation of already trained African analysts and managers (Truran, 2009). Trained manpower capable of developing and manufacturing renewable energy technologies is a prerequisite for their successful dissemination.

Governments and ministries in Africa suffer from a shortage of qualified RETs personnel. In most African countries, usually there are few or no trained people capable of developing and manufacturing solar devices. In Zambia, for instance, at one time, only one engineer was responsible for co-ordinating all renewable energy activities of the government (Karekezi et al., 2012). Nieuwenhout et al. (2001), while assessing the solar photovoltaic uptake issues in developing countries, found out that system failure is a contributing factor to the uptake of solar photovoltaic systems. System failure is related to the poor quality product. The products do not meet the stipulated market standards. The authors state that there is need for standardization of the solar devices in order to achieve quality and increase the uptake of the devices in developing countries. Mulugetta et al. (2000) report similar findings in Zimbabwe where the poor quality of solar devices is stated to be a barrier to diffusion of solar energy. In Kenya, the same reason affected the uptake of solar photovoltaic

systems (Lay et al., 2013). Adopters consider good quality of solar devices as a crucial aspect to consider before adopting a new technology.

The benefits of high quality solar technology surpass those of other sources of energy like thermal generators which require fuel in order to operate. This is because solar energy does not require other costs once a solar device is installed for it uses power from the sun which is free. In this context therefore, the adoption of solar technology depends on the quality of the devices and on the market (Sayigh, 1999). The other advantage of solar energy is that it does not pollute the environment. Neither does it cause fire accidents nor explosions.

In most African countries, local production is limited and there are no solar energy production facilities at national level (Margolis and Zuboy, 2006). Entirely dependence on foreign technology for spare parts and devices poses a crisis when the technology is not available. There is also over dependence on foreign personnel to install and operate large scale energy projects. All these act as barriers to adoption of solar energy that need to be eliminated in order to improve adoption rate.

2.3.2 Economic and financial barriers

From the economic point of view, the cost of solar devices is still generally perceived as high. Regarding the sociotechnical dimension, several studies imply that the complexity of interaction between people and solar energy can hinder adoption.

According to Birol (2010) economic barriers are usually related to the high cost of solar devices. The diffusion of solar devices is also affected by the cost of other energy sources in the region because the potential adopters might have to choose between solar technology and conversional sources of energy. If the costs of competing sources are low, these can constitute a barrier to solar adoption. The lower the cost of solar technology, the more likely that people will adopt it. Consequently, high costs for investments in solar devices are often perceived as barriers to adoption of solar energy. The high costs of solar technology are mentioned in many studies that are based in many countries such as South Africa, South Korea, Greece and the US (Book, 1999). High initial cost is one of the most significant flaws of the solar energy system; for example, the average price per watt for solar energy was

$3.70 in the USA in early 2016 (Kabir et al., 2018). Examples of such high costs of solar devices are spread over for both off-grid and national grid for instance, in Ethiopia and Senegal (Pode, 2013).

Financing plays a major role in the formulation of RET policies. Studies have shown that one of the main obstacles to implementing renewable energy projects is often not the technical feasibility of these projects but the absence of low-cost, long-term financing. This problem is complicated by competition for limited funds (Khatib, 2012). The challenge of financing projects for RETs is to develop models that can provide these technologies to consumers (including low income people) at affordable prices while ensuring that the industry remains sustainable. As shown earlier, limited policy support for RETs in the region is indicated by minimal budget allocation to renewables at government level. Consequently, the private sector is left to bear the burden of financing RETs.

Kulworawanichpong and Mwambeleko (2015) carried out a study on the costing and design of a solar energy (stand-alone) in Tanzania, and they noted that SHSs failures were mainly due to inefficient load demand estimation. Similarly, Campana et al. (2016) noted that in Namibia the main problem identified with SHSs during implementation process was incorrect design and poor installations resulting in unsatisfied customers. According to George et al. (2019) the major barrier to adoption of solar energy in Kenya was lack of money among low-income households. Therefore, low-income households found it difficult to change from using kerosene and other conversional fuels for lighting to solar energy.

Similarly, Aly et al. (2019) did a study on barriers to large-scale solar power in Tanzania. Key barriers were identified at different levels as institutional, financial and technological barriers. Institutional barriers for the diffusion of large-scale solar power technologies were found to be predominant and they often triggered financial and technological barriers. There was a high risk perception for solar power projects by Tanzanian financial institutions.

According to Kombluth et al. (2012) high initial cost and the technical expertise needed for professional installation and maintenance are barriers to adoption of solar energy. Low income households could not afford to pay initial cost of solar devices. Nonetheless, not all

solar devices are expensive. Solar home solutions and pico solar are affordable even to low-income households. These off-grid solar devices are suitable for informal settlements because they are easy to use and are portable. Similarly, a study done by Karekezi and Kithoyoma (2003) in different African countries cited finances as one of the main barriers to adoption of solar.

There are a number of economic and financial barriers to adoption of solar energy. Margolis and Zuboy (2006) stated that households may lack the capital to invest in a solar energy technology or find the upfront or initial cost too high to start a new solar energy project. Additionally, solar energy projects are capital intensive and have low economies of scale. They actually require long term for payback. Usually, those dealing in solar energy are unaware of the market potential that solar energy devices have. There are limited government subsidies in many countries. Banks are not willing to give loans to big projects. Further, there are always risks associated with solar energy projects regarding their performance. Ohunakin et al. (2014) argue that a basic barrier to the development of solar technology in Nigeria is the high cost of initial costs, including high installation costs with long payback times. High initial costs also reflect high risk perceptions of investors and general lack of financing instruments as well as fragmented or undeveloped financial sectors. There is also lack of incentives on import or local manufacturing of solar devices in the country. Import duties are not allowed on solar PV in Nigeria; when the PV to be imported into the country forms a part of the complete solar device including battery storage, it attracts a 21 percent import duty. This has forced the initial investment cost of solar devices to be high above other conventional energy sources (such as diesel generators whose duties are stable, regular and the product readily available when needed). Liu (2018) asserts that high production cost is the case of small share of solar energy in US in the total energy consumption. He argues that although there has been a significant reduction in the cost of producing one watt of power by using solar energy, it is still higher than the cost of electricity by using fossil fuels and even wind. Another major barrier is the lack of comprehensive and practical laws to production of clean energy. All these act as barriers to adoption of solar energy.

2.3.3 Social barriers

The quality of PV system is of vital importance for adoption. It can be influenced by the local conditions of the user's environment, political and financial arrangements that may vary from country to country (Karakaya and Sriwannawit, 2015). In Ethiopia, there is growing skeptism toward products manufactured in Asia, especially those from China. Customers mistrust the goals and do not want to purchase them. The lack of adequate knowledge among both adopters and non-adopters is a crucial barrier. It may result in improper usage and inability to maintain solar devices. This may create a negative perception and prevent potential customers from adopting solar devices. Available modes of energy ought to have a certain level of reliability in order to guarantee sustainable use from the households' point of view (Kachapulula-Mudenda et al., 2018). In a Solar Home Systems Project conducted in the Eastern Province of Zambia it was discovered that people were less willing to pay if the systems were not delivering the advocated services. Furthermore, those businesses which were offering good quality components were more successful than those that were supplying low-cost unreliable systems. Similarly, the Kenya Energy Policy, Law and Regulation Handbook Volume 1 identifies lack of awareness on the potential, prospects and economic benefits offered by the solar power as one of the challenges that need to be addressed in the policy in order to encourage increased use of solar PV systems in Kenya. Hankins (1995) observes that in order to increase the awareness of the solar PV industry, a concerted effort should be established between the public sector through formulation of policies that encourage the uptake of solar energy. This coupled with media advertisements, training and technical assistance, will go a long way to increase the awareness in the solar PV industry (Bhandari, 2010). A low level of awareness about the benefits, functional characteristics and efficiency of renewable energy technologies available for use by households is another factor which prevents successful adoption of RETs in Zambia.

Ugulu (2016) did a research in Nigeria on determinants of adoption of solar energy. The study established that low PV and electricity awareness were critical barriers. Many households held an impression that electricity was cheap and that acted as a huge barrier. Subsidies that were given for decades were the cause of that consumer outlook. In addition, the view that tradionally, publicly provided service and capital intensive projects are

responsibilities of government further impacts investment. For consumers that still hold such opinions, solar uptake would be viewed as far too expensive. Little interest and donor dependence were recently reported as barriers to uptake in rural Tanzania and Mozambique (Alhborg and Hammar, 2014).

Social barriers to adoption of solar energy are presented in this literature review as stated here. Margolis and Zuboy (2006) argue that some aspects of social barriers include people weighing the actions by their social peers when making a decision about adopting solar energy technology or have trust issues with the novel technology. Further, the diversity in adoption barriers and household situations making the adoption of energy efficient technologies a hard to capture process. The level of awareness about socio-economic and environmental benefits from solar energy among the citizens and decision makers at different political and administrative level is very low in Nigeria (Ohunakin et al., 2014). The current flow of information about the development, various application disseminations and diffusion of solar energy resources and technologies are also inadequate. There is inadequate and insufficient education of consumer or solar device users. Also people still lack social acceptance and participation as they still stick to traditional means of electricity which is a big hurdle for new solar energy projects. Moreover, some solar energy projects often come with strong opposition from local communities like the installation of solar panels on roofs. If some problem suddenly occurs, residents do not have any practical knowledge about how to fix their own devices. These act as barriers to adoption of solar energy.

2.3.4 Policy barriers

Regarding policy barriers, there are still several barriers related to the policy dimension and technology management that act as barriers to adoption of solar energy. Ineffective policy measures and inappropriate management can hamper the diffusion process in a variety of contexts (Walker, 2008).

Karekezi et al. (2012), observe that the success of solar energy adoption depends to a large extent on existing government policies. The government should create an enabling environment for solar energy dissemination and mobilising resources as well as encouraging

private sector investment. However, most governments do not have clear policies on the development and promotion of solar energy.

A study was carried out by Wamukonya (2007) in Botswana on knowledge of government policies designed to promote the use of solar energy. It was found that the majority of the respondents had no knowledge of such policies. Findings by a study conducted by Zahedi (2006) support Wamukonya's argument. Zahedi (2006) states that countries that improve in their uptake of solar energy have done so partly due to the intervention of governments. Governments have intervened using policies such as tax holidays, tax rebates and duty exemptions on the companies dealing in the solar photovoltaic products. Experience in Africa shows that the introduction and success of any renewable technology is to a large extent, dependent on the existing government policy (Tsoutsos and Stamboulis, 2005).

Government policies are an important factor in terms of their ability to create an enabling environment for RETs dissemination and mobilising resources, as well as encouraging private sector investment (Karekezi et al., 2012). Most of the early policy initiatives on renewables in the region were driven by the oil crises of the early and late 1970s. In response to the crises, governments established either an autonomous Ministry of Energy or a department dedicated to the promotion of sound energy policies, including the development of (RETs). For example, Zambia responded by outlining policy proposals in its Third National Development Plan (1979-83) to develop alternative forms of energy as partial substitutes for conventional energy resources. Unfortunately, once the energy crisis subsidised, government support for energy development and RET activities diminished significantly. Now most of the remaining support is at rhetorical level. There is little done by the Zambian Government to support and develop solar energy which is affordable by low income people (Bowa et al., 2017).

Most governments do not have a clear-cut policy on the development and promotion of RETs, which continue to be undertaken within an energy planning and policy vacuum. As a result, RETs development follows an ad hoc path, with no clear link to national power master plans, which are rarely available, or out of date (Karekezi and Majoro, 2002).

In Malawi, the policy vacuum has meant that the majority of RETs dissemination efforts have not only been ad hoc, but have also operated largely as informal sector activities outside the framework of government machinery, thus, failing to mobilise the fiscal support of the Central Government and its major donors (Kafumba, 1994).

Zambia's policy direction regarding RETs is guided by the new National Energy Policy (2019) which is an outcome of consultative reviews of preceding policy tools. With respect to renewable energy, the policy tool seeks to address barriers to the use of RETs. However, in its present state, the policy emphasises grid-connected hydropower at the expense of other renewable energy technologies, although other Government development guidelines such as the National Development Plans (Transitional: 2002–2005; Fifth: 2006–2010 and; Sixth: 2011–2015) and the Vision 2030 mention the importance of incorporating other RETs to meet Zambia's growing energy needs. The Renewable Energy Strategy of 2010, a follow-up implementation plan to the National Energy Policy offers a broader renewable energy perspective, with specific targets for electricity generation using various RETs. Nonetheless, the strategy has not been adopted for implementation. The policy on renewable energy is there but its focus is on grid solar energy and not off-grid solar such as pico solar and solar home solutions which are affordable to low-income people.

Limited policy support for renewables is further demonstrated by the low budgetary allocations to renewables in most countries. Most countries place more emphasis on the petroleum and power sectors, which supply a small portion of the population, than on renewables. Kachapulula-Mudenda et al. (2018) used a desk research approach to analyse capacities which should be possessed by Zambian households and possible barriers constraining widespread deployment of RETs.

RETs offer viable opportunities for sustainable energy provision to households in Zambia. Despite efforts to promote the use of renewable energy in households, its adoption has remained fairly low. Hence, the need to make an inquiry into households' capabilities needed for the acquisition and adoption of renewable energy technologies. Kachapulula-Mudenda et al's. (2018) paper reviews the requisite capacities of households for the adoption of renewable energy services and discusses some of the barriers hampering renewable energy adoption among households. Findings reveal that there is need for a broader,

multidimensional understanding of access to renewable energy in order for deployment to be effective. Barriers to successful adoption of clean energy technologies include policy inadequacies; underexploited renewable energy sector and heavy reliance on hydro-power utility. Since most of the aforementioned challenges are institutional in nature, the paper recommends a baseline assessment to understand knowledge, perceptions, attitudes and drivers for renewable energy technology adoption among households.

According to the Ministry of Energy and Water Development (2018) the Government of the Republic of Zambia remains supportive and committed to facilitating the development of the renewable energy sub-sector. In addition, the Government continues to enhance its efforts in creating an enabling environment through establishment of appropriate policies, regulatory and institutional framework. However, development of renewable energy remains significantly low due to barriers that influence the scaling up of solar energy such as; lack of a renewable energy strategy; lack of strong policy and regulatory framework for renewable energy off-grid systems; inadequate human resource capacity in solar technologies; inadequate private sector participation; and high investment capital costs and lack of financing mechanisms for solar energy projects. However, there is lack of prioritisation of solar energy in the National Budget. Very little expenditure is allocated to small and medium scale renewable energy technologies as compared to the conventional energy sector.

Ondraczek et al. (2012) argue that the incorrect assumption that grid connection is the only way to provide affordable energy is an obstacle to basic, incremental energy access in informal settlements. Financial and practical barriers to extending the grid can often leave urban communities un-serviced for decades, when alternatives such as off-grid solar technologies are readily available and increasingly affordable. Although more frequently associated with rural electrification, off-grid SHSs or mini-grids are equally suitable for urban informal settlements as a medium-term or even long-term alternative to unaffordable or impractical grid-electrification. SHSs, in particular, offer a number of benefits that make them well suited to quickly meeting the basic needs of African informal settlement households.

Haanyika (2008) states that solar energy and small-scale solar energy have high investment capital costs, which need guarantees of long-term stable income to ensure financial viability. Fiscal incentives and some form of smart subsidies would enable the development of renewable energy projects and make them financially attractive to private sector participation. Although Zambia's National Energy Policy (2019) mentions some measures that need to be considered in order to scale up adoption of solar, it does not mention the need to promote affordable solar devices such as pico solar and solar home solutions which can be bought by low-income people. There is need therefore, to promote production of small affordable solar devices such as solar home solutions and pico solar.

Similarly, the Rural Electrification Master Plan states that the Government recognises the importance of new and renewable sources of energy (Moono, 2014). According to the National Energy Policy (2019) policies regarding new renewable sources of energy include to: promote wider range of renewable energy technologies; strengthen institutional capacity for research in renewable energy; enhance coordination among key stakeholders for effective implementation of renewable energy technologies. Despite the policy mentioning measures to be taken to promote new renewable sources of energy, little has been implemented. The policy does not mention any measures to be taken to be manufacturing SHSs and pico solar. SHSs and pico solar can help a lot to the low income households because they are affordable.

Specific policy measures which act as barriers to adoption of solar energy assessed in this study are discussed. Irfan et al. (2019) state that confusing policies regarding the participation of private investors are a drawback to adoption of solar energy. Policies instituted by the government have not supported the profitable exploitation of renewable energy resources (generally and particularly solar energy) for any intending investors. High support in the form of subsidies are given to encourage energy generation from conventional energy sources leading to a fall in their prices and thereby creating an unfair competitive environment for solar energy exploitation; this has led to a slow in demand of solar energy devices (Wyllie et al., 2018). High priority has been given to traditional sources of energy and there is lack of structural regulations for renewable energy (Liu, 2018). More subsidies are available for fossil fuels as compared to solar energy and other renewable technologies.

There is lack of government policy supporting energy efficiency (EE/RE). There is lack of information dissemination and consumer awareness about EE/RE technologies compared with conventional energy and inadequate financing options for EE/RE projects. Put together, all these act as barriers to adoption of solar energy.

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA

3.0 Introduction

This chapter presents the profile of the study area in terms of general physical features and social economic characteristics. It covers characteristics such as location and economy of George Settlement**.** It also looks at history, climate, hydrology, geology, demography, soils and vegetation of Lusaka. The section further discusses the reasons for selecting George Settlement for the study.

3.1 Physical Characteristics

The City of Lusaka is the capital city of Zambia and is located within longitudes 28° 13’ and 28° 25’ east of the Greenwich Meridian, and latitudes 15° 20’ and 15°28’ south of the Equator. The City lies 1280 meters above sea level. It covers an area of 375 km² of mostly flat relief.

3.2 Demographic Characteristics

Lusaka City has a population of about 1.7 million (CSO, 2010). Its 2015 estimated population was 2,236,090 (CSO, 2010). According to the Central Statistics Office (CSO, 2014), George Settlement has a population of 130,000 people.

3.3 History

The City of Lusaka was established in 1905 and its name originated from Chief Lusaka, who owned land within the development areas of the current Lusaka Central Business area (Mulenga, 2003). The village was located at Manda Hill. The development of informal settlements in Lusaka and Zambia as a whole can be traced to the period around the 1960s especially with the advent of independence in 1964 (Carey, 2009). As urbanisation without formal employment gathered pace, those without formal employment gathered themselves in the informal settlements (Carey, 2009).

The study area is George Settlement in Lusaka. George Settlement draws its name and origin from George Hadjipetrou, who served with the English Army until the end of World War Two when he was demobilized (Hansen, 1992). Mr. George, as he was popularly known,

went into brick making business with a few workers who settled near the source of the clay used for making bricks. This small group of people constituted what was to become George Settlement.

3.4 Geology

In terms of geology, the carbonate rock/dolomite and schist are mainly distributed in Lusaka. This explains why Lusaka is prone to flooding due to the nature of underlying geology which outcrops the entire City of Lusaka (LCC, 2016).

3.5 Soils and Vegetation

The soils of Lusaka vary according to the underlying geology (LWSC, 2014). In terms of the vegetation, vegetation cover has been impacted by urbanization where the original woodland savannah with dominant munga tree is found on few pockets while the settlement is dominated by exotic trees like mango and guava and few shrubs that are being used as hedges or boundary edges.

3.6 Hydrology

The Lusaka area is drained by the Kafue River which eventually joins the Zambezi River near Chirundu Town. It is also drained by a number of small streams, namely Chunga, Chalimbana and Ngwerere. Sixty percent of Lusaka's population currently relies on groundwater, while the rest is supplied by the Kafue River (LCC, 2016). However, underground water is polluted by septic tanks within settlements.

3.7 Climate

Lusaka features hot summers and warm winters, with cold conditions mainly restricted to nights in June and July. Its coolest month, July, has a mean monthly temperature of 14.9 °C (58.8 °F) and the hottest month is October with daily average temperatures at around 32°.

3.8 Socio-economic characteristic of George Settlement

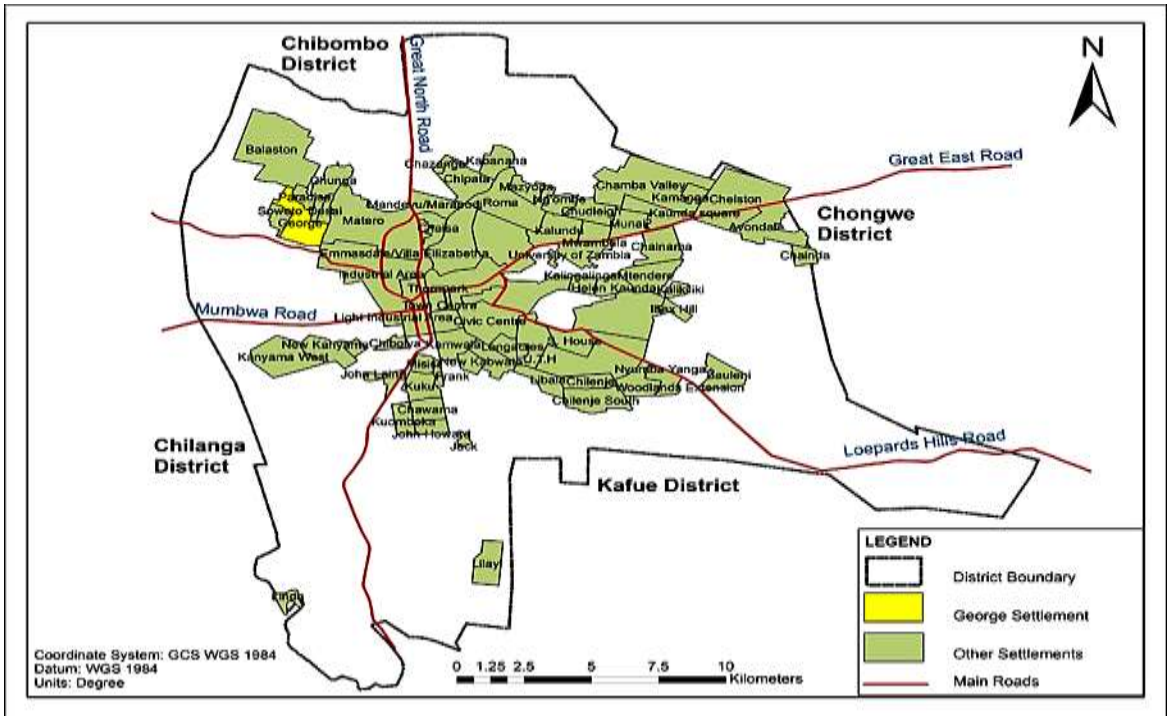
George is a former squatter settlement in Lusaka, which was legalized and upgraded in the late 1970s. George Settlement has had both social and economic problems for years. Some have been there since the settlement was founded, but others are new on the scene. These include lack of regular income among residents, inadequate social services such as housing,

water and sanitation, access roads and electricity. Most of the access roads in existence are in poor state. The settlement has a large population which shares inadequate housing, water and sanitary facilities. The majority of the houses are not electrified. In addition, most residents struggle to sustain their lives in the settlement because they have no regular sources of income.

3.9 Location

Lusaka is the administrative capital of Zambia and is at the intersection of major communication routes as shown in Figure 1. The central location gives Lusaka its strategic importance as the centre of business activities, apart from its administrative significance. George Settlement is situated on the North Western side of Lusaka City, on the western part of Matero. The Settlement has grown since the days of its founder, the late George Hadjipetrou who died in 1995. Figure 1 shows the location of George Settlement.

Figure 1: Location of George Settlement



Source: Author, 2019

3.10 Reasons for choosing the study area

The study focused on George Settlement because the settlement is nearest to one of the major market areas. Besides that, the settlement is accessible to the researcher in terms of proximity and cost of transport.

3.11 Social constructivism

Constructivism is a research paradigm that denies the existence of an objective reality, asserting instead that realities are social constructions of the mind and that there exist as many such constructions as there are individuals (although clearly many constructions will be shared) (Mills et al., 2006). To ensure a strong research design, researchers must choose a research paradigm that agrees with their beliefs to an ontological interrogation. In the first instance, they should make the epistemological and methodological possibilities that are available clear. We are all influenced by our history and cultural context, which in turn shape our view of the world and the forces of creation and the meaning of truth. Often these underlying assumptions about the world are conscious and taken for granted.

CHAPTER FOUR: METHODOLOGY

4.0 Introduction

This chapter outlines the methodology used in this study. The research design, data collection, sampling methodology and data analysis tools used in the study are elaborated in this section.

4.1 Research design

The study used a case study approach. According to Ghosh et al. (2006), a case study is a very good method of collecting information about a group of persons or an institution. A case study is an intensive study through which one can know precisely the factors and causes of particular phenomenon. A case study approach is therefore, an approach that involves focusing on a specific and bounded case (Sain-Baden and Major, 2013). The study required direct contact between respondents, key informants and the researcher. An in-depth study is needed to understand people's values and aspirations regarding using solar energy for lighting. The design was selected because it would enable the researcher gather information and get in-depth understanding about the problem context of adoption of solar energy in George Settlement.

4.2 Sampling method

For institutional survey, five (5) key informants were sampled using purposive sampling method; two (2) from REA, one (1) from ZESCO and two (2) from The Ministry of Energy. According to Denscombe (2014), purposive sampling involves selection of participants on the basis of some personal attribute that is relevant to the purpose of the study. The respondents for the institutional survey, in this study were therefore, selected because of the information they held on the subject under study. In purposive sampling, the sample is "hand-picked" for the research on the basis of relevance and knowledge. Therefore, key informants for this study were chosen based on the researcher's knowledge on their roles in influencing decisions on solar energy for lighting in informal settlements by virtue of their institutions.

For the household survey in George Settlement, a sample consisting of 50 respondents was conveniently selected. The reason for choosing 50 respondents was that more than 50 respondents would make it difficult to analyse qualitative data. Sandelowski (1995) argues that 50 interviews is a large sample for a qualitative study. He states that such a volume of data would inhibit meaningful, timely qualitative analysis. Respondents were selected by the researcher moving from one house to another asking available household heads if they were willing to participate in the study. If a household head was willing to participate, then they were included in the study and vice versa. Bryman (2008) states that "a convenient sample is one that is simply available to the researcher by virtue of its accessibility". According to Etikan et al. (2016) convenience sampling (also known as haphazard sampling or accidental sampling) is a type of non-probability or non-random sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study. Convenience samples are sometimes regarded as 'accidental samples' because elements may be selected in the sample simply as they just happen to be situated, spatially or administratively, near to where the researcher is conducting the data collection. The reason for choosing convenience sampling was to collect information from participants who were easily accessible to the researcher as recommended by Bryman (2008) and Etikan et al. (2016). However, convenience sampling has weaknesses such as having a sample that does not represent the general population. There are often underlying and unmeasured attributes associated with members of the convenient population and the measure of interest. Further, estimates based on convenience sample are biased. Nonetheless, since the study is qualitative and it is a small sample, the results are not generalised to the entire George Settlement. The results of the study just represent the selected sample.

4.3 Data collection

The research methodology involved the collection of both primary and secondary data. Primary data were collected from household heads in George Settlement using structured questionnaire. Some variables of solar energy which were assessed to determine how they influence people to use solar energy for lighting include: environmentally friendly, easy to use, observability, pre-testing, compatibility and relative advantage. Data were also collected

through interview guide with key informants at ZESCO, Ministry of Energy and REA. Appendices I and II show structured questionnaire and an interview guide respectively. Direct observation was also used in collection of primary data.

Secondary data used in this study consisted of information extracted from published and unpublished materials such as books, journals, reports and government documents. Government documents included; Rural Electrification Master Plan and the National Energy Policy.

4.4 Data analysis

Data were analysed using thematic and descriptive statistics. Thematic analysis was used to identify patterns and to group the data into themes as stated by (Marks et al., 2004). In thematic analysis, data were extracted from results. The goal of a thematic analysis is to identify themes that are patterns in the data that are important or interesting, and use these themes to address the research or say something about an issue. Data were analysed through themes, where issues emerging from data caused by various themes related to objectives and research questions of the study were structured. The, interesting findings were coded. Some themes coded include: extent of adoption of solar energy, factors that influence adoption of solar energy and barriers to adoption of solar energy. This study attempted to summarise, interpret and make sense of the collected data using thematic analysis and descriptive statistics. Descriptive statistics were used to summarise the sample. They involved the use of absolute percentages. The data were then presented in tables as frequency distribution and explanations were presented in prose.

4.5 Limitations of the study

The main limitation of the study was the limitation of the small samples and qualitative research. Fewer men than women were sampled because most men were engaged in activities away from home. The researcher however, proceeded with the study despite having a small sample because a qualitative research does not require a big sample.

The other limitation was unavailability of key informants from government institutions. Nevertheless, the researcher overcame this by starting the data collection early enough to create room for the tight schedules of the respondents.

CHAPTER FIVE: FINDINGS AND DISCUSSIONS

5.0 Introduction

This chapter presents the findings and discussions of the results. The first part presents socio-economic characteristics of respondents while the parts that follow cover the main research objectives which are discussed under the headings, adoption of solar energy; factors that lead to using solar energy and barriers to adoption of solar energy.

5.1 Socio-economic characteristics of respondents

The study targeted household heads in George Settlement and of a total of 50 respondents interviewed, the majority (92 percent) were females and eight percent were males. As for employment status, the research found that the majority (70 percent) of the respondents were self-employed. The other 30 percent of the respondents were unemployed. Table 1 shows the findings on employment status of respondents.

Table 1: Employment status of respondents

Employment status of Respondents	**Frequency**	**Percent**
Employed in informal sector	8	16
Business person	27	54
Unemployed	15	30
Total	**50**	**100**

Source**:** Field Data, 2019

Concerning income, most (44 percent) of the respondents earned less than K500 per month, 40 percent earned between K500 and K1000 per month and 16 percent earned more than K1000 per month. Table 2 shows the findings on income of respondents.

Table 2: Monthly income of respondents

Monthly income	**Frequency**	**Percent**
Less than K500	22	44
Between K500 and K1000	20	40
Above K1000	8	16
Total	**50**	**100**

Source: Field Data, 2019

The study revealed that more women than men were interviewed as mostly females were found to be at home while the male counterparts were engaged in activities away from home. This was attributed to the fact that most men had gone to work at the time interviews were conducted. The women in George Settlement were found at home at the time of interviews because they played the role of house-keeping apart from economic roles. This is similar to findings carried out by Simiyu et al. (2019) in Kisumu's informal settlements in Kenya. The similarity is that they also found that most of the respondents in their study were women. This study found that none of the respondents was employed in the formal employment. Those who were self-employed mostly engaged in grocery businesses commonly known as *tuntemba*.

5.2 Adoption of solar energy

Results revealed that there was a low adoption of solar energy among the sampled respondents. The study established that the low adoption was due to low income of respondents and high cost of solar energy devices.

5.2.1 Extent of adoption

The majority (82 percent) of respondents did not have solar energy devices. Only 18 percent of the respondents had solar energy devices. Results revealed that there was a low adoption rate at 18 percent of the respondents. The study established that low adoption of solar was attributed to low income among households, high cost of solar devices, poor quality of solar

devices and insufficient policy support. The types of solar devices used by the respondents interviewed were solar panels and solar lamps.

5.2.2 Use of solar devices

Results show that of the 18 percent of the respondents who adopted solar energy devices, 10 percent used solar panels with storage batteries and bulbs for lighting. They also used the above mentioned gadget for charging phones and powering radios. The rest eight percent used solar lamps and solar lanterns for lighting. Plate 1 shows a solar lamp, a solar lantern and solar panels used in George Settlement.

Plate 1: Some solar devices used in George Settlement

Source: Field Photos, 2019

5.2.3 Cost of solar devices owned by respondents

The study found that the solar devices owned by respondents cost between K30 and K350. Results indicated that 12 percent of the respondents who owned solar devices bought them between K30 and K150. The other six percent of the respondents bought their solar devices between K151 and K350.

A number of respondents who were interviewed indicated that solar is able to light the whole house unlike a candle which just lights a small place. For example,

A 62-year-old single woman said this:

> *"I am one of the 20 people who were trained in assembling solar panels. We were trained for 6 weeks by people from Uganda. I use a solar panel and a solar bulb for lighting. Solar energy can be used any time one wants to use it. It does not give any problems to people. It produces bright light and we also use it for charging phones. Solar helps for lighting especially during load shedding*'', (Pers. Com., 2019 a)

Similarly, a 25-year-old married man said the following:

> "*Solar has no limitations as to who should own it. Everyone can own solar devices whether their house is in good or bad state. It does not burn a house or people. Solar energy simplifies everything as one can be charging phones, lighting the house, the yard and for powering radio or TV"*, (Pers. Com., 2019 b)

Another respondent, a widow aged 53 commented:

> "*Solar is able to produce light that can brighten the entire house and even charging phones can be done using solar. I have never heard of problems such as fire accidents of burning children in a house or any other accidents caused by solar"*, (Pers. Com., 2019 c)

Another respondent, a married 20-year-old woman said this:

> "*Solar serves people well especially if one has children, one can easily light the whole house and take care of the children. It also helps breast feeding mothers to breast feed their babies well in light at night*", (Pers. Com., 2019d)

Additionally, a 56-year-old woman stated the following:

> "*I use solar. It is good because it shines brightly and gives pride to the owner and the light it produces is bright and it makes the house look shiny. Furthermore, it reduces the cost of buying candles every day"*, (Pers. Com., 2019 e)

A 42-year-old married woman said:

> *"Solar shines brightly in the house when I light it. I feel proud of it. People wonder whether there is electricity or not at my house. They ask me, "Did ZESCO install electricity here or not"? Even in the rural areas people who have grass thatched houses are able to use solar because it does not cause fire'',* (Pers. Com., 2019 f)

The majority (64 percent) of the respondents who were not using solar energy expressed interest in solar energy and some indicated that they were willing to start using solar devices. Others revealed that solar gives pride to the owner when they light solar devices in their houses because solar shines bright. For example,

A man aged 42 stated the following:

> "*Solar is better than candles because if one uses candles, one needs to be buying candles every day or regularly. But using solar does not require daily expenses for it just requires charging the device in the sun which is free*", (Pers. Com., 2019 g)

Furthermore, a 68-year-old widow indicated:

> *"I have no money for buying solar devices. When money is available, I will buy a solar panel and put it at my house for I am renting a house now. As of now I use candles for lighting*'', (Pers. Com., 2019 h)

When asked what would be the likely trend in adoption of solar energy in informal settlements, one key informant at The Ministry of Energy said the following:

> "*Most people are not aware of solar energy. People might afford to buy solar home solutions but they are not aware of solar energy and that some solar devices are affordable. They need sensitisation on availability of even affordable small solar home solutions such as pico lamps''*, (Pers., Com. 2019 I)

She further stated that:

> "*It is educated people who have knowledge about solar or clean renewable energy and the need to protect the environment. Most people who are not educated do not know about solar energy and the need to protect the environment. Producers of solar devices should consider energy efficiency by producing durable solar devices*'', (Pers. Com., 2019 j)

A key informant at Rural Electrification Authority said this:

> *"There are small devices such as pico solar lighting solutions or solar home solutions which are affordable. Some cost K120 while others cost K150. Others are large and are also used for lighting. Rural Electrification Authority provides solar home solutions of various types and sizes. Devices are arranged in such a way that solar is harvested and is used as an alternative source of energy", (*Pers. Com., 2019 k)

He added that*:*

> *"Sellers, sell different solar devices but I have never visited the areas in the informal settlements to see what they sell there",* (Pers. Com., 2019 l)

One key informant at Zambia Electricity Supply Corporation said:

> "*Uptake of solar is likely to increase especially for pico solar because technology is increasing with time. People are changing life styles. They are changing forms of energy also and are adopting renewable forms of energy*", (Pers. Com., 2019 m)

The study established that most (84 percent) of the respondents had a bit of knowledge of solar technology for they had seen solar devices either from neighbours or in villages when they visited their relatives. As such, they were willing to adopt solar energy as soon as they had money for buying solar devices. These results are consistent with the assertion by Leach (1992) who asserted that as income rises, households move first, from using traditional fuels, such as kerosene, and then to modern fuels, such as electricity from the grid. Similarly, Heltberg (2004) and Gebreegziabher et al. (2012) argue that empirical literature has confirmed that income is one of the main demand side factors determining household fuel choice. This is in line with the findings of Palm and Tengvard (2011) where non-adopters gave such reasons for not buying a solar device. This aspect of newness is contributing to a negative view of the innovation characteristic of relative advantage in terms of economic aspects of an undeveloped technology as well as compatibility in terms of a lack of knowledge of previous private usage.

5.3 Factors that lead to using solar energy for lighting

Results established that adopters consider certain qualities of solar devices before they adopt them. Some of these qualities are presented and discussed in these results.

5.3.1 Relative advantage

Results show that the majority (98 percent) of the respondents strongly agreed that solar energy has relative advantage over other forms of energy such as candles for it does not require spending money every day to buy solar devices. Results also indicated that solar energy is better than candles and kerosene because it does not cause fire accidents or diseases. The rest, two percent of the respondents did not know whether solar has relative advantage or not.

5.3.2 Compatibility

The study found that most (92 percent) of the respondents strongly agreed that solar is compatible with individual situations. The rest eight percent of the respondents did not know whether solar is compatible or not.

5.3.3 Complexity

In terms of complexity, the majority (80 percent) of the respondents strongly disagreed that solar is complex. The results also indicated that 14 percent of the respondents agreed that solar is difficult to use and understand. Further, four percent of respondents did not know whether solar is difficult to use or understand or not. The rest two percent of the respondents disagreed that solar is difficult to use and understand.

5.3.4 Observability

The study reveals that most (72 percent) of the respondents strongly agreed that solar is observable. The study also indicated that 16 percent of the respondents strongly disagreed that solar is observable. Another eight percent of the respondents did not know whether solar is observable or not. Additionally, two percent of the respondents disagreed that solar is observable. The rest two percent of the respondents agreed that solar is observable.

5.3.5 Pre-testing

Results show that the majority (88 percent) of the respondents strongly agreed that solar can be tested before it is adopted. On the other hand, six percent of respondents did not know whether solar can be tested before adoption or not. Another four percent of respondents disagreed that solar can be tested before adoption. Lastly, two percent of respondents agreed that solar can be tested before it is adopted.

5.3.6 Environmentally friendly

Concerning environmentally friendly, most (94 percent) of the respondents strongly agreed that solar is environmentally friendly. The other four percent of the respondents did not know whether solar is environmentally friendly or not. Finally, two percent of respondents strongly disagreed that solar is environmentally friendly.

5.3.7 Easy to use

In terms of being easy to use, the majority (90 percent) of the respondents strongly agreed that solar is easy to use. The rest 10 percent of the respondents indicated that they did not know whether solar is easy to use or not.

A number of respondents expressed interest in using solar energy. For example:

A 54-year-old married woman said the following:

"*Solar is better than all forms of energy as when bought, no other costs are involved afterwards. Moreover, it only uses sunlight which is free*", (Pers., Com., 2019 n)

A 26-year-old divorced woman stated the following:

> *"Solar is good for people like us, who do not have electricity as it is the same as electricity. Solar is better than candles because it does not burn houses"*, (Pers. Com., 2019 o)

Additionally, married woman aged 27 stated:

> "*Solar is good as in case of power failure, one can charge a solar device and use it. Whether one has electricity or not, one can still use solar energy. If one has electricity, one can use solar energy to save electricity bills*'', (Pers. Com., 2019 p)

A divorced woman aged 36 said this:

> "*Solar is good as compared to candles because we who use candles can cause fire accidents. But solar energy does not cause such problems. I strongly agree to use solar energy because it has no harmful effects'',* (Pers. Com., 2019 q*)*

A key informant at Rural Electrification Authority said this:

> "…*Solar is adopted quickly for it is spreading fast. It can be taken to many areas quickly. Its devices can easily be delivered. It is less restricted to applications than other forms of energy such as hydro-electricity. For example, you can go to George Settlement and tell people that you want to set up a solar plant, which cannot be the case with hydro-electric power station*", (Pers.Com.,2019 r)

The main findings of the study are that solar energy has relative advantage over candles in that it does not produce smoke like candles and kerosene do. Neither does it cause fire accidents or diseases. Solar energy was also found to be of relative advantage over other forms of energy in that it does not require spending money every day in order to use it for it uses radiation from the sun which is free. Results also show that solar energy is compatible. The study also revealed that solar devices are observable and can be tested to see if they work before buying them. Further, solar energy is generally seen as an environmental friendly technology because it does not pollute the environment. A finding in this study is also that solar energy is seen as being very easy to use, which indicated that the characteristic of complexity does not apply to the respondents' situation. The majority of the respondents who had not adopted solar energy expressed willingness to adopt solar energy for lighting.

The findings of this study are in agreement with Davis (2014) who argued that the key benefits of using solar electricity especially for home use is the fact that solar electricity is a very quiet source of power. It does not cause dangers such as fire explosions. It requires minimal maintenance and increases the value of a home. Solar panels have a long life span of above 20 years, save money and above all, they provide clean renewable energy. The variables of solar energy that are assessed in this study include: relative advantage, compatibility, pre-testing, environmentally friendly, and easy to use and observability.

5.4 Barriers to adoption of solar energy

Results on barriers to adoption of solar energy indicate four categories of barriers namely; technical and environmental barriers, financial and economic barriers, social barriers and policy barriers.

5.4.1 Technical and environmental barriers

There are some technical and environmental characteristics that were assessed in this study. They include; durability, low out-put of power, quality of solar devices and genuineness.

5.4. 1.1 Durability

In terms of durability, the study established that the majority (48 percent) of the respondents strongly agreed that solar energy is durable. Additionally, 26 percent of respondents agreed

that solar energy is durable. About 18 percent of respondents did not know whether solar energy is durable or not. The other four percent of the respondents disagreed that solar energy is durable. Lastly, four percent of the respondents strongly disagreed that solar energy is durable.

5.4.1.2 Low out-put of power

The study found that most (68 percent) of the respondents strongly disagreed that solar energy produces low power. About 16 percent of the respondents remained neutral. The other six percent of the respondents disagreed that solar energy produces low power. Further, six percent of the respondents strongly agreed that solar energy produces low power. Lastly, four percent of the respondents agreed that solar energy produces low power.

5.4.1.3 Quality of solar

Regarding quality of solar energy technology, the majority (36 percent) of the respondents agreed that poor quality of solar energy devices acts as a barrier to its adoption. Additionally, 28 percent of the respondents did not know whether quality of solar energy devices acts as a barrier to adoption of solar energy or not. Further, 14 percent of respondents strongly disagreed that quality of solar energy is a barrier to its adoption. The study established that 14 percent of the respondents strongly agreed that quality of solar energy devices influences its adoption. Lastly, about eight percent of the respondents disagreed that quality of solar energy acts as a barrier to adoption.

5.4.1.4 Genuineness

Some respondents indicated that some solar manufacturers manufacture fake solar energy devices that do not last long. They expressed disappointment at buying such devices. For instance:

A 28-year-old married woman commented:

> "*Some solar devices are not genuine. They do not produce enough light to light a house bright and others do not last long, especially the Chinese products"*, (Pers. Com., 2019 s)

In terms of influence of cultural norms and practices on the use of solar energy technology acting as barriers or opportunities, interview information with Rural Electrification Authority revealed that solar technology has been adopted in parts and not as a whole application due to lack of knowledge by adopters. Therefore, this causes disappointment to adopters. One key informant stated this:

> "*Solar technology has been adopted in parts. For example, some people will buy a solar panel and a battery without a power controller. Or they may buy a wrong battery which may not perform well. As a results, such people will think that solar technology is not reliable or efficient just because they lack knowledge about solar technology*'', (Pers. Com., 2019 t)

5.4.2 Economic and financial barriers

The study established that most (90 percent) of the respondents cited low income (average monthly income K750) as a barrier to adoption of solar energy for lighting. The other 10 percent of the respondents were neutral. Regarding economic and financial barriers results indicate that there is low income (90 percent) among respondents.

5.4.2.1 High maintenance cost

The study found that the majority (58 percent) of the respondents did not know whether high maintenance cost acts as a barrier to adoption of solar energy or not. The other 20 percent of the respondents strongly disagreed that high maintenance cost acts as a barrier to adoption of solar energy. Another 18 percent of the respondents disagreed that high maintenance cost acts as a barrier to adoption of solar energy. About four percent of the respondents agreed that high maintenance cost acts as a barrier to adoption of solar energy.

5.4.2.2 After sales service

In terms of offering after sales service the majority (46 percent) of the respondents strongly agreed that sellers of solar offer after sales service. About 30 percent of the respondents were neutral. The other 12 percent of respondents strongly disagreed that sellers offer after sales service. Additionally, 10 percent of the respondents agreed that seller offer after sales service. Lastly, two percent of the respondents disagreed that sellers offer after sales service.

5.4.2.3 Cost of solar accessories

Regarding cost of solar device accessories acting as a barrier to adoption, most 68 percent of the respondents were neutral. The other 16 percent of the respondents strongly disagreed that the cost of solar device accessories acts as a barrier to adoption of solar energy. About 14 percent of the respondents strongly agreed that the cost of solar device accessories acts as a barrier to adoption of solar energy. The rest two percent of the respondents disagreed that the cost of solar accessories acts as a barrier to adoption of solar energy.

Some respondents indicated that Government was supposed to help to lower prices of solar devices. They expressed the need for government to help to increase supply of solar devices to ensure that they are affordable. A 38-year-old divorced woman stated the following:

> "*Government should provide help to us so that prices of solar devices are sold at affordable prices. Government should also improve the supply of solar devices so that they are supplied in large quantities to lower the prices*'', (Pers. Com., 2019 u)

Similarly, a 36-year-old married man stated the following:

> "*Solar is good as it can help to light even at shops. I am running a shop and using a solar lantern and so it helps me very much. If government helps residents by ensuring that prices of solar devices go down, then people will be buying solar devices and will stop criticising government on failure to provide power to the community*'', (Pers.Com.,2019 v)

A female married respondent aged 38 said this:

> "*Government should ensure that prices of solar devices are reduced so as to enable people buy them.*'', (Pers.Com. 2019 w)

5.4. 3 Social barriers to adoption of solar

Various social barriers were stated in the results as indicated in the variables that were assessed.

5. 4.3.1 Poor aesthetics

The study revealed that the majority (78 percent) of the respondents strongly disagreed that solar panels can make the roof of a house look untidy/unattractive/ugly. The study found that, 16 percent of the respondents strongly agreed that solar panels can make the roof of a house look unattractive/untidy/ugly. The rest six percent of the respondents were neutral.

5. 4.3.2 Dependability

In terms of dependability, the results indicated that the majority (82 percent) of the respondents strongly agreed that solar energy is dependable. Another 10 percent of respondents did not know whether solar energy is dependable or not. About six percent of the respondents agreed that solar energy is dependable. The other two percent of the respondents strongly disagreed that solar energy is dependable.

5.4.3.3 Safety of solar

Regarding safety of solar energy, the study revealed that most (88 percent) of the respondents strongly agreed that solar energy is safe. And 12 percent of the respondents did not know whether solar energy is safe or not.

5.4.3.4 Knowledge of solar energy

In terms of having knowledge of solar, most (88 percent) of the respondents strongly agreed that they have knowledge about solar energy. About eight percent of respondents showed that they have no knowledge about solar energy. The rest four percent of the respondents were neutral.

5.4.3.5 Negative health impacts

Regarding solar energy causing negative health impacts, the majority (78 percent) of respondents disagreed that solar energy causes negative health impacts. The other 12 percent of the respondents did not know whether solar energy causes negative health effects or not.

And 10 percent of the respondents strongly agreed that solar energy causes negative health impacts.

A few respondents showed that they had little knowledge about solar and stated that they would not describe solar as they did not know much about it. For example, a 39-year-old woman stated the following:

> "*I cannot say solar is good or bad to use because I do not know about solar for I have never used it before*'', (Pers. Com.,2019 x)

Another respondent, a 32-year-old married man stated the following:

> "*I see some people using solar but I do not know exactly how solar works. So I cannot tell whether solar produces enough light or not",* (Pers. Com., 2019 y)

5.4.4 Policy barriers to adoption of solar energy

Results established that policy barriers to adoption of solar energy include: unclear regulations, insufficient policy support and subsidies and incentives. The results also indicate that unclear regulations do not act as barriers to adoption of solar energy.

5.4.4.1 Unclear regulations

The study revealed that most (86 percent) of the respondents strongly disagreed that there are unclear regulations on solar energy adoption. The results also reveal that 14 percent of respondents were neutral.

5.4.4.2 Insufficient policy support

In terms of insufficient policy support, results show that the majority (78 percent) of the respondents strongly disagreed that government, NGOs and other stakeholders in energy provision promote the use of solar energy for lighting. About 10 per cent of the respondents strongly agreed that government, NGOs and other stakeholders in energy provision promote the use of solar energy for lighting. The rest 12 per cent of the respondents were neutral.

5.4.4.3 Subsidies and incentives

Concerning government subsidies and incentives, the results revealed that the majority (66 percent) of respondents strongly disagreed that there are government subsidies and incentives for solar energy. Another 16 percent of respondents disagreed that are government subsidies and incentives for solar energy. The other 16 percent of the respondents were neutral. Finally, two percent of the respondents agreed that there are government subsidies and incentives for solar energy.

When asked what was needed to be done to promote affordable solar energy technology, one key informant at Rural Electrification Authority stated this:

> *"There is need to strengthen policy direction. Government has made efforts to scale up the uptake of solar energy. Access to market and affordable prices should not be different. Transport costs should be considered so that sellers are able to make profits without exploiting customers. There should be price harmonisation*", (Pers. Com., 2019 z)

Concerning policy measures for solar technology, interview information revealed that Rural Electrification Authority had a general policy to improve solar uptake. This is what one key informant at Rural Electrification Authority stated:

> "Our *general policy is that we are trying to improve the uptake of solar energy by introducing pico solar which are small off grid solar components which are affordable"*, (Pers. Com., 2019 aa)

Regarding policy on solar energy, one key informant at Zambia Electricity Supply Corporation expressed the following:

> "*The energy policy aims at addressing barriers to adoption of solar energy.It further strives to increase public awareness of benefits of solar energy and deployment of solar applications in the country*", (Pers. Com., 2019 ab)

In terms of barriers to adoption of solar energy, the study revealed that the major barriers include: economic and financial, policy and technical and environmental barriers. Other barriers are high cost of solar devices (88 percent), insufficient policy support (78 percent).

Concerning insufficient policy support, the study found that there is not enough funding from government or private sector for solar energy to ensure wide spread adoption in the country. The study revealed that there are no government subsidies and incentives to solar energy to make it cheap and affordable to low income households. The National Energy Policy (2019) just mentions solar energy without implementation through sufficient funding in the budget allocation. The results also established that poor quality of solar devices (36 percent) acts as a barrier to adoption of solar energy because some of the solar devices are not durable. The study also established that some solar devices have low output of power. Quality of technology matters in determining adoption because adopters would observe the solar devices from others who bought them and if they see that the device is durable, they will also buy a similar one. Results indicated that there are no restrictions in policy regulations as to who should own solar or what type of house one should have in order for them to own a solar device.

The results of this study are similar to those of the study carried out in Zimbabwe by Makonese (2016) on barriers to adoption of solar energy. His study revealed that lack of consistent policies and regulatory frameworks to support solar energy was cited as a barrier to adoption of solar energy. The study further established that policies in Zimbabwe were biased towards fossil fuels. In addition, although the government of Zimbabwe had adopted an energy policy, there was no specific policy for solar energy.

The results of this study are similar to the results of the study undertaken by George et al. (2019) in Kenya on barriers to adoption of solar. Their study revealed that the major barrier to adoption of solar energy in Kenya was lack of finances among low income households. Therefore, the low income people found it difficult to switch to solar electricity from kerosene, candles and other conventional fuels

The results of this study are similar what Karekezi et al. (2012) observed. He observed that the success of solar energy adoption depends to a large extent on existing government policies. The government should create an enabling environment for solar energy dissemination and mobilising resources as well as encouraging private sector investment. However, most governments do not have clear policies on the development and promotion

of solar energy. Zambia is not an exception because the results of this study reveal that there is little support for solar energy from Government or private sector and NGOs.

The results of this study agree with the National Energy Policy (2019) which states that renewable energy sources are increasingly being used but still remain insignificant in terms of contribution to the total national energy supply. It adds that despite potential in relative terms, solar energy and small-scale solar energy devices have high investment capital costs, which need guarantees of long-term stable income streams to ensure financial viability. Fiscal incentives and some form of smart subsidies would enable the development of renewable energy projects and make them financially attractive to private sector participation. Although the policy mentions some measures that need to be considered in order to scale up adoption of solar energy, it does not stress the need to promote affordable solar devices such as SHSs and pico solar which can be bought by low income people. There is need therefore, to promote production of small affordable solar devices such as solar home solutions and pico solar.

Similarly, the Rural Electrification Master Plan states that the Government recognises the importance of new and renewable sources of energy (GRZ 2017). It further states that solar power generation accounts for three percent of the total installed generation capacity. The level of investment in solar energy electricity generation has been low due to among other things high cost of capital and inadequate regulatory frameworks for renewable energy systems that have caused uncertainties for investments. However, the policy does not state inclusion of off-grid solar energy which is affordable to low income people.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

The study finds that adoption rate of solar energy as an alternative for lighting in George Settlement is very low. The reasons for low adoption of solar energy include low income among residents. The study found that none of the sampled respondents is in formal employment and that most of them earn low income while others have no income at all. Therefore, it is difficult for most of them to find money for buying solar devices. The other reason for low adoption of solar is high cost of solar devices. The prices of solar devices are too high for low income households.

In terms of factors that lead to using solar energy for lighting, the results show that the respondents' perceptions of solar energy that promote adoption include: solar being; environmentally friendly, observable, pre-tested, compatible, easy to use and solar having relative advantage. The study established that solar energy is better than candles in that it does not produce smoke like candles do. The results also indicate that solar energy is cheaper than candles because it uses radiation from the sun which is free. The key conclusion is that the majority of the respondents who have not adopted solar energy for lighting are willing to adopt it.

Regarding barriers to adoption of solar energy for lighting, the conclusions are that the major barriers to adoption of solar include low income among residents. The other barriers are high cost of solar devices. Since respondents earn low income and some have no income at all, they cannot afford to buy solar energy devices. The study cited absence of subsidies and incentives for solar devices as a barrier to adoption. The study established that there is not enough funding from either government or private sector for solar energy to ensure wide spread adoption. Results indicate that poor quality of solar devices acts as a barrier to adoption of solar energy. Since this study is a small qualitative study, the findings cannot in any way be generalized to the entire George Settlement but the results just represent the selected sample.

6.2 Recommendations

Based on the conclusions of this study, it is recommended that strategies for improving adoption of solar energy for lighting and to overcome barriers to adoption of solar energy should involve participation of the stakeholders including: policy makers, the private sector, NGOs and individuals. This can be done in various ways as recommended.

1. It is suggested that city authority should establish solar energy empowerment schemes. The schemes should be aimed at empowering residents with job opportunities in order to raise their income and increasing the number of solar energy devices in the residential areas.
2. It is recommended that Zambia Development Agency (ZDA) should consider off -grid solar solutions as a sector for job creation.
3. Zambia Commission for Economic Empowerment should engage in small-scale solar manufacturing at Multi-Facility Economic Zones (MFEZ).
4. It is proposed that Zambia Development Agency (ZDA) should promote Small and Medium Enterprises (SMEs) to create employment opportunities for local people by supporting local businesses in George Settlement. This will help to improve the residents' income levels so that they can afford to buy solar devices.
5. It is recommended that the private sector sets up off-grid power projects in some of the informal settlements in order to increase the supply of solar energy.
6. The Ministry of Energy should prioritise solar energy by allocating adequate funds in the National Budget to it so as to enable solar devices to be supplied in large quantities. Large supply of solar devices will lower the prices of the commodity and enable low income households to afford them.
7. It is proposed that the Ministry of Higher Education should include in the curriculum for tertiary level, courses on manufacturing and assembling of solar devices. This will help to increase the number of solar devices in Zambia and in turn, lower the prices thereby making them affordable for low income households.

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APPENDICES

Appendix A: Structured Questionnaire for Household Heads in George Settlement

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Geography and Environmental Studies

Dear Distinguished Respondent,

I am Cosmas Kaambo, a Postgraduate Student at The University of Zambia studying Master of Science in Spatial Planning. I am conducting a study on "Solar as an Alternative Source of Energy for Lighting in Informal Settlements'': A Case of George, Lusaka. This study is needed in partial fulfillment of the completion of the award of the Master of Science in Spatial Planning Degree at The University of Zambia.

You have been chosen to participate in this study by answering the questions bellow. Your cooperation will be highly appreciated. The information you provide is purely for academic purposes. It will be treated as confidential and will not be shown to anybody else. Participation in this research is voluntary and your views are important, valued and welcome. Your assistance will be greatly esteemed.

Instructions:

Tick against the appropriate response or fill in the blank spaces.

Section A: General and Personal information

1. Sex of respondent Male ☐ Female ☐

2. Age

below 18 ☐ 18-29 ☐ 30- 39 ☐ 40-49 ☐

50-59 ☐ 60 and above ☐

3. Marital status:

married ☐ single ☐ divorced ☐ widow ☐ widower ☐

4. Highest level of Education:

Primary ☐ Secondary ☐ tertiary ☐

5. Employment status:

employed in formal sector ☐ employed in informal sector ☐

unemployed ☐ Business person ☐

6. Monthly income:

less than K500 ☐ between K500 and K1000 ☐ more than K 1000 ☐

7. How long have you lived in this compound?

State…….

Section B: Adoption of solar energy-energy for lighting

Those who have adopted solar energy

8. Do you use solar energy**?**

yes ☐ no ☐

9. What kind of solar device do you use?

State……

10. When did you start using solar?

State……

11. How much did it cost you to buy the solar device you use?

State……

12. What do you use the solar for?

State……

13. For how long have you been using solar?

State……

Those who have not adopted solar energy

14. Why are you not using solar energy?

Explain……

15. When are you likely to start using solar?

State……

Section C: Factors that lead to using solar energy for lighting

Indicate the degree to which you agree or disagree to the following statements regarding the perception of Solar Energy Technology in your compound. Use a scale of 1-5 where; (1) is strongly disagree; (2) disagree; (3) neutral; (4) agree; and (5) strongly

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
16. Relative advantage (is solar better than fossil fuels?)					
17.Compatibility(fit with individual situation)					
18.Complexity(difficult to use and understand)					

19.Observability(visible to others)					
20.Trail ability(whether or not solar can be tried before adopted)					
21.Solar energy is environmentally friendly technology					
22.Solar energy is easy to use					
23.Solar energy is suitable for home use					

Section D: Barriers to adopting solar energy technology

Please indicate the degree to which you agree or disagree with the following statements regarding barriers to adoption of Solar Energy Technology in your compound.

Use a scale of 1-5 where; (1) is strongly disagree; (2) disagree; (3) neutral; (4) agree; and (5) strongly agree

Technical and environmental barriers

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
24.Short product Lifespan					
25.Safety issues					
26.Reliability					
27.Low output					
28.Quality of solar technology					

Economic and financial barriers

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
29.High upfront cost					
30.High maintenance cost					
31.No subsidies for purchasing solar					
32.After sell service					
33.Cost of solar accessories					

Social Barrier

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
34.Poor aesthetics					
35.Dependability					
36.Perceived safety of solar					
37.Knowledge of solar technology					
38.Negative health impacts					

Policy Barrier

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
39.Unclear regulations					
40.Insufficient policy support					
41.Lack of government subsidies and incentives					
42.Rigid building regulations					

43. Is there anything you feel I did not or should have asked that you would like to mention?

Explain……

Appendix B: Interview Guide for Key Informants at ZESCO, the Ministry of Energy and REA, on Solar Energy as an Alternative Energy Source for Lighting: A Case of George, Lusaka

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Geography and Environmental Studies

1. What kind of clean, renewable energy technologies are suitable for informal settlements?
2. What kind of solar technologies are available for informal settlements?
3. What kind of businesses for solar energy technologies operate in informal settlements?
4. What type of solar technologies do they sell?
5. What kind of affordable solar energy technologies would you recommend to be promoted in informal settlements?
6. What needs to be done to promote affordable solar energy technologies?
7. Does the local community afford to buy solar technology available?
8. What is the likely trend in adopting solar energy technologies in the future?
9. What cultural norms and practices influence the use of solar energy technologies? (Barriers and opportunities)
10. Are there any policy incentives for solar technology?

Thank you for the time spent on the interview.

THE END