



Energy Poverty of Rural Households in Malawi: Potential for renewable energy options and more efficient use of biomass to reduce vulnerability

By

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DECLARATION

I, Felton Otrain Manani Phiri, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature.....

Date.....

*To my parents: Reverend Otrain Bapton Manani Phiri and Mrs Ethel Manani,
and to Tinna, Takondwa OM II, Mphatso Divine & Tinali Audetta.*

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ABSTRACT

Most of the people in Malawi live in rural areas and are poor, depend on rain-fed subsistence agriculture and use traditional biomass as a source of energy. In the face of changing climate this dependence on rain-fed agriculture and traditional biomass makes them to be more vulnerable. Furthermore, reliance on biomass as a source of energy degrades the environment and also cause human suffering thereby increasing their vulnerability. A number of interventions are being put in place by Malawi government and other stakeholders to reduce vulnerability of the rural poor. One of such is rural electrification using stand-alone renewable energy technologies such as solar home systems which are hoped to positively transform livelihoods through provision of efficient and reliable energy.

This study explores the potential for using renewable energy options in reducing people's vulnerability and also how efficient use of biomass can reduce vulnerability and limit deforestation in Malawi. The research focuses on solar energy and efficient use of biomass through improved cook stoves. The issue of reducing vulnerability is addressed by looking at how use of solar energy and improved cook stoves improve people's adaptive capacity. The study also looks at whether Malawi's current energy policy promotes use of renewable energy. It uses Sustainable Livelihoods Framework by DFID.

The study is carried out in Chitala and Chimonjo villages, Salima district, Malawi. The sample is made of beneficiaries of the solar electrification project that was implemented in the two villages by the Barefoot College, India, and relevant key informants. The study uses mixed methods research in data collection and analysis.

The study shows that use of solar energy in the two villages has improved the health, income, education, and social life of participants. It also shows that both solar energy and improved cook stoves have environmental benefits. Furthermore, Malawi's current energy policy has increased access to and use of renewable energy.

The paper concludes that use of solar energy and efficient use of biomass reduces people's vulnerability to climate change. Efficient use of biomass has been found to reduce deforestation in Malawi. Furthermore, both solar energy and improved cook stoves mitigate climate change. Lastly, Malawi's current energy policy promotes use of renewable energy.

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LIST OF ABBREVIATIONS AND ACRONYMS

3SF	3 Stone Fire
BAREM	Barrier Removal to Malawi Renewable Energy
CC	Climate Change

CCODE	Center for Community Organisation and Development
CE	Centralized Electrification
CFL	Compact Fluorescent Light
CG	Centralized Generation
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CSP	Concentrating Solar Photovoltaic System
DANIDA	Danish International Development Assistance
DE	Decentralized Electrification
DFID	Department for International Development
DG	Distributed Generation
DoEA	Department of Energy Affairs
DP	Development Partners
DRE	Decentralized Renewable Energy
EP	Energy Poverty
ESCOM	Electricity Supply Corporation of Malawi
FES	Fuel Efficient Stoves
FGD	Focus Group Discussion
GHG	Green House Gases
GOM	Government of Malawi
GW	Gigawatts
HDI	Human Development Index
IAP	Indoor Air Pollution
ICS	Improved Cook Stoves
IEP	Integrated Energy Policy
IGA	Income Generating Activities
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Providers
kWh	Kilowatt Hour
kWp	Kilowatt Peak
LDC	Least Developed Countries
LED	Light Emitting Diode
MAREP	Malawi Rural Electrification Programme
MBS	Malawi Bureau of Standards

MEET	Malawi Environment Endowment Trust
MERA	Malawi Energy Regulatory Authority
MES	Malawi's Energy Sector
MHPF	Malawi Homeless People's Federation
MMR	Mixed Methods Research
MW	Megawatts
NEP	National Energy Policy
NGO	Non-Governmental Organisation
NO ₂	Nitrogen Dioxide
NSREP	National Sustainable and Renewable Energy Programme
ORESSI	Other Renewable Energy Sources Supply Industry
PV	Photovoltaic
RE	Renewable Energy
REC	Rural Electrification
RET	Renewable Energy Technologies
ROI	Return on Investment
SD	Sustainable Development
SE	Solar Engineer
SHS	Solar Home Systems
SO ₂	Sulphur Dioxide
TECRET	Training and Testing Center for Renewable Energy Technologies
TV	Television
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
VAT	Value Added Tax
VSC	Village Solar Committee
WHO	World Health Organization

“...access to modern affordable energy services in developing countries is essential for the achievement of the internationally agreed development goals, including the Millennium Development Goals, and sustainable development, which would help to reduce poverty and to improve the conditions and standard of living for the majority of the world’s population.”
(UNDP 2012)¹

¹ Excerpt from the United Nations General Assembly declaration of 2012 as the International Year of Sustainable Energy for All

CHAPTER 1 - INTRODUCTION

1.1 Introduction

The use of renewable energy (RE) has existed for centuries, but it is only in recent decades when there has been increased scope in recognition of its potential and more emphasis being placed on its promotion and use. This positive change is as a result of its ability to meet energy demands while at the same time being environmentally friendly. This increased emphasis on RE has led to a number of initiatives and policies being made (local and international) as well as conventions being ratified.

One of such conventions and initiatives was the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil in 1992, where an environment and development document, to operationalise the concept of sustainable development, entitled “Agenda 21” came into effect (Karekezi 2002; United Nations 1992a). The other important global convention that looked at renewable energy was the United Nations Framework Convention on Climate Change (UNFCCC) which was ratified and came into effect on 21st March 1994 (United Nations 1992b). In both cases there was renewed emphasis on the importance of RE to meet energy needs, while conserving the environment for future generations. Furthermore, it was also realised that since energy is essential for development there was need to use RE, among other energy forms, so as to make development sustainable.

The issue of RE and sustainability comes against the background that in pursuant of development, there has been an overdependence on fossil fuels which has resulted into a number of repercussions including damage to the environment. Worse still the central grid electricity, which has been the main focus of many governments in the past decades, is failing² to provide energy to the rural poor leaving a lot of people still reliant on biomass and thus suffering from energy poverty (EP) and lacking development. The study aimed at finding out the potential for using RE options in reducing the vulnerability of rural livelihoods and also how these renewables can limit deforestation in Malawi. It is envisaged that the use of RE and efficient combustion of biomass can transform rural livelihoods and hence decreasing their

² This is because grid extension to spatially dispersed populations is very expensive (roughly \$10,000/km), and also difficult to economically justify particularly with the low load factors, low capacity utilisation rates and higher maintenance costs typical of these communities (Jones & Thompson 1996; Liming 2009).

vulnerability. It is essential to provide efficient means of using biomass to the rural people since the use of biomass will continue for the foreseeable future even in the presence of various renewable energy technologies (RET).

The research was conducted in two villages in Salima district, Malawi, where a number of households are using solar home systems (SHS) obtained through a development project. The research endeavoured to look at what both solar energy and biomass are used for in these two villages, as well as the benefits being realised and challenges being faced in their utilization.

According to the UNDP (2012) provision of clean and affordable energy services will help to reduce poverty and improve the living standards of the world's majority living in the rural areas. This is why a number of countries and organisations are embarking on various projects that will see rural populations having access to RE.

1.2 Background

Energy remains a dynamic force in the growth, development and survival of all human societies (Turyareeba 2001). This, according to Sopian et al. (2011), is because energy is required for meeting all of the basic needs such as food, health, agriculture, education, information, and other infrastructure services. However not everyone has access to the required energy, be it in traditional or modern form. Access to energy services vary from country to country with people in developed countries having better access than those in developing countries. According to the Malawi population and housing census of 2008³, Malawi's population stood at slightly above 13 million⁴ (NSO 2013) of which only 6.7% have access to electricity and 87% use firewood for domestic purposes. Furthermore, of this population of about 13 million, 84.7% live in the rural areas (NSO 2013). These statistics show that the majority of Malawi's population does not have access to electricity or modern forms of energy, hence suffer from EP, and these live in rural areas.

Lack of access to modern energy has a number of consequences such as limiting income generation, negatively affecting the health of women and children, and also contributing

³ The Government of Malawi through the National Statistical Office conducts a Population and Housing Census every 10 years (NSO 2013).

⁴ World Bank estimates in 2012 showed that Malawi's population had reached 15,906,483 in that year (World Bank 2013b).

towards deforestation and climate change (Sovacool 2012). The lack of access to modern energy is one of the contributing factors to why people in the rural areas of Malawi are poor, live in areas where most of the natural resources are depleted or are being depleted at a fast rate and also have low living standards. The government of Malawi (GOM) then realized that in order to eradicate poverty and improve the living standards of the rural masses there was need to provide a reliable and more efficient form of energy and in this case electricity. In order to do this, the GOM with the help of development partners (DP), embarked on rural electrification (REC) programs using grid electricity. Furthermore, this REC was also done with the realization that it will be impossible to attain the Millennium Development Goals where people do not have access to clean and efficient energy. According to Sopian et al. (2011) access to energy has a clear correlation with the Human Development Index (HDI) where higher energy consumption figures are associated with highly developed countries. Figure 1 below illustrates this.

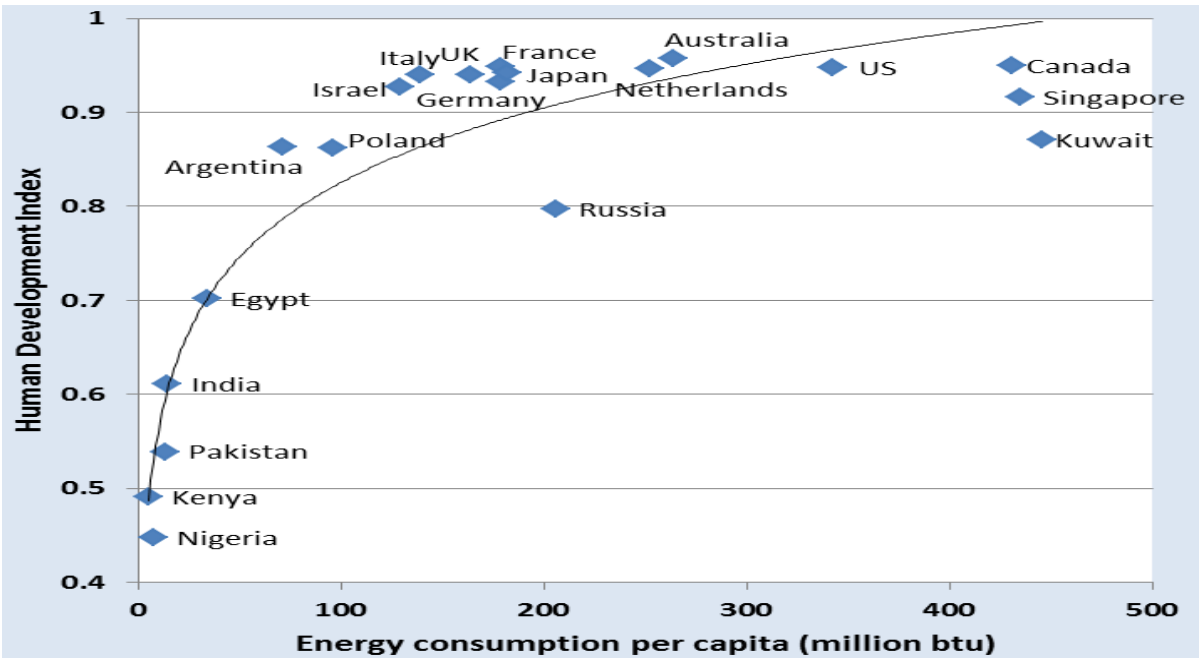


Figure 1: Energy and HDI Correlation (Šlaus & Jacobs 2011)

The GOM’s REC program mainly focused on using grid electricity, in a centralized approach, which targeted areas of population concentration in the rural areas such as rural growth centers, towns and trading centers. This approach left out isolated or dispersed settlements as they were deemed not economically feasible to be connected to the grid. However, even though these centers were areas of population concentration in the rural areas, they represented a small

portion of the rural population since majority of the rural population lives in dispersed or isolated settlements away from these centers. This then shows that the centralized approach was not going to cater for the majority of the rural population. This is where use of stand-alone RETs such as solar power, wind power, geothermal and other renewables come into play. It is with this realization that GOM together with DPs decided to change the REC approach from the centralized one (with total dependence on grid electricity) to decentralized one (where stand-alone renewables will be used). However, this change in approach does not mean that GOM has totally abandoned the centralized approach in REC but rather it has incorporated the decentralized approach into the REC so as to reach out to more people. To this effect, several villages in Malawi have been solar electrified by GOM or DPs such as the Barefoot College, India, using the decentralized approach.

Despite these solar electrification efforts mentioned above, many rural areas in need of modern energy remain untouched and biomass fuels continue to be the norm for both lighting and cooking. This has resulted into still having more rural people living in poverty and being more vulnerable. Furthermore, with increase in population, there is increased use and pressure on biomass fuels resulting into escalation of disadvantages from it. It is against this background that this paper examines how the use of RE can reduce vulnerability of rural livelihoods and also how these renewables can limit deforestation in Malawi.

1.3 Problem statement

The majority of Malawi's population live in the rural areas and is poor. They depend on fossil fuels such as kerosene for lighting and biomass for cooking and also lighting, both of which bring a lot of disadvantages. RETs such as solar electricity are seen as a way of taking out these people from the energy poverty (EP) that they are facing. However, it is just a small proportion of the population that is accessing solar electricity and those who have it do not use it for cooking since cooking requires more energy than the amount currently provided by the stand-alone solar electricity units. In this case more people are still dependent on biomass for cooking, more especially fuelwood. This study envisage to assess the potential for RETs, with emphasis on solar energy, in solving rural EP and also outline how rural households can use biomass more efficiently to limit deforestation. It further looks at how solar electrification and efficient use of biomass can reduce vulnerability in rural areas.

1.4 Study objectives

The following are the study objectives for this paper.

1.4.1 Main objective

The main goal of this study was to find out the potential for using RE options in reducing the vulnerability of rural livelihoods and also how these renewables can limit deforestation in Malawi. In addressing the issue of reduced vulnerability, the study looks at how use of solar energy and efficient use of biomass in the study area can improve people's livelihoods and adaptive capacity to climate change. In the case of limiting deforestation, the study looks at how efficient use of firewood using improved cook stoves (ICS) reduces the amount of firewood used and thus limiting deforestation.

1.4.2 Specific objectives

This research was guided by three specific objectives from which a number of research questions were set. These are as follows:

1.4.2.1 Objective 1

National energy policy to improve access to renewable energy is explored

The study sought to explore the Malawi national energy policy 2003 (*NEP 2003*) and how it guides improving access to RE in Malawi. Under this some of the areas meant to be looked at include the main issues being addressed in *NEP 2003* on how GOM intends to improve access to RE in rural areas and the policy instruments that GOM has put in place to improve access to RE in Malawi. Lastly, the research examined to what extent the policy has been implemented and the challenges being faced in its implementation.

The following were the research questions for this objective:

1. *What is the national policy on improving access to RE in Malawi?*
2. *To which degree has the policy been implemented to achieve improved access to RE options in rural areas in Malawi?*

1.4.2.2 Objective 2

The impacts of RE options on reducing energy poverty are analyzed with a focus on solar energy

Through this objective, the study sought to analyze how use of RE (solar energy) has impacted livelihoods of the people in the concerned households in general. In addition to the impacts at household level, the study also looked at these impacts on women and men separately to find out if there are noticeable differences. This is because men and women play different roles in

these rural societies as determined by culture. The study further looked at whether use of solar energy has reduced EP and vulnerability in these households.

The research question for this objective was as follows:

What is the impact of RE options on men's and women's livelihoods?

1.4.2.3 Objective 3

Pressure on biomass energy for domestic use in rural areas is reviewed and options for more efficient use and climate change mitigation explored

The study sought to review the pressure being put on biomass arising from domestic use. This review was done by looking at whether there has been any change in acquisition of the biomass. This took into consideration increase in population which could also trigger an increased demand in the use of biomass domestically. Furthermore, the study looked at whether there have been changes in the use of biomass and also if there are options for more efficient use of biomass to reduce increased pressure on it. Seeking for more efficient use of biomass took into consideration that efficient use of biomass will reduce disadvantages that arise from its inefficient use including climate change and will also help to reduce vulnerability. Additionally, the study sought to find out if there are differences in the acquisition, control and use of energy types based on gender. It was essential to do this in order to come up with options for efficient use of biomass taking into consideration the differences in gender roles.

The research questions for this objective were

- i. Has there been a change in the acquisition and use of biomass for domestic purposes in the last twenty years?*
- ii. How do gender roles reflect on use and control of types of energy?*

1.5 Justification of the study

This study is significant to various stakeholders with the main ones being those in development programs, RE, rural households as well as policy makers. The study could help development practitioners to come up with sustainable livelihoods programs that not only aims at transforming people's lives but takes on board the concerns of both male and female members of the society and incorporates them in their programs as a means of transforming people's lives. For those dealing with RE, the study will provide a basis for understanding how energy issues affect the men and women and be able to come up with energy programmes that addresses the energy concerns of both. It will also help them to come up with programs that

will reduce EP in rural areas as well as look at how use of biomass can continue sustainably and efficiently. Policy makers could use this to come up with RE policies that are relevant, non-conflicting and those that could see a transformation of the lives to improve livelihoods.

It was also necessary to do this research since there has been little research of this type done in Malawi that was as comprehensive as this one, where both RETs and biomass were studied together extensively, and where gender and climate change issues were also incorporated in the study. This paper will strengthen Malawi's research work in this area.

1.6 Conceptual framework

This research looked at how provision of RE options (with a focus on solar energy) and efficient use of biomass can positively transform (socially and economically) people's lives in the study area thereby reducing their vulnerability. This comes from the background that rural areas of developing countries suffer from EP which is one of the factors preventing people from living meaningful and vibrant lives and as a result become stuck in poverty. Furthermore, EP increases people's vulnerability and is also responsible for unsustainable use of natural resources, most especially forests. The research also looked at the disadvantages arising from inefficient use of biomass which includes contributing towards climate change and respiratory diseases. In this paper focus was put on solar energy as a RE that can help transform people's lives in rural areas for the better. To explain this, the Sustainable Livelihood Framework developed by DFID in 1999 was used. This is particularly important because the framework has all the main elements of this paper as pointed out above. The framework is illustrated below.

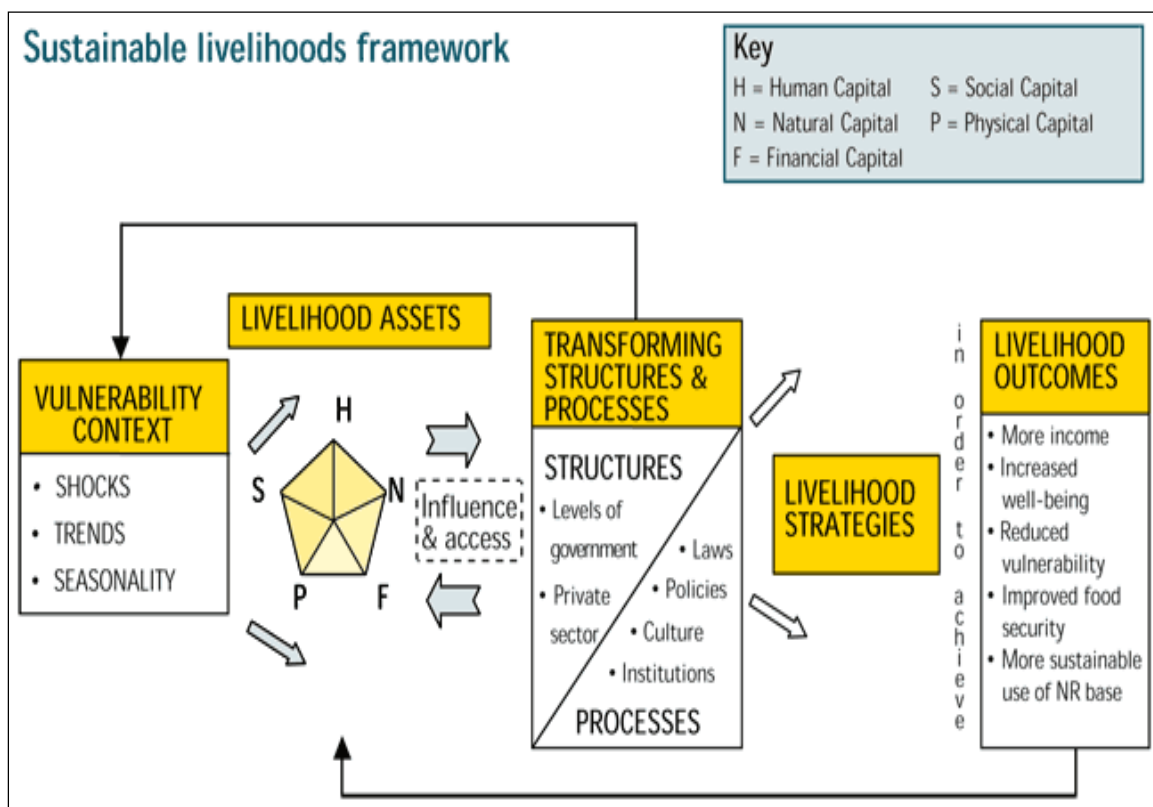


Figure 2: Sustainable Livelihood Framework (DFID 1999)

EP affects negatively a number of livelihood assets such as human capital (due to diseases and other ailments, lack of adequate education), natural capital (due to unsustainable use of the natural resource base), social capital, financial capital and physical capital. This condition decreases the rate at which people can go through shocks, trends and seasonal changes. This then means that EP increases people’s vulnerability.

The first part of the model looks at vulnerability context. The three main issues that make up the vulnerability context are trends, shocks and seasonality. Firstly, under trends two issues are important in this study, thus population increase and resource depletion. Population increase is one of the factors that cause resource depletion in developing countries as more pressure is exerted on the limited resources available so that everyone should have a piece of the pie. Secondly, shocks such as droughts or floods result into no or very low agricultural produce thus people suffer from hunger and nutrition problems. Other shocks such as economic, where prices of goods and services have all of a sudden gone up due to steep depreciation of the currency or inflation, leaves the people in a difficult situation as they fail to pay for the goods and services they need due to lack of money. Thirdly, seasonality of prices, production, employment and health is another important issue to consider in vulnerability context. Largest proportion of the

rural population is made of smallholder subsistence farmers who are dependent on rain fed agriculture where they cultivate during one season only in a year. These mainly grow food crops and sometimes crops that would double as food and cash crops where they sale the surplus to get money to meet other domestic needs. Sometimes these farmers would also grow cash crops like cotton and tobacco at a small scale so that they have some income at the end of the farming season. Harvest period⁵ is therefore the main time these people will have some income. However, despite selling their crops, the primary focus of these farmers is to grow crops to have enough food in their households. On the other hand, during the rainy season most of these farmers do not have money as it is several months after the previous harvest, but this is also the time they have more activities in their gardens to ensure crops grow well. This lack of money then makes it difficult to hire labor and consequently failure for others to earn an income from farm jobs. Furthermore, others fail to go and work in other people's fields even if there is an opportunity to do so due to the demands from their own gardens and they prioritize their own crops so that they have food in the coming season. Rainy season also registers increased disease infections, such as malaria, as conditions are more favorable. Diseases reduce one's capacity to work and earn an income. This shows variation in earnings at household level from one season to another which is precarious in the face of shocks especially when they fall off season.

The model's second part deals with transforming structures and processes. In this study the transforming structures are government departments (such as those of energy, forest, environment and gender), non-governmental organizations and the private sector. These can change the situation that these rural people are in through the provision of RE as well as an enabling environment for the adoption of such. In the case of processes, there are laws, policies, culture and institutions which all have to be changed or adjusted to accommodate adoption of RE as part and parcel of one's life. To make this more successful there will be need to review and change the laws, cultural practices (since other cultural beliefs will not accommodate use of human waste for biogas), religious beliefs (where others refuse to use solar energy since they worship the sun) and institutions governing energy issues. The institutions should have the capacity to handle this energy transformation. The two research questions that are dealing with the national energy policy on improving access to RE will be dealt with (analyzed) using this part of the model. The formulation and implementation of the policy involved a number of

⁵ The crops are sold at low prices during this time because of high levels of supply on the market.

stakeholders such as the government of Malawi departments on one hand and the private sector on the other. Its formulation also took into consideration the existence of other policies (so that they should not be conflicting) and relevant laws or acts to make it legally binding. A number of institutions were also involved in both the formulation and implementation of the policy. The framework will then help to see if all these eventually lead to improved access to RE with the resulting improved livelihoods.

The model's third part deals with livelihood outcomes. It is envisaged that once RETs and efficient ways of using biomass are provided, the people will have increased income (as they will be using the electricity from RE to venture into small-scale businesses as well as cutting down expenses on kerosene and other lighting sources), increased wellbeing (due to reduced emissions and exposure to such), improved food security (more time will be spent on the farm than collecting fuelwood and being down with disease) and they will also be able to use the natural resource base sustainably (as deforestation will be reduced through efficient use of fuelwood). Use of natural resource base sustainably will result into an increased availability of the resources due to an improved natural replacement rate and hence more people having increased access to it. All these will improve people's wellbeing and enhance their adaptive capacity to climate variability while at the same time enabling them to live sustainable livelihoods. According to Chambers and Conway (1991), a livelihood is sustainable when it can cope with and recover from stresses and shocks and be able to continue improving, maintain or enhance its capabilities and assets, while not undermining the natural resource base. This part of the model will help in analyzing the study's research question on the impact of RE options on men's and women's livelihoods.

The last two research questions in the study concern livelihood assets. These will be analyzed using the part of the model that deals with livelihood assets. However, while the research question that looks at changes in the acquisition of biomass for domestic purposes is covered by all five aspects of the livelihood assets, the research question that is looking at gender roles on use and control of types of energy is covered by the human and social capital aspects of the livelihood assets.

All in all, the Sustainable Livelihood Framework (DFID 1999) described above is a useful tool in this study as it has helped in clarifying the research questions. It is also providing a way to understand and analyze people's livelihoods in the study area and the effectiveness of two

energy projects in the area, namely: solar electrification project (main focus of this study) and use of improved cook stoves (ICS) to improve efficiency in biomass usage.

1.7 Definitions of basic terminologies and concepts used in the study

The following are the key terms that form the basis of this research and the definitions that have been used in this research. This is done to clear any misunderstandings that can arise from use of these terms as they carry different meanings in different contexts.

1.7.1 Renewable energy

This refers to energy sources which are not based on the burning of fossil fuels or the splitting of atoms, such as nuclear energy, but from natural processes that are replenished constantly (OECD/IEA 2005; Utah 2013). Renewable sources of energy are also referred to as alternative or modern energy sources. They include energy mainly generated from solar, wind, geothermal, hydropower, ocean resources, biogas and liquid biofuels (OECD/IEA 2005). According to Martinot et al. (2002), traditional biomass such as fuelwood and crop residues burned in stoves forms part of RE together with the other technologies outlined by OECD/IEA (2005) above. In this thesis however, traditional biomass will not be part of RE since fuelwood is harvested unsustainably from the study area's indigenous forests and at the same time most people in the study area do not use ICS for cooking. Therefore, for the purpose of this thesis, RE shall refer to energy derived from natural sources such as solar, wind or geothermal and which are replenished constantly by natural processes when used.

1.7.2 Solar energy

Solar energy can be defined as electrical energy harnessed from sunlight. There are two main ways electricity is obtained from solar energy. The first one is through the use of solar photovoltaic (PV) modules which are solid-state semiconductor devices that convert sunlight into direct-current electricity (Devabhaktuni et al. 2013). The second way and also regarded as more efficient is through the use of concentrating solar photovoltaic systems (CSP). CSP systems use lenses or mirrors to focus sunlight gathered over a large area into a small area where high temperature heat is produced and converted into electricity through a thermal generator (Devabhaktuni et al. 2013). The most common method that has been employed in REC projects in Malawi using solar is solar PV modules. Therefore, in this thesis, the term solar energy shall refer to use of solar PV modules to convert sunlight into electrical energy.

1.7.3 Biomass

Biomass is defined as any plant matter (which includes wood, timber and pulp production waste, vegetal waste, crop residues) as well as animal waste or dung, used directly as fuel or converted into other forms such as charcoal before combustion (IEA 2002). Traditional biomass involves combusting these using inefficient ways such as traditional three-stone fire. Almost all people in the rural areas of developing countries use traditional methods of combusting biomass. Forms of biomass used in the study area include fuelwood, vegetal waste, timber production waste and crop residues. In this thesis, the term biomass shall refer to the forms mentioned in the preceding sentence.

1.7.4 Energy poverty

EP refers to lack of access of households in developing countries to modern and clean energy sources, and their consequent reliance on solid biomass fuels for cooking and other domestic uses (Sesan 2012). In addition, IEA (2010a) and Practical Action (2013) defined EP as lack of energy services to meet basic needs for cooking, heating, lighting, communication, healthcare, education and income generating activities (IGA). EP is characterised by people's heavy reliance on biomass fuels such as firewood and crop residues hence unable to meet other energy requirements such as in telecommunication. For the purpose of this thesis, EP shall refer to lack of access of rural households in developing countries to modern and clean energy services to meet their basic needs and consequent heavy reliance on biomass fuels which are combusted in an inefficient manner.

1.7.5 Vulnerability

Adger (2006), defines vulnerability as “the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt”. According to Drèze and Sen (1989) the term vulnerability refers to entitlement failure among people in the face of societal and environmental shocks and changes. For the purpose of this thesis, both definitions are applicable.

1.8 Thesis outline

Chapter 1 introduces the study. It gives a brief background and justification of the study. It also provides meanings of key terms and an explanation of conceptual framework used. An outline of research objectives and their description has also been provided.

Chapter 2 provides an explanation of the research design and methodology. It provides reasons for choice of the study area, sampling approach used, and also data collection and analysis methods used. It further outlines limitations of the methodology implored in this study as well as challenges encountered during the study and how they were dealt with. Ethical issues that were considered during the study have also been presented.

Chapter 3 provides the contextual background of the study area. It describes the study area by providing the physical location, socio-economic characteristics as well as the social services available in the area. A description of climate and vegetation of the area has also been provided in this chapter as well as the solar electrification project, which forms the basis for this study. Finally, a profile of Malawi has been provided.

Chapter 4 is the literature review. In this chapter scholarly work that has been done already on this topic is presented. It takes into consideration different views that scholars have on the various aspects of the topic under discussion.

Chapter 5 is the presentation and discussion of the findings.

Chapter 6 provides the conclusion of the study. In this chapter a summary of the findings of the study is provided as well as recommendations that can help in eradicating energy poverty in the rural areas so as to improve peoples' livelihoods are suggested.

CHAPTER 2 - RESEARCH METHODS

This chapter provides an explanation of research design and methodology used. It describes sampling approach as well as data collection and analysis methods used. It further outlines limitations of the methodology implored in this study and challenges encountered by the researcher during the study and explains how they were dealt with. Ethical issues that were considered during the research have also been brought forward and discussed in this chapter.

2.1 Research Design

Research design can be referred to as a plan for conducting research and it provides a framework for collection and analysis of data (Bryman 2012). Additionally, Yin (2003), states that a research design is the logical plan that links research questions to be answered in the study to the data to be collected and conclusions to be drawn. It describes how data is to be collected and analyzed. Research design selected for a particular study depends on the nature of study to be conducted and quality of results depend much on relevance of research design chosen to the study done. In this research study I used a mixed methods approach.

2.1.1 The mixed methods research

According to Creswell (2014) mixed methods research (MMR) involves the collection and analysis of both qualitative (open-ended) and quantitative (closed-ended) data in response to research questions or hypotheses where the two forms of data are integrated in the study. There are several reasons given for using MMR in a particular study. In this study, I used MMR in order to draw on the strengths of both qualitative and quantitative methods together in one study. In addition to this reason, the following abilities or qualities of MMR, according to Bryman (2012), were also considered in this study: completeness (provides a more comprehensive account of area of enquiry), triangulation (of the findings in order that they may be mutually corroborated) and explanation (one of the two methods can be used to explain findings generated from the other method).

Qualitative research is concerned with how participants perceive an issue or problem. According to Creswell (2014), a researcher in qualitative research focuses on learning the participants' understanding or meaning of the problem or issue. On the other hand, quantitative research is concerned with how researcher understands the problem or issue at hand. MMR therefore allows understanding of the issue under study from both sides.

2.1.2 Choice of study area

The two villages of Chitala and Chimonjo in Salima district, Malawi, were chosen for this study based on the following criteria.

2.1.2.1 Ease of accessibility

Based on this criterion, these two villages were chosen because of their proximity to Salima boma⁶ and also ease of travel between the villages and the boma. The two villages are close to Salima boma and it is also easy to get to these villages from Salima boma since they lie nearer to the main road that goes through Salima from the southern region to the northern parts of Malawi running along the shores of Lake Malawi. There are two good gravel roads that connect these villages to this Lake Shore road.

These two conditions made it easier for me to stay at Salima boma and commute to the study area on daily basis. The research area does not have accommodation service for guests and as such I had to stay at the boma where this service is available which also gave me access to other essential services such as banking, service station and eateries.

2.1.2.2 Compatibility to the study

These two villages are among several villages in Malawi where solar electrification projects were implemented and as such they provided a ground for which to study RE options. Furthermore, these people even though they received solar electrification they continue to use biomass, most especially firewood, for cooking. This then provided a room for studying effects of biomass use on health as well as environment in the same area and also using same sample. It was also easier to compare these two types of energy used in these villages (solar energy and fuelwood) in terms of ease of accessibility, usage, benefits and problems.

2.1.3 Validity and Reliability

Validity and reliability are the two widely used criteria for assessing the quality of a social research. They are rooted in quantitative research (positivist approach) (Golafshan 2003), even though they are also used in qualitative research (naturalistic approach). However, even though reliability and validity are widely used in both types of research to assess research quality, other

⁶ Boma refers to district headquarters where there is a concentration of businesses, public or social services as well as government offices.

qualitative researchers prefer to use trustworthiness and authenticity. I have used validity and reliability to assess the quality of my research.

Validity refers to whether an indicator (or set of indicators) has actually measured a concept it was meant to measure in the study (Bryman 2012), or whether the research has measured that which it was intended to measure. In this way validity is more concerned with the accuracy of the data analysis and interpretation. The results obtained by a researcher reflect the quality of the data obtained, analysis made as well as accuracy of the two. My research has been able to measure what it was intended for by using multi-model approach in both the data collection and analysis. Triangulation was also done to enhance the data collected which boosted overall quality of the data collected.

Reliability is when the same study is repeated by another investigator, using the same procedures and instruments, is able to produce similar results as the previous investigator did (Yin 2003). This shows that reliability is more concerned with the extent to which results are consistent over time using the same instruments in a similar study. Reliability demands transparency on the part of the researcher in the study. To satisfy this I have managed to write all processes involved in this study in detail so that any other researcher can use it and obtain similar results. However, even though these processes have been detailed, it might be difficult to obtain similar results as the ones in this study since life is continuously changing. The factors on the ground that enabled me to obtain these results might not be there tomorrow when another researcher does a similar study. Factors such as political changes, natural catastrophes (droughts, floods, earthquakes) as well as man-made catastrophes (war) have large impacts on the population when they occur and these could alter the conditions under which the previous study was conducted.

2.2 Sampling

Sampling refers to the process of selecting a part of the population to participate in a study representing that population. Sampling of this research involved the following.

2.2.1 Sampling method

Two main methods were used to select the sample to participate in this study. Firstly, I used Stratified Random Sampling (SRS), which falls under Probability sampling, to select a sample of 100 households from the solar electrified households in the two villages. Berg and Lune (2012) points out that SRS is used when the identified population to be studied contains subgroups and there is need to have each of such subgroups represented in the final sample.

SRS was ideal in this study since the solar electrified households in these two villages contain people with diversity and this was to ensure the sample was representative of the population. In order to select a representative sample from households with solar electrification to participate in this study, a list was provided that contained all households that had been solar electrified in the two villages. The names on this list were those of responsible or contact persons for particular household's solar energy who were either household heads (male or female⁷), or spouses. Each household had one responsible person on the list. The list was firstly stratified basing on gender into male and female. After this, each of these categories was further stratified in terms of age (youth and aged) and also financial status (those who are doing well financially and those not). After this stratification, I then randomly selected a sample from each stratum based on sampling fraction allocated to it so that the final sample should represent all the strata identified. This ensured that specific characteristics of individuals in the population are represented in the sample and the sample reflects the true proportion in the population of individuals with certain characteristics (Creswell 2014).

Key informants were selected using Purposive sampling, which falls under non-probability sampling. They were identified based on their relevance to this research. However, even though selection was purposive others participated through snowballing. Snowball sampling is a non-probability sampling in which the researcher asks the participants to identify others with similar knowledge and contacts them to participate in the study (Bryman 2012).

2.2.2 Sampling procedure

Sampling procedures of this research involved identification of the population to be studied, sampling method to be used to select participants as well as determining sample size and units. Study population can be defined as the universe of units from which a sample is to be selected (Bryman 2012). I identified the study's population as households in the villages of Chitala and Chimonjo in Salima district, Malawi, which had been solar electrified as well as key informants from various categories related to the study. In addition to households being solar electrified I wanted also the participants to be mature enough (above 20 years old) so that they can produce sound responses and those who have been living in these villages for the past ten years, from

⁷ Female household heads are the women who head their families after losing their husbands through divorce or death.

the date of the study. It was necessary to include the ten years so that participants should be able to compare properly period before and after solar electrification.

The study was conducted from a sample of 110 subjects, where 100 were households with solar electrification and the remaining 10 were key informants. I intended to achieve a 50:50 gender balance in the sample of 100 households. However this was only achieved in Chimonjo village. In Chitala village the sample was made of 28 female and 22 male. 2 male participants in Chitala village were not interviewed as they had travelled on the interview day, while the third one refused on the grounds that he will not be of much help to the study as he is usually on the road and as such has very little knowledge about energy usage in his household. The spouses of these three were then interviewed hence having such ratio in favor of the females. The figure below illustrates the gender representation in the whole sample.

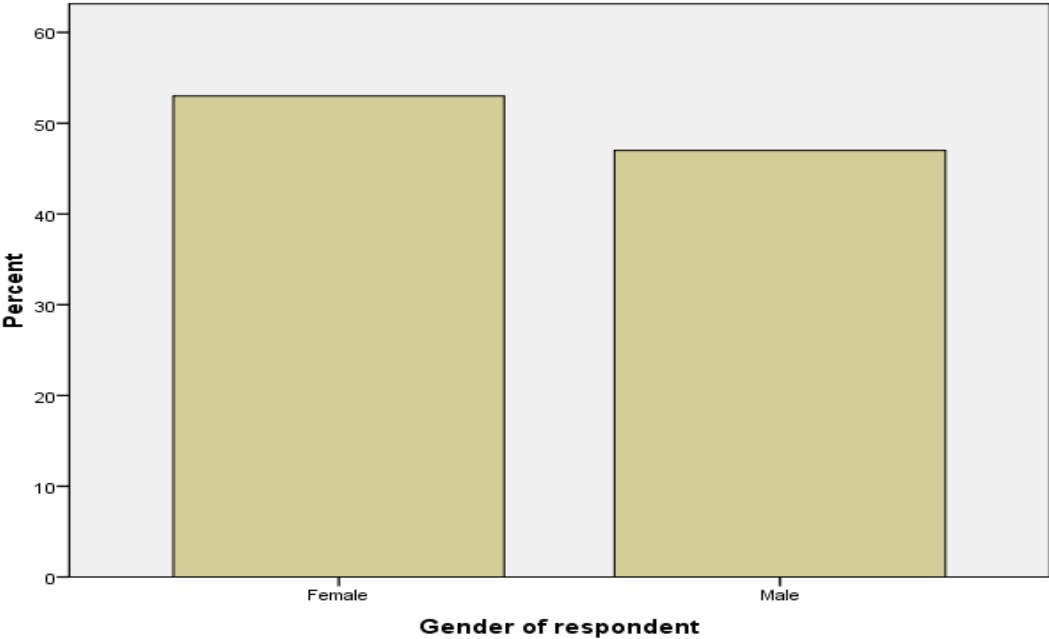


Figure 3: Gender representation of respondents in the study

The households in the two villages which matched my criteria were identified with the assistance of the solar engineers responsible for a particular village. The solar engineers keep records of all households which had been solar electrified in the area under study. The sampling methods used in this study have been discussed in section 2.2.1.

2.2.3 Key characteristics of participants

One of the key components in social research is to have a sample that is heterogeneous. This is important because a heterogeneous group brings forward a variety of responses stemming from their varied experiences, attitudes and other personal attributes. In this section I will explain key characteristics of the study’s participants.

I required the participants in this study to be more than 20 years old. This was essential as these people are mature enough to have noticed what has been happening in their surroundings and villages, either good or bad, and as such be able to produce reasonable and meaningful responses. Furthermore, these would be able to relate their current life to the past and most probably be able to explain the household’s energy use patterns before solar electrification and present. This minimum age requirement of 20 years meant that at the time the households received the solar energy the youngest participant would have been in the late teens. The figure below illustrates the age distribution of the respondents.



Figure 4: Age distribution of respondents in the study

In this study the youngest respondent was 23 years old while the oldest was 75 years old. Most of the respondents were in their 30s and 40s.

In addition to the respondents being able to discuss energy use patterns in their households, I also required them to discuss their economic life. With this in mind the age requirement was meant to give a good representation of the economically active people in the villages who can

ably relate to economic conditions in their households now and before solar electrification. These would also be the people who are doing something for themselves and have their own families. From this sample, 90% represents economically active group while 10% are the economically non-active group translating into a low dependence ratio in the sample.

I also focused on a balanced gender representation in the sample so that I achieve consensual and balanced opinion between male and female members of the villages on issues under discussion. It was necessary to do this since men and women usually have different opinions on issues that affect them so to avoid biases in the data they had to have a balanced representation in the study.

2.3 Data collection and analysis

Data for this study was collected from both primary sources (field research) and secondary sources (documents).

2.3.1 Methods of data collection

A mixed methods approach of collecting data from primary sources was used. Creswell (2014), defines mixed methods research as an approach to enquiry that combines both qualitative and quantitative forms of research in one study. Under these two, a number of techniques were used to obtain data. The following ways were employed in this study.

2.3.1.1 Quantitative interviews

To collect data quantitatively, I administered 100 structured interviews to 100 households which formed part of the sample for this study. On average one interview lasted about 1 hour 50 minutes. However even though this was a structured interview, other participants were providing long responses explaining things and this usually resulted into new insights being brought up. Some issues brought up were not on the questionnaire but relevant to the study. I did not throw away this information but treated it as equally valuable and thus recorded it in my field journal which I always kept handy. Appendix 1 is the questionnaire that I used to collect data from these households.

2.3.1.2 Key informant interviews

Qualitatively, interview guides were used on the 10 key informants and also on the 2 focus group discussions (FGD) with selected beneficiaries of the solar electrification project. The following table summarises key informants that were involved in this study.

Table 1: Summary of Key Informants interviewed

Rank of informant	No. interviewed
Director of Renewable Energy, Ministry headquarters	1
District Forestry Official, Salima	1
Forestry Officials, Ministry headquarters	2
Solar Engineers, Chitala & Chimonjo villages	3
Board member, Malawi Homeless People's Federation	1
Head teacher (local primary school), Chimonjo village	2

Source: Own Field Work, 2013

I approached 2 health officials at Chitala Health Centre to be involved in the study but they declined citing that they have been at the facility less than five years and as such would not be of much help. They were however willing to provide relevant data which they would retrieve from their records. I gladly accepted this offer and provided them with specifics on the type of data that I wanted from their facility's records.

I used different interview guides for the key informants depending on the informant to be interviewed. This is because they have different professions and as such cannot be asked same questions. However, even though they happened to be on different sides of the issue, they were all equally very important to the study hence my effort to produce different interview guides for them. Table 2 below lists down the interview guides used for particular key informants.

Table 2: Location of interview guides for key informants

Rank of informant	Interview guide used
Solar Engineers	Appendix 2
Chief District Forestry Officer, Salima	Appendix 3
Forestry Officials, National headquarters	Appendix 4
Director of Renewable Energy, National headquarters	Appendix 5
Board member, Malawi Homeless People's Federation	Appendix 6
Head teachers (local primary school)	Appendix 7

Source: Own field work, 2013

2.3.1.3 Focus Group Discussions

The study was planned to have four FGDs, where each of the two villages of Chimonjo and Chitala would have two. However, I managed to conduct one FGD in each village, giving a total of 2 FGDs for the whole study. The failure to conduct two of the remaining FGDs was due to that there were political tensions in the area towards the end of the study as it was time for primary elections (in preparation for the May 2014 Tripartite elections) and I was advised not to conduct any group meetings.

Each FGD was made up of 10 participants with an equal representation of both male and female. Furthermore, these FGDs were also made up of people with diverse personalities and attributes. The idea here was to bring together a cross section of people from all aspects of life in the village such as the youth, elderly, business people, farmers, community leaders and other personalities to have a discussion on issues under study. I did this because people usually have different views on the same issue so by bringing these together they would air out their views on the matter and sort out any differences that might have been there before. This would bring understanding and consensus on the issues being discussed and the final answers would be representative of the village.

During these FGDs I made it a point that every participant should chip in at one point or the other in the discussions. This was to prevent other members who are either very clever or good at public speaking from dominating the whole discussion and thus only their views on the matter being heard. This would not have represented the views of the grouping or rather the sample and as such wrong data being obtained. When all participants are active in the discussion, the data obtained is well balanced. This is the type of data that I obtained from the two FGDs I conducted in this study.

The questions that I used in these FGDs were open ended. I used an interview guide which had a set of guiding questions reflecting the topics I wanted to be covered in the FGDs. The discussions did not follow the way questions were arranged on the interview guide as it was meant to be sort of an informal discussion. Additionally, I also used a lot of follow-up questions during these FGDs to investigate further some of responses which were being provided.

2.3.1.4 Observations

In a research study, observations involve both seeing and listening. Creswell (2014), identifies four forms of observation in a research as follows: *Complete participant* –where the researcher conceals role; *Observer as participant* – where the role of the researcher is known by the participants; *Participant as observer* – where the observation role of the researcher comes secondary to the participant role; and *Complete observer* – where the researcher simply observes without participating. Yin (2003), however, identifies *direct observation* and *participant observation* as two forms of observation in research. Bringing the two authors together, Creswell’s first three forms of observation can be equated to Yin’s participant observation, while Creswell’s last form would be equated to Yin’s direct observation. For simplicity’s sake, I will use direct observation and participant observation in this study.

Participant observation refers to an observation process where the researcher or observer assume roles within a situation and participate in the events being studied with the participants (Creswell 2014; Yin 2003). The role of the observer as a researcher maybe concealed or not but the important thing is the participation of the researcher. Participant observation is however well suited for ethnography, which is a long term study where the researcher becomes a part of the community as they live together with the members of the community. On the other hand, direct observation is a short time observation and the researcher does not require immersing themselves in the social setting. The role of researcher is not concealed and the observation part is also known. I used direct observation in this study to gather supporting information or evidence.

My observations were done in two ways. Firstly, I was making deliberate transact walks of the study areas just to observe, and secondly I would make such observations when I am conducting interviews. These observations were done with consent from the villagers and accorded me an opportunity to collect additional information. One of the observations I did in the villages was to look at the kitchens and cooking places when I am conducting interviews. This was to help me understand the conditions of their kitchens in terms of size, ventilation, cooking stoves in use, type(s) of energy used for cooking as well as building materials used. Another one was when I make the transact walks I would check the immediate environment in terms of trees and other vegetation, facilities or social services provided as well as economic activities taking place in the villages. Sometimes I would have informal conversations with some villagers and if the issue is relevant to my study I would record it as part of the observation. I would also

sometimes hear what the villagers are saying amongst themselves and again if it is relevant I would record it in my journal. All these observations, either listening or seeing, brought in new insights that helped me in understanding the issues under study. According to Yin (2003), observations are often useful in providing additional information about the topic being studied.

2.3.1.5 Secondary sources

I collected secondary data from sources such as journals, text books, reports as well as online data bases. These were obtained either from online search engines or physically in the libraries and offices. Not only were these used to support primary data, they were in other cases an authority on their own.

2.3.2 Methods of data analysis

Data for this research study was analysed in two ways:

2.3.2.1 Quantitative data

Quantitative data was analysed using the computer statistics software called SPSS. This involved coding the data collected on the 100 questionnaires and entering it into SPSS. Data coding and entry represented the hardest part of the research process. I entered data from some of the questionnaires in evenings when I returned from the field and this was also used to check on quality of the data I had collected that day. Most of the data entry was done after all the field work was conducted, and this was then followed by quantitative data analysis.

During analysis both univariate and bivariate methods were used. Univariate analysis involves analyzing one variable only at a time while bivariate analysis is used to examine the relationship between two variables (Bryman 2012). Univariate analysis provided the basis for descriptive analysis. Apart from using SPSS to run bivariate and univariate analysis, I also used SPSS to produce histograms for simpler descriptive analysis. In addition to SPSS, some graphs were produced using Excel.

2.3.2.2 Qualitative data

I used thematic or content analysis to analyse the data derived from FGDs, key informant interviews, notes in the field journal and qualitative responses from household interviews. Berg and Lune (2012) describes content or thematic analysis as a careful, detailed, systematic examination and interpretation of a particular body of material aimed at identifying patterns, themes, biases and meanings where the content is “coded” as data in a form that can be used to address research questions. Before conducting thematic analysis in this study, I firstly

transcribed all qualitative data collected and then coded it using coding tables and colours. According to Bryman (2012), coding is the breaking down of data into their component parts and these parts are then assigned labels.

In order to perform thematic analysis, I identified the core themes in the study and then distinguished these themes both within and between transcripts I had made from all the qualitative data I collected (Bryman 2012). My interest in doing this was to identify the core themes that will enable me answer the research questions.

I started analysing the qualitative data as soon as I started collecting it. This was done in order for me to check on the quality of the data being collected, that is whether the data am collecting or the responses am getting falls within the themes of the study or not. It was also done to improve on my skills for the next session as well as to dig deeper in areas that I feel there was something missing in the preceding session.

2.4 Ethical considerations and Challenges

2.4.1 Ethical considerations

Ethical issues are very crucial in any social research and as such they cannot be ignored by any researcher. The reason for this is that social scientists delve into the lives of other human beings and following the study conducted various policies, practices and even laws may be made (Berg & Lune 2012). It is essential, therefore, that ethical issues are considered throughout the whole research process from topic selection, proposal writing, field work, all the way to dissemination of research results. A social research has the potential to alter people's lives and as such the whole process has to be guided by ethical principles. This section looks at ethical principles that I used as guidelines in this study.

Diener and Crandall (1978) quoted in Bryman (2012), pointed out four ethical principles that form guidelines in a social research and these are: *harm to participants*, *lack of informed consent*, *invasion of privacy* and *deception*. In addition to these four, other researchers identify *confidentiality* as another ethical guiding principle. In this study I used the four ethical principles as outlined by Diener and Crandall (1978) to guide my work. I should also point out that most of these principles are intertwined in that in pursuant of one principle you end up using one or several of the other principles, hence *confidentiality* has been dealt with under *harm to participants* in this study.

Before conducting the research, I informed all possible respondents that they had been selected to participate in the study. I also informed them of the nature and purpose of the study and also that whatever they say will be safe with me and no harm will be done to them for participating in the study. After giving them all this information, I then asked if they were willing to participate in the study or not. This was done to obtain informed and voluntary consent from them as required in the guiding principle of *informed consent*. Once they had freely given consent to the interviews was when they were allowed to participate in the study. No form of inducement was used to obtain consent from these people to participate.

Secondly, the principle of *harm to participant* dictates that no participant should be subjected to any form of harm, physical or psychological, arising from their involvement in research. According to Bryman (2012), the issue of harm to participants also includes maintaining *confidentiality* of records where identities and records of individuals remain confidential and not identifiable even in publishing or disseminating results. All participants in this study were not subjected to any harm and their names will not be mentioned to protect their identities and also save them from possible harm. In addition, I also assured participants of the confidentiality of information they will provide and that it was not going to be used in any other way, apart from the stated academic purpose, without obtaining permission from them.

The third ethical guiding principle is *invasion of privacy*. This principle entails that a researcher is not allowed to invade the privacy of the participant and that the participants reserve the right to refuse having their privacy invaded (Bryman 2012). Invasion of privacy looks at asking questions of a very personal nature that deals with a person's private life which they would not be comfortable bringing to the public. There is a limit to which a person's private life can be divulged to the public, beyond which cannot be condoned. The issue of privacy and informed consent are related in that the researcher obtains consent from the participant after full information about the nature of the research has been given to the participant, and the participant is aware of what they are getting into. However, this does not mean the participant should answer every question, and where they feel their right to privacy is being infringed upon they have right not to answer such questions. My study did not involve such type of questions or information to maintain the participants' privacy.

Deception is the fourth ethical guiding principle. This principle requires the researcher to avoid use of any form of deception on the participants, for instance representing the study differently

from what it actually is (Bryman 2012; Yin 2014). All participants in this study new about the nature of the study and they were not deceived in any way at any point in the study. Furthermore, when I was making observations in the study area people knew what I was up to as I had previously communicated to them to that effect.

2.4.2 Limitations and challenges

Every social research has a number of limitations or challenges. This study encountered the following limitations.

2.4.2.1 Household's lack of documentation on income and expenses

I had problems believing the amounts of money households claimed they were either receiving or spending. This is because all the households that were involved in this study did not keep such records in written format. It could be attributed to low education levels or a lack of household record keeping in general for most households. This resulted in some guessing the figures or exaggerating where the figures presented were either too big or too small. To reduce these anomalies and also for ease of verification, I simplified the questions on income and expenditures as much as possible with calculations being based on smaller units and also on a shorter period like daily or weekly which was then converted to monthly. My role in these calculations was just to assist participants with simple addition and multiplication and not suggesting amounts in any way.

2.4.2.2 Failure to keep appointments on the part of interviewees

There were a number of occasions when time was wasted because the interview candidate was nowhere to be seen. This was because they either had forgotten about the appointment or felt they should attend to more pressing issues at that time than being interviewed. This feeling of not prioritizing the interview was mostly due to that there were no economic gains to be made by being interviewed, so they thought they would rather go and do something which will earn them some income or just going ahead to work on some of their tasks. I sorted out this by explaining again to them the importance of the interview and convincing them to attend it despite that there were no monetary gains. As for those who had forgotten, I simply had to ask them to offer me another appointment at their convenience. In both cases, interviews were rescheduled and finally took place.

2.4.2.3 Weather conditions of the study area

The area under study falls in one of the districts in the country that experience higher temperatures throughout the year. This is because the district lies at low altitude as it is in the

Great East African Rift Valley floor. I did my field work during the months of October and November when it is summer in Malawi. In summer, more especially the month of October, Salima district as with other low lying districts in the country, experiences very high temperatures. These high temperatures make the area to be very hot. Furthermore, in some days the district becomes very windy and dusty.

2.4.2.4 Access to data and key informants

Access to data and some key informants has also been a problem during this study. The study required use of secondary data obtained from offices and sometimes the officials in these offices were not that willing to release the documents. Some would be asking for payments for the public documents while others would just tell me outright that the document I am looking for was lost. I sorted out this by asking for help from other people in accessing these documents. I also refused to pay for these documents as they are free and have to be treated as such. As for the key informants who were problematic to access I had to reschedule meetings at their convenient time as well as asking them if they can arrange for me to meet someone who is equally knowledgeable as them in the issues I wanted to talk to them about, in the event that they cannot manage to see me.

CHAPTER 3 - CONTEXTUAL BACKGROUND

This chapter provides a description of the study area, its solar electrification project as well as Malawi's current energy status. A discussion of the REC process in Malawi, including approaches used, has also been provided. Furthermore, the role of RE in the midst of EP and climate change has also been described.

3.1 Description of the study area

3.1.1 Location of the area

The area under study, Chitala and Chimonjo villages, is found in Traditional Authority Khombedza's area in Salima district, Malawi. Salima District is located in the central region of Malawi and has a total land area of 2,196 square kilometres, which represents 2.3% of Malawi's total land area (NSO 2013). The district shares boundaries with Nkhotakota to the north, Dowa and Ntchisi to the north-west, Lilongwe to the west, and Dedza and Mangochi to the south. The entire eastern part of the district borders Lake Malawi. Figure 5 (Map of Malawi showing Salima district) illustrates the position of Salima district in relation to its surrounding districts.

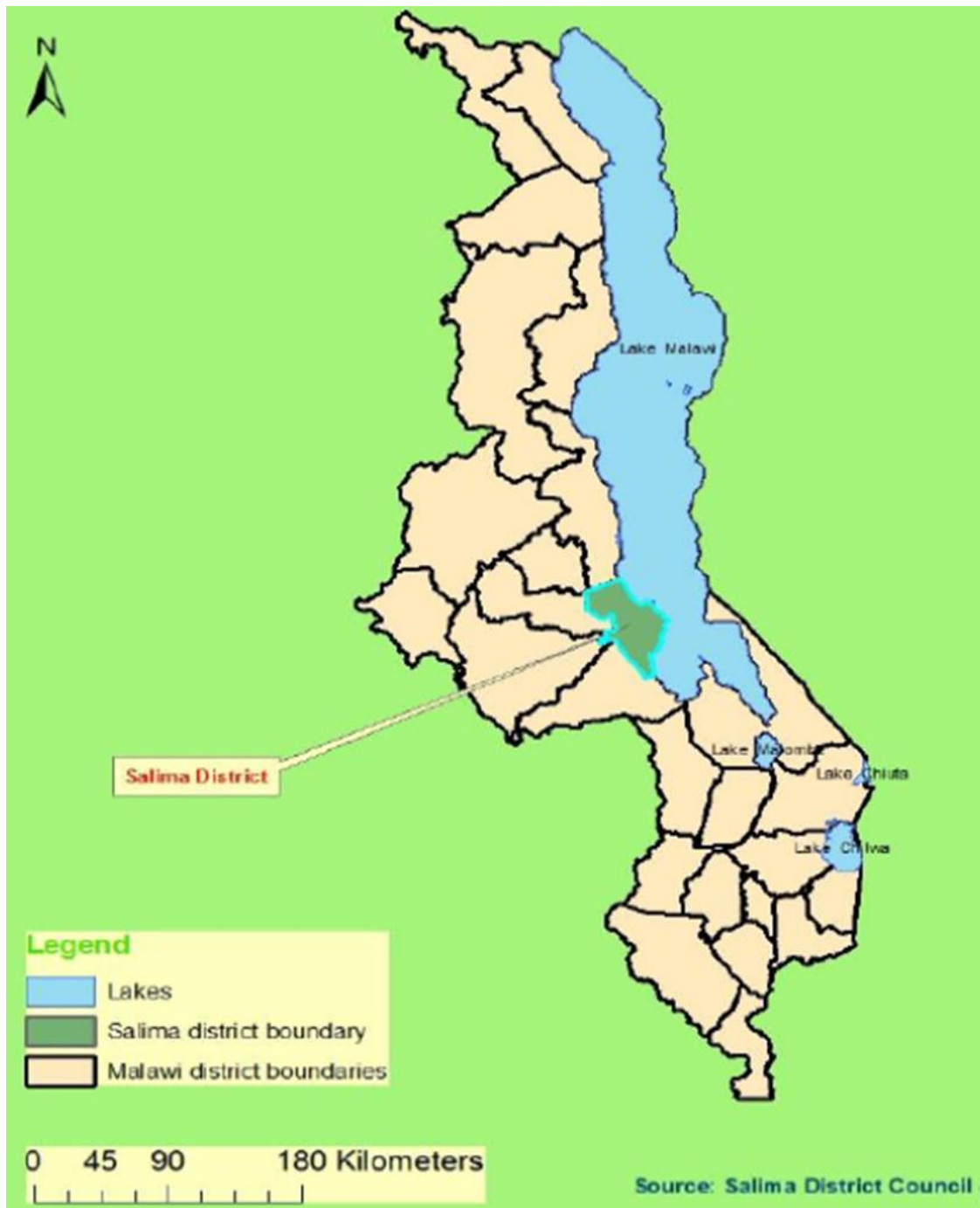


Figure 5: Map of Malawi showing Salima district (GOM 2011)

Chitala and Chimonjo villages are located northwest of Salima boma at a distance of about 32km and 35km respectively from Salima boma. Both villages are a few kilometres off the Salima – Nkhotakota main road (Lakeshore road), and are connected to this road by a series of well-maintained gravel roads.

Chitala and Chimonjo villages in Salima are among the four villages in Malawi which were solar electrified using the barefoot approach, an initiative and brainchild of Barefoot College of India. The other villages are Kaphuka (Dedza district) and Makunganya (Zomba district).

3.1.2 Socio-economic characteristics of the area

3.1.2.1 Income levels

People in the area understudy are poor and they depend on farming as their main source of income. The farming practice being carried out in this area is seasonal and this determines when they have more money or not. Seasonal farmers usually have more money after harvest when they start selling their produce and no or little money during crop growing period which affects amount of inputs and yields obtained.

There are two important cash crops cultivated in the area, thus cotton and groundnuts. The soil and climatic conditions of the area favour the cultivation of these two crops. However, the majority cultivate cotton due to the high prices offered by the buyers. Other crops cultivated in the area understudy double as cash and food crops. Figure 6 below illustrates the main cash crops grown in the area.

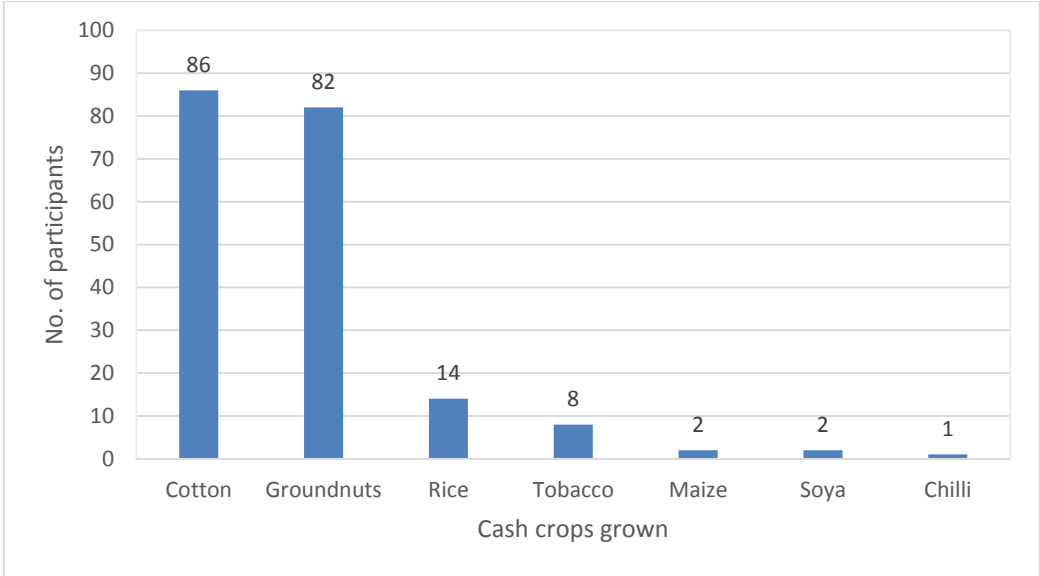


Figure 6: Main cash crops grown in the study area

The most important food crops cultivated in the area are maize and groundnuts, where maize is cultivated by every household and groundnuts by the majority. For the crops that double as food and cash crops their primary role is food and they are usually sold when the households have surplus. However, in other instances some households will also sale these food crops not

necessarily that they have surplus but because they are faced with an emergency that needs money or that they need to meet other household needs. The sale is usually to unscrupulous traders, who offer the villagers very low prices for their commodities, since there are no organised and well regulated commodity markets in the area as well as in nearby villages. These low prices result in the villagers selling more of their food in order to raise enough money for the need that they have at that particular time. Figure 7 below illustrates the major food crops cultivated in the area.

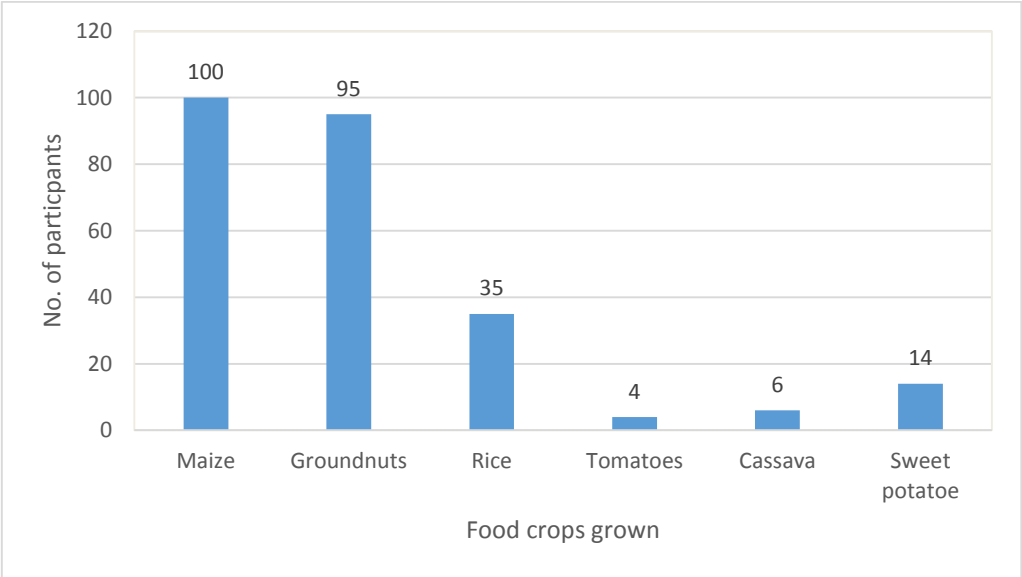


Figure 7: Main food crops grown in the study area

People in the study area also raise livestock. The main types of livestock kept are chickens, cattle, goats and pigs. These are reared mainly for food and can be sold when the family is in need of money. However, at the time of this study most families in Chimonjo village had lost all or most of their chickens to a poultry disease outbreak and this explains why the number of families owing chickens is less than those owing goats. In a normal Malawian village setting every household owns a number of chickens, even the poorest. Figure 8 below illustrates the types of livestock kept in the study area.

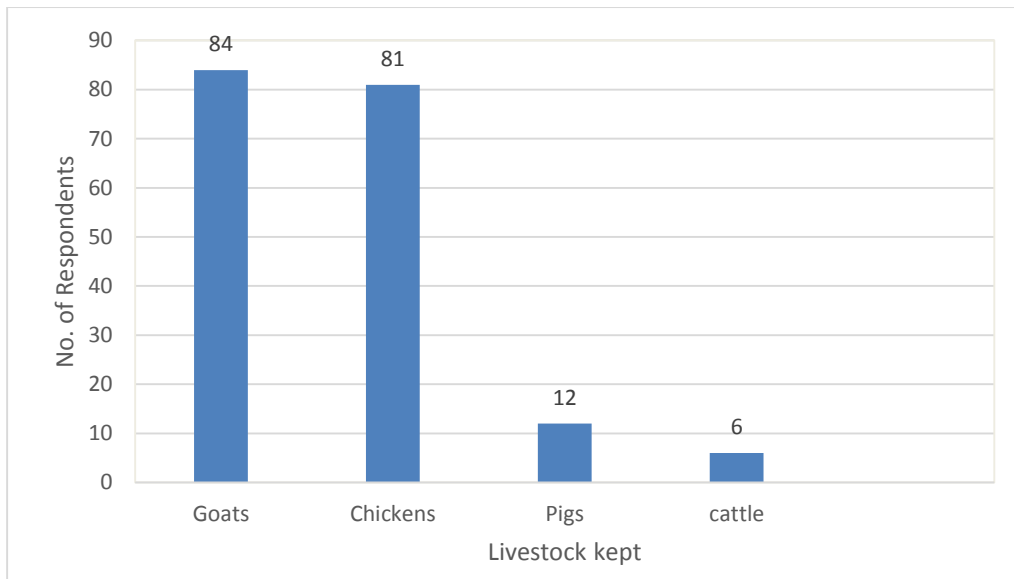


Figure 8: Livestock kept in the study area

Overall, people in the area are small scale peasant farmers who mainly grow crops and raise animals for food. The amount of money earned from farming is low to sustain the needs of a household throughout the year. In addition to farming, other minor sources of income are piece works, small scale businesses, as well as remittances from family and friends. Despite all these, monthly earning for the majority is still very low translating into poverty stricken households. For example, 40% of the respondents indicated that they earn less than \$24.00 a month, translating into \$0.81 per day thus living far below the international poverty line of \$1.25 per day per person. Figure 9 below illustrates income levels of households in the area.

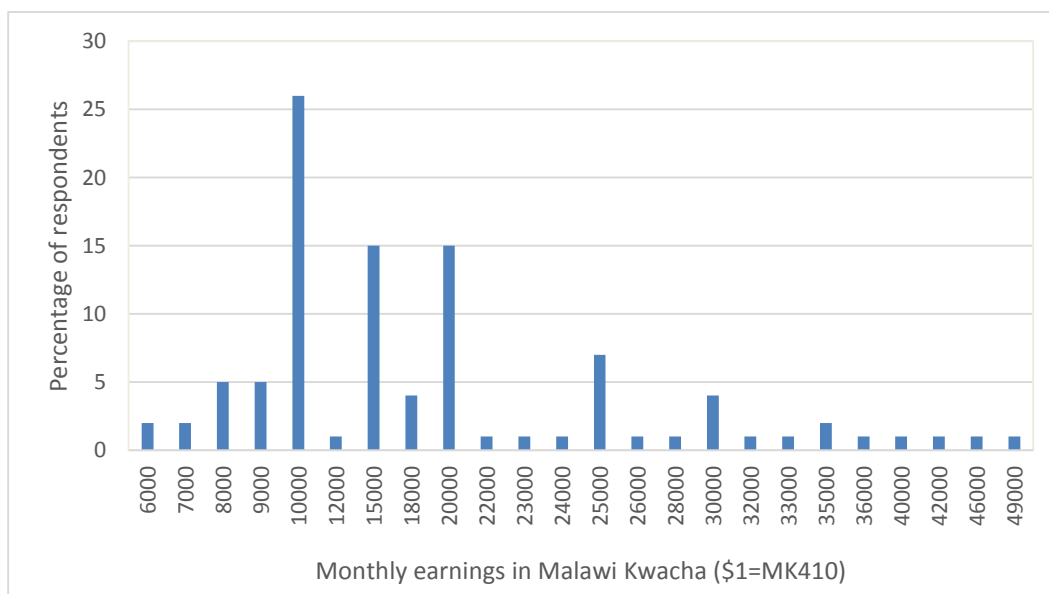


Figure 9: Average monthly earnings in the study area

From the description of income levels above, it shows that the majority of people in the area are poor and as such vulnerable to shocks and stresses that can come their way. They would not be able to withstand the shocks as their income earning capacities are very limited. The environment (indigenous forests) from which most of the poor depend on for their livelihood is also fast being depleted as it is used unsustainably. These factors leave the poor in a very precarious condition, but which can be changed.

3.1.2.2 Social services in the area

A number of social services have been provided for in the area by both the government and non-governmental agencies. There are 3 primary schools of which 1 was established by Central African Presbyterian Church and 2 were established by the GOM. There is 1 health centre within the study area which was established by Roman Catholic Church and is currently run by Christian Health Association of Malawi. Major illnesses are referred to the district hospital located at Salima boma, about 33km from this facility.

Several boreholes were drilled in the area which provide potable water to the people thereby reducing water borne diseases that arise from drinking unsafe water. The area also enjoys some good gravel road network which makes the area easily accessible and also enhances the mobility of the residents.

3.1.3 Climate and vegetation of the area

The study area experiences a hot tropical climate with mean annual temperature of 22°C, where the highest temperatures are experienced in October at 33°C and the lowest temperatures between May and July reaching 12°C (GOM 2011). The annual temperature range for the area is 21°C.

The vegetation type of the area is savannah woodlands characterized by grasslands with scattered trees (GOM 2011). The dominant tree species in the area are *Faidherbia albida* and *mangifera indica*. The former is more valuable in agroforestry due to its ability to improve soil fertility, through its fallen leaves, and this is the main reason for its survival in the area and most parts of the lake shore, despite a high demand for fuelwood. In the areas where this tree is growing people are able to cultivate crops, under and around the tree, and produce high yields without applying any chemical fertilizers. *Mangifera indica* is more valuable for its fruit -the mango. Most people reserve this tree in their fields due to the returns they obtain from it, either cash after selling the fruit or food from the fruit, when the fruit season arrives. The mango fruit

is ready to be eaten during the rainy season, and this is also the time most of the families in rural areas do not have enough or any food at all. The fruit provides a relief to such households. However, when this tree interferes with the growing of crops it is usually cut down so that the crops grow well.

3.2 The area's solar electrification project: the Barefoot Approach

In this section I will provide a description of the solar electrification project in the area under study. The description will cover the two villages at the same time as the solar electrification processes in these two villages were being done simultaneously.

3.2.1 Background

The two villages of Chitala and Chimonjo are among the four villages in the country which were solar electrified using the Barefoot Approach. The Barefoot Approach involves demystification of technologies and decentralising their uses by transferring their access, control, management and ownership to poor rural men and women, who can barely read and write in order to improve their lives (Barefoot College 2012). The villages were identified in 2007 by a non-governmental organization called Centre for Community Organisation and Development (CCODE) which is based in Lilongwe, Malawi, for the solar electrification project. CCODE worked in partnership with another non-governmental organization called Malawi Homeless People's Federation⁸ (MHPF), which was already operational in the study area from 2005. Both CCODE & MHPF are registered with the Malawi government. This solar electrification project was implemented by CCODE using the Barefoot Approach which train semi-literate rural women to solar electrify their villages (CCODE 2009).

When CCODE identified these two villages, they preferred to work with the groups in these villages that were already working with MHPF and not establish new ones. CCODE then chose to work with the self-help groups in the two villages that were working with MHPF. This meant that members of these groups were given priority in the solar electrification project of the two villages. However, even though membership of the local grouping made one to be given priority, that alone did not warrant receipt of the SHS. A number of other conditions had to be

⁸The MHPF was involved in other developmental projects in the area such as helping members to have decent housing, proper sanitation as well as women empowerment which all aimed at improving the living standards of the people in the area.

met as well, one of which was that a recipient of the solar equipment must have been making monthly contributions faithfully in their grouping.

3.2.2 Implementation of the electrification project

The project was implemented with financial support from Trocaire, Cara Malawi, UNDP and Barefoot College of India (CCODE 2009). The early stages of implementation of the project involved identifying two semi-literate women from each village who would travel to India to be trained as Solar Engineers (SEs) for 6 months at the Barefoot College. Apart from being semi-literate, these women were to be stable, married, resident in the village, and matured enough and also have status in the community. The main reason for choosing women in these villages to become SEs was that women are stable in the villages and do not leave or migrate to other areas. This stability was essential to ensure continuity and success of the project. The choosing of women to become SEs was also in line with what MHPF was doing in the two villages where it allowed women to take a leading role in development projects in their communities through its women empowerment programmes. The selected women upon successful completion of the training would return home and be responsible for assembling of the solar equipment when it arrives⁹, distribution (with the help of the village solar committee), as well as installation and maintenance.

A village solar committee (VSC) was put in place in each of the two villages to look into management issues of the solar project at village level so as to ensure neutrality, efficiency and continuity in all undertakings of the solar project. Setting up of this committee was done as soon as names of would-be recipients were selected. Selection of names was done by local committee of MHPF in the two villages which was responsible for running all other programmes of the grouping. The names were selected from the membership list of self-help groups working with MHPF in the two villages. Upon selection of the names, those selected were given mandate by MHPF and CCODE to organise themselves as an independent group and come up with a VSC to provide leadership to their grouping as well as manage all the group's activities. MHPF and CCODE provided guidance during selection of members of the VSC. All this was done before the would-be SEs had left for the six-months training in India.

⁹ The solar equipment was to be purchased from India by the Barefoot College.

The VSC is made up of SHS recipients only and comprise 10 members. The structure of the VSC is as follows: 1 Chairperson, 1 Deputy Chairperson, 1 Secretary, 1 Deputy Secretary, 1 Treasurer, and 5 executive members. Solar engineers in the two villages are not members of the VSC but are required to attend all meetings conducted by it alongside the SHS recipients. The VSC runs independent of both the MHPF and CCODE, even though both of these helped in its establishment. Some of the core responsibilities of the committee include registering new members, collecting monthly contributions from SHS recipients, giving monthly allowances to SEs and the watchmen for the SE's workshops as well as purchase of spare parts for the solar equipment received.

The two villages were solar electrified late 2009, upon return of the SEs from India, as well as receipt and assembly of solar equipment in August of the same year. A total of 135 households were electrified where 60 were from Chitala village and 75 from Chimonjo village. According to the SE of Chimonjo, 120 households had met all the requirements to receive the solar equipment but only 75 received leaving a balance of 45 who were put on a waiting list. In case of Chitala, the SE informed me that at the moment there are 186 households on the waiting list and most of them are new members who joined after seeing the benefits solar electrified households were having.

The solar electrification project implemented in the area is a decentralized type, where each household generates and uses its own power. The solar PV application implemented in the study area is a solar home system¹⁰ (SHS) made up of 1 solar PV module or panel of 20 watts capacity, 1 mobile phone charger, 1 charge controller, 1 wet-cell battery and 1 solar lantern¹¹ (SL). Each household received 1 SHS, provided and installed free of charge to the household. The solar PV modules received have a useful life span of 25 years while that of wet-cell batteries (with good maintenance) is 8 years. Upon receipt of the SHS, each recipient was required to sign a contract agreement form with the VSC where they promised to take care of

¹⁰ A typical SHS consists of PV module(s) that charge a battery bank to supply DC electricity to run electrical appliances such as CFL/LED lamps, DC fan, TV, etc. and a charge controller which controls the energy inflow and outflow into and from the battery bank (Palit 2013).

¹¹ A solar lantern is a portable lighting device using either CFL- or LED-based luminaire, housed in an enclosure made of plastic or metal that contains a rechargeable battery (either sealed maintenance free lead acid or NIMH or Li ion) and necessary electronics (Palit 2013).

the SHS received, to use it on the designated house (and not to transfer it to any other village) as well as not to sale it or use it as collateral for any form of credit, amongst several issues. In the event that VSC notices any form of abuse on the SHS or the recipient does something contrary to the contract, the contract document gives the VSC powers to confiscate the unit from the recipient and give it to any other member on the waiting list. All the recipients signed the contract and no one has lost their unit through confiscation by VSC, following any form of abuse, which shows that recipients are taking good care of the SHS. However, 2 recipients lost their panels to theft some months after receiving them, one of which was recovered and the other one was replaced through a cost-sharing agreement between the recipient and VSC. They are still looking for this second panel.

In addition to the SHS, the two villages have each a workshop which is used by the SEs and each workshop is fitted with a 60 watt solar module plus its own charge controller, wet-cell battery, mobile phone charger, SL and a TV. All the spare parts (newly purchased and damaged), SHS in need of repairs as well as all the tools of the SE and records are kept in these workshops. The nature and amount of equipment kept in these workshops necessitated the hiring of the watchmen by the VSC. Next to the SE's workshop is a video show room which is run by the VSC where the TV provides entertainment to both recipients of SHS and non-recipients. TV or video shows in the video show room is a form of revenue generation¹² for the VSC to enable it meet some of its financial obligations.

However, even though the SHS were given for free to all the recipients, they are required to make a monthly contribution of MK200.00 each to the committee. This is in addition to the MK100.00 they make monthly to MHPF. In this case, each SHS recipient has a total contribution of MK300.00 at the end of month to make where MK200.00 goes to the VSC and MK100.00 to the MHPF while non-recipients have only MK100.00 to contribute to MHPF. The MK200.00 monthly contributions cover monthly allowances of all the SEs in the two villages, the watchmen for SE's workshops as well as purchase of spare parts for all the solar equipment being used by the recipients. The money is collected by the VSC and recipients usually bring their contributions to the committee when they come for meetings. In very isolated cases, the VSC appoints some of its members to go and chase for contributions from

¹² All people accessing this service are required to pay for it at the door of the VSC video show room

defaulters. The VSC operates an account with the Malawi Savings Bank (Salima Agency), a state owned commercial bank, where all the money collected is deposited into before being used and will only be withdrawn whenever there is need to use it. The Chairperson, Secretary and Treasurer of the VSC are the 3 signatories to this account. Financial records pertaining to names of SHS recipients who have made their contributions in that particular month as well as the total money collected in that month and used is kept by the treasurer. These records are made available to all members to see except names of recipients who have made their contributions or not, in respect of member's privacy.

One of the core functions of VSC, as mentioned already, is to purchase spare parts for all SHS under its jurisdiction so that even the poorest recipient has access to spare parts. This was to ensure that everyone's SHS is functional despite their financial status and also lessening the burden of SHS recipients from having to go around looking for 1 spare part thereby losing some productive time at home. The committee sends one of its members or one SE to go and buy spare parts for several SHS at once and this saves time and transport money for a lot of people. This also ensures that only appropriate spare parts are purchased and fitted on the systems as the ones sent to buy are those who are conversant with the spare parts. However, the program of buying spare parts for all recipients of SHS is now not regular, as was the case 2 years ago, due to shortage of money that the VSC can use for such.

3.2.3 Problems being faced by the project

Despite the efforts of the VSCs in managing the solar projects in the two villages, there are a number of problems being faced by those who received the SHS. One of such problems is the general lack of spare parts for solar equipment on the Malawi market. This results in people having to wait long for their equipment to be fixed by the SE and thus losing out on revenue generated from the use of SHS and other benefits.

The second problem involves dependability of the spare parts found on the Malawi market. The recipients observed that it took them over a year from the date they started using their SHS to the date of its first maintenance but once they started replacing the parts with the locally purchased ones the period between parts replacement has been getting shorter and shorter. This shows that most of the spare parts found on the market are not dependable as they do not take long before they are damaged once they have been fitted on the SHS.

The third problem is that the spare parts being purchased to replace the damaged ones are not only short lived but also expensive. This comes against the background that there is a general lack of spare parts on the market and then the few that are found are expensive. In addition to scarcity, the spare parts have also become expensive following a down turn of the country's economy in the last 3 years, which has seen a general rise in inflation and prices of goods and services. The prices are prohibitive to most of the recipients and a general drain of the money that would have been used for other essentials in the home.

Fourthly, a good number of SHS recipients are not making their monthly contributions faithfully. This has resulted into the VSC being hit by shortage of money and failing to meet some of its financial obligations such as allowances for SEs, watchmen as well as purchase of spare parts for all recipients. This has generated negative consequences for the project especially piling up of damaged SHS in the SE workshops waiting for spare parts to be purchased as well as purchase of substandard spare parts by those who can afford to buy using own money. Since it is now taking long for the VSC to purchase the spare parts, it has allowed all recipients who cannot manage to wait for the VSC to buy for them and can also afford buying with own money to go ahead and purchase their spare parts.

Another problem comes from the substandard spare parts which are being purchased by the recipients who go to buy themselves using own money. These substandard spare parts become a hazard to the efficient operation of the units as usually they are not fully compatible with the SHS. This then means that the new parts become damaged quickly and then the system taken back for repair resulting into more work for the SE as well as more money being spent by the recipient as they look for new spare parts. This frequent repairing becomes a drain on the hard earned money of the recipients and loss of benefits from the SHS use.

The other problem is that the monthly allowance of MK3 000.00 given to the SEs is too little considering the current cost of living. Ever since the SEs started receiving this amount in 2009, it has never been revised upwards. However, during the same period (2009 – 2013) Malawi's national currency, Malawi Kwacha or MK, has lost its value against the United States dollar and other major currencies. This devaluation would have necessitated an upward revision of allowances given to the SEs, as has been the case with the general prices of goods and services in the country, but so far no adjustments have been done on it. To make matters worse, sometimes the SEs would go for months without receiving any allowances since the VSC does

not have enough money. These monetary issues result in the SEs being demotivated and more willing to grab every opportunity that arises for a private job. However, despite this demotivation, the SEs do not abandon their work in the two villages as they currently focus on helping fellow villagers and not the money even though they would have loved to be compensated on time for their time.

Lastly, the wet-cell batteries for the SHS are getting weaker and weaker, primarily due to poor maintenance. This poor maintenance has resulted into less power than expected being produced at times and also making the batteries to fast approach the end of their useful life and as such requiring replacement. However, some of the recipients who have tried to replace their batteries have ended up going back to the old battery saying that even though it was weaker, it was better than the one they just bought. This is either due to that there is a problem with replacement batteries on the Malawi market or that these people had gone for the cheap batteries which they can easily afford but translated to be substandard.

All in all, problems listed in this section are hampering the smooth running of the solar projects in the two villages and it would be appropriate to have them addressed to ensure that recipients are attaining maximum benefits from the project. Addressing these problems would also ensure that the donor's investment does not go to waste but rather attain the intended objectives. Furthermore, it would provide a reference point for the success of future REC programmes using off-grid solar PV applications.

3.3 A profile of Malawi

3.3.1 General information

Malawi is one of the least developed countries in the world, ranking 170 out of 187 countries on the 2013 human development index (HDI) (UNDP 2013). The country is found in south-eastern Africa bordering Zambia to the west, Tanzania to the north and northeast and Mozambique to the south and south east. Malawi's gross national income per capita is low, standing at \$320 in 2012, and translating into a low income developing economy (World Bank 2014). As a developing country¹³, the backbone of Malawi's economy is agriculture which accounts for 30% of the gross domestic product (NSO 2010). Most of the people in Malawi are

¹³ The World Bank in 2011 categorised low income developing countries as those with a low GNI per capita per year of about \$1,035 and less (World Bank 2013).

poor, where 73.9% of the population live below the international poverty line of \$1.25 (in purchasing power parity terms) a day (UNDP 2013), while the national poverty line puts the poor at 50.7% of the country's population (World Bank 2014). Currently the government is putting in place policies and programs to diversify the economy so as to eradicate poverty as well as achieve higher levels of economic growth and development.

3.3.2 Malawi's current energy status

As a developing country, one of the hurdles Malawi faces in its quest for economic growth, poverty eradication and meaningful development is lack of sufficient and reliable energy. Malawi relies on hydro-electric power which is produced by a government owned company, Electricity Supply Corporation of Malawi (ESCOM), whose total installed capacity (where 20% is lost due to transmission) is not enough to meet the current suppressed demand (Tenthani et al. 2013). This has resulted into massive load shedding and worse still the rural areas, where the majority of Malawi's population live, fall victim in terms of connectivity and provision as urban areas are prioritized due to their economic activities. As a consequence of this the rural masses heavily rely on biomass fuels as a source of energy and as such being hit by EP and also enduring its consequences.

3.3.3 Energy poverty

Energy poverty (EP) can be defined as the lack of energy services to meet basic needs for cooking, heating, lighting, communication, healthcare, education and income generating activities (IEA 2010a; Practical Action 2013). Globally EP is hitting hard on the people in most developing countries more especially south Asia and Sub-Saharan Africa. As indicated in the preceding paragraph, in Malawi EP is rampant in the rural areas where 95.3% use firewood and 0.4% use electricity as sources of energy for cooking while 3.4% use firewood and 1.7% use electricity as sources of energy for lighting (NSO 2013). Failure to access electricity in the rural areas has resulted into the majority of the rural poor being stuck in poverty. This has also resulted into the rural areas failing to develop. Having realized the potential that reliable energy sources can have in transforming rural areas both economically and socially, the GOM embarked on REC program which initially targeted the trading centers. To date more than 200 trading centers in the rural areas have been electrified¹⁴.

¹⁴ Malawi's REC has been carried out in phases from the 1980s to current with the main implementers being ESCOM, GOM through Energy department and the Japanese Government

3.3.4 Rural electrification

REC aims at providing the rural people with access to clean and efficient energy so as to eradicate EP in these areas thereby improving people's lives both socially and economically. Malawi's REC programme is both grid and off-grid, with the former dominating so far where selected rural areas are being connected to the national grid. However, the areas that have received these connections are still very limited due to low financial capacity on the part of the government to purchase required materials for the programme and also low power generation capacity on the part of ESCOM.

3.3.4.1 Approaches to rural electrification: Decentralized versus Centralized

Factors which affect the decision to connect a rural area to electricity grid are spatial distribution of households, household electricity demand and the potential of households to pay the bills for electricity supplied (Narula et al. 2012). Most of the rural households in Malawi are sparsely distributed and this makes it costly to connect them to the grid (also referred to as central grid). It is for this reason that Malawi's REC using grid or centralized electrification (CE) targeted areas of population concentrations in the rural areas such as trading centers. It was also believed that people in these areas can afford to pay electricity bills as these are points of economic activities. Furthermore, people in rural areas of Malawi are poor and as such their demand for electricity would be limited to lighting and worse still their ability to pay bills is questionable. This becomes risky for the power provider to connect them. The low demand means less revenue collected against heavy initial capital in connecting them. This also explains why CE in rural areas is not making good progress. All in all, low demand for electricity in the rural areas, long distribution lines (due to sparse population), low load densities and associated high transmission and distribution costs and power losses make REC programs through conventional grid extension economically unattractive to the utility companies (Mahapatra & Dasappa 2012). Power providers, including Malawi's ESCOM, do not find it to be a viable business undertaking. This brings in decentralized electrification (DE) as an option.

Decentralized electrification is also called distributed generation (DG). This refers to the production of electricity near or at the point of use with capacities of not more than 10MW (Tenthani et al. 2013). This power can be used locally or where there is surplus generation the surplus can be fed into a national grid through interconnection at a sub-station. For REC to be successful there is need to use DE approach which is achievable through RETs.

The use of DE or DG in rural electrification has a number of benefits. Firstly, since DE is localized there is less or no environmental damage done thereby being able to sustain the environment. On the contrary one literature argues that, centralized generation (CG) or grid electrification has environmental concerns through transmission and distribution of electricity, where the laying of long distance transmission lines results into land degradation (Tenthani et al. 2013). Secondly, the cost of RE based systems which form the backbone of DE is gradually decreasing thereby making it to be a cost effective option in REC (Mahapatra & Dasappa 2012). Thirdly, because of localized generation capacity, DE technologies can be able to provide power to the most remote areas in the country, which would be uneconomical to be connected using CG. Furthermore this localized generation makes DE technologies more efficient in terms of energy production, connectivity and distribution. This is because of the short distance covered which also ensures that there is no loss of power in transmission.

Therefore in order to make the REC programs successful in Malawi, there is need to use DE or DG approach through RETs as it has more benefits than the CE or CG approach through grid electrification. The current CE approach is missing out on some potential customers in the remote parts of the rural areas.

3.3.4.2 Renewable energy as an option for rural electrification

Barry et al. (2011), explain that RETs need to be implemented to improve current lack of access to reliable and efficient energy. Malawi has vast resources of untapped renewable energy. For instance the country lies in the tropical regions where the sun is usually shining throughout the year and is almost overhead thus making it possible to generate more energy from solar technologies. According to Girdis and Hoskote (2005), Malawi's average daily insolation is about 5kWh per square meter, and is relatively uniform throughout the year. This makes solar to be the country's potential source of energy.

In addition to solar energy, numerous rivers in Malawi have potential for establishment of micro as well as mini-hydro electrical power plants. Some of these rivers lie in remote areas where connection to the grid will be very costly and in some cases rendered impossible, and thus if these rivers were to be used to generate hydro-electric power, they would provide energy to these remote areas.

However the current use of these resources is very minimal, but in order to give the rural people access to modern energy, it is essential that the energy from these renewables be harnessed. Furthermore, it is also envisaged that these renewables will help in climate change mitigation and adaptation since biomass fuels contribute towards climate change.

3.3.4.3 Opportunities for climate change mitigation and adaptation

RE sources have a large potential to displace emissions of greenhouse gases from combustion of fossil fuels and thereby mitigate climate change (IPCC 2012). Rural areas depend on fuelwood as a source of energy and this has effects on environment and also the climate due to high levels of emissions. A change to RE and more efficient use of biomass will help to mitigate climate change as these are efficient and releases less emissions. In terms of RE, Marti (2010), states that RETs deployment is a concrete mitigation action, since it avoids additional emissions from fossil fuel energy generation, and may even reduce current emissions if it results in fuel switching. As for the ability of efficient use of biomass in climate change mitigation, Panwar et al. (2011) points out that an improved biomass single stove can save about 700 kg of fuel wood per year and at the same time reducing CO₂ emissions by 161 kg per year.

RE sources can also be used in climate change adaptation. Most of the people in rural areas depend on agriculture for their livelihood, and this puts them in a state of vulnerability when effects of climate change are experienced. For instance when there is drought these people will have low or no yields at all and that translates to less or no food. If they had other means of livelihood they could use those to survive the impacts of this drought. So the coming in of RETs will be handy as these people will have other means of livelihood, enough to make them survive the impact. According to Marti (2010), RETs are an important adaptation measure, since access to this form of energy is likely to enhance economic and social resilience of the rural communities, whose livelihoods could be affected by climate change.

CHAPTER 4 - LITERATURE REVIEW

RE is currently one of the widely researched topics. This is because of the emphasis and importance that has been placed on it recently, which has seen an increase in its promotion and use. This has further triggered a need to provide adequate and relevant information where necessary. Different scholars have taken up this initiative to provide relevant information and used different approaches in studying and analyzing this subject, depending on their angle of emphasis, resulting into diverse research work on the subject. However, only a few of these have been comprehensive enough to analyze several key issues such as RE policies, impacts of RE as well as options for more efficient use of biomass in one research as is the case with this study. In the context of Malawi, research work of this nature is very difficult to find. It is therefore the aim of this study to contribute towards filling up that gap with quality research work. In this chapter, I will bring forward some scholarly work that has been done on this topic which is relevant to my study. This will be done by highlighting some key issues addressed in literature and also the approaches used.

4.1 National policies to improve access to renewable energy

The recent emphasis placed on RE sources has resulted in most of them exhibiting strong growth¹⁵ in terms of installed capacity in the recent years (Timilsina et al. 2013). This growth has also translated into an increased RE share in the total global energy supply mix. In developing countries, RE is mainly targeted for REC where it is aimed at eradicating EP, improving living standards of rural poor as well as for climate change mitigation and adaptation. Governments and policy makers are coming up with policies that aim at improving access to RE sources thereby achieving their aims in the REC and also increasing the RE share in the country's total energy supply mix. Solangi et al. (2011), defines energy policy as a strategy in which government decides to address issues of energy development along with development of the energy industry to sustain its growth which also includes energy production, distribution and consumption. In this section, I will present some of the policies aimed at improving access to RE.

4.1.1 Description of renewable energy policy instruments

Most of the governments' policies aimed at improving access to RE target both the supply and demand sides together, while a few would put much emphasis on one side, depending on their

¹⁵ For example solar PV has grown from 10GW in 2007 to 100GW in 2012, while wind power has grown from 94GW in 2007 to 283GW in 2012 (REN21 2013b).

situation. On the supply side, the high initial costs in production, research and development, which translate into high cost of final product, are seen as a barrier to its development as well as deployment. On the demand side, the low income of consumers is seen as one of the factors that negatively affect demand or limit its acquisition. These policies therefore aim at reducing costs (to make final product affordable and hence attractive) accelerate market penetration and also promote innovation in RE sector (Zhao et al. 2013). According to Solangi et al. (2011), Timilsina et al. (2012), Zhao et al. (2013) and Timilsina et al. (2013), the main policy instruments that countries employ to increase RE access include feed-in tariffs (FIT), capital subsidies, tax credits, tax exemptions, investment incentives, tradable energy certificates (TEC), renewable portfolio standards (RPS), public investments (PI), micro-credit financing and production quotas. These policy instruments can be put into three categories as Regulatory policies, Fiscal incentives and Public financing (KPMG 2012; REN21 2013a). Policy instruments considered in this paper have been briefly described in the following paragraphs.

Regulatory policies include FIT, RPS, RE Targets and TEC. *FIT* refers to a payment made by electricity utilities to producers of electricity from RETs in their service area, which are relatively expensive or may not be competitive with conventional technologies for electricity generation, for an obligatory purchase of their electricity (Menanteau et al. 2003; Timilsina et al. 2012; Timilsina et al. 2013). The amount given to the producer, usually above market rates and determined by the public authorities, is made of cost of electricity produced plus some profit and it is aimed at attracting potential investors into the RE sector as they are guaranteed of long term profits. *RPS* refers to set penetration targets of RE in the total electricity supply mix at the national or provincial levels where electricity suppliers, either utilities or distributors, are legally required to have certain percentage of their electricity supply coming from RE sources in the area (Timilsina et al. 2012). These standards are also referred to as obligatory quotas. *RE Targets* are set goals which a country aims to achieve in the generation of electricity from RE within a specified number of years. The emphasis is on increasing the share of RE in the country's electricity production.

Fiscal incentives include capital subsidies, tax credits, tax exemptions and investment incentives. *Capital subsidies* refer to investment grants or capacity payments, output or production based payments or soft loans (where interest rates are very low) given to investors or producers of RE (Timilsina et al. 2012). These are made to assist in the cost of investment, operation or both. According to Timilsina et al. (2012) subsidies are the primary instrument to

support solar energy development in the world. *Tax credits* refer to the reduction on the taxes payable to the government for qualified and certified RE producers. The *tax credit* facility, varying from 10% to 30% or above of the RE investment cost, allows for those who have invested in RE to deduct a portion of their investment cost directly from their overall tax bill (Energysage 2014). *Tax exemptions* refer to the facility provided by the government where no sales tax or VAT is paid on RETs as well as allowing companies that generate electricity from RE not to pay tax for a specific period of years. *Investment incentives* include provision of loans and loan guarantees at below market rates, market price support and regulation, which provide above market prices or demand for RE produced and sold, and also preferential access to government land for location of the industry (Nam et al. 2013).

Public financing covers such policy instruments as *PI* and *micro-credit financing*. *PI* refers to RE investment done by the government with own funding or in collaboration with development partners (DP) and sometimes DP implementing the RE projects on their own. Timilsina et al. (2012), points out that *PI* is regarded as one of the main drivers of solar energy development in developing countries where many developing countries host a number of government and/or donor-funded projects to support solar energy under their REC programs. *Micro-credit financing* is an end user financing scheme where a microfinance institution, commercial bank or credit cooperative provides energy-related financial products to low-income consumers to enable them to access RETs (Arc Finance 2012). Both *micro-credit financing* and *PI* have been known to directly assist poor people in the rural areas to have access to RETs.

4.1.2 Most common policy instruments used

Zhao et al. (2013), studied a panel dataset of 122 countries for the period 1980 – 2010 to evaluate the effects of renewable electricity policies on renewable electricity generation. Using wind, wave, tide, solar, biomass and waste as sources of RE in electricity production they found that only investment incentives and FIT were effective in promoting the development of these types of RE sources.

Solangi et al. (2011), conducted a study on global solar energy policies (SEP) in several countries across the globe deemed to have successful SEP. These countries include China, Canada, France, Germany, Spain, Malaysia and Pakistan. In this study, Solangi et al. (2011) found out that the most common policy instruments that encouraged the development and utilization of solar energy sources in these countries were FIT, RPS, incentives, subsidies and

targets. The study further showed that FIT, RPS and incentives were the most dominant policy instruments used.

In another study on RE policies, Moosavian et al. (2013) reviewed the RE policies in seven leading countries that actively champion use of solar PV to generate electricity. These countries are Australia, Canada, China, Japan, France, Germany and the United States of America (USA). The study primarily focused on these countries since they have registered successful growth in the use of solar PV to generate electricity for a long time. The results of the study show that the most common RE policies employed in these countries were FIT, RPS, incentives, subsidies and tax exemptions.

From the studies above, it can be concluded that there are a few RE policies which have been dominant and effectively promoted RE in the countries that have registered successful stories in the RE sector. These policies are FIT, RPS, incentives, subsidies, tax exemptions and targets. However, it is possible that one policy can work much better in a particular environment and perform miserably in another. Zhao et al. (2013) emphasises the need to develop RE policies citing the crucial role they play in promoting RE generation, but goes on to warn that effectiveness of RE policies is subject to diminishing returns as the number of policies increase. This shows that there is need to formulate a few RE policies which are the most relevant in that particular situation.

4.2 Solar energy and rural electrification

Rural electrification (REC) is seen in literature (Bhandari & Stadler 2011; Chakrabarti & Chakrabarti 2002; Chaurey & Kandpal 2010; Haanyika 2008; Laufer & Schafer 2011) as one way of attaining development in the rural areas. This comes against the background that most of the people in developing countries live in rural areas and these areas lack access to energy services that can transform their lives or improve their living standards. The kind of rural development that is being emphasised now is sustainable development (SD). According to the G8 renewable energy task force¹⁶ (G8 2001) and the IPCC (IPCC 2012) provision of clean,

¹⁶ The G8 Renewable Energy Task Force, which includes members from the private and public sectors of both developing and developed countries, as well as multilaterals and non-governmental organisations, was formed following the recommendation from the Okinawa Summit in 2000 to have such. The Task Force was to assess the barriers and to recommend actions to better encourage the use of renewables in developing countries (G8 2001). For more

affordable, and reliable energy is a key element towards SD. This is where renewables such as solar energy come into play as they qualify in all the three.

The importance and impacts of using stand-alone or decentralized solar PVs to achieve REC in the developing countries has been well documented in literature (Bhandari & Stadler 2011; Chakrabarti & Chakrabarti 2002; Chaurey & Kandpal 2010; Haanyika 2008; Laufer & Schafer 2011). This is basically due to its ability to provide energy to remote areas which are economically not feasible to be connected to the main grid and also due to its environmental friendliness. However, despite the ability of solar PVs to provide electricity in these uneconomic areas, other researchers (Jackson & Oliver 2000; Wamukonya 2007) have argued against the cost effectiveness of such projects citing the high initial cost. The rural poor for which these are targeting usually do not afford to purchase these on their own and as a result governments have in most cases provided subsidies and other financial incentives to these people, at the expense of other sectors.

On the issue of environmental friendliness, other writers (Devabhaktuni et al. 2013; Dubey et al. 2013; Martinot et al. 2002; Tsoutsos et al. 2005) argue that solar energy has some environmental problems emanating from both manufacturing and disposal of batteries and PV panels. The chemicals used to manufacture PV panels such as mono-crystalline silicon, polycrystalline silicon, micro- crystalline silicon, copper indium selenide, cadmium telluride, lead, brominated flame retardants, cadmium, and chromium are highly toxic to both the workers (during manufacturing) and the environment after usage (Devabhaktuni et al. 2013; Dubey et al. 2013). When dead solar products are not properly disposed¹⁷ of, the hazardous chemicals in them cause environmental damage.

In terms of high initial cost, the articles by the G8 (2001) and Oliver and Jackson (2000) have argued and documented that the cost of solar PV is currently going down. This is attributed to increased production volumes, improvements in manufacturing technology which has reduced the manufacturing cost, increasing market shares and improvements in performance of PVs

on the G8 Okinawa Summit of 2000 see <http://www.g8.utoronto.ca/summit/2000okinawa/finalcom.htm>

¹⁷ In most cases dead solar PVs and batteries in the developing countries are simply thrown away into rubbish pits, nearby bush or just on the ground somewhere.

(G8 2001; Oliver & Jackson 2000). This argument shows that PVs will soon be more affordable even to the rural populous. According to IEA/OECD (OECD/IEA 2011) solar energy is expected to reach competitiveness on a large scale in a few years' time. Additionally, the initial high cost of SHS is a one off thing as after purchase SHS enjoy low maintenance rates and no user fee (if one owns it).

In conclusion, despite solar PVs having cost and some environmental issues they still remain a viable option in REC. Proper disposal and recycling will prevent environmental contamination. In addition, solar energy systems such as PVs provide significant environmental benefits in comparison to conventional energy sources, thus contributing, to the SD of human activities (Kaygusuz 2009; Tsoutsos et al. 2005). All in all, the benefits of using the PVs in RE outweigh the problems that can be faced in using them.

4.3 Solar energy and socio-economic impacts

International organizations such as the World Bank (World Bank 1996), G8 (G8 2001), and UNDP (UNDP 2012), have placed emphasis on the use of RE in the rural areas of the developing countries to attain SD. Studies on RE and more specifically on solar energy (Gustavsson & Ellegard 2004; Jacobson 2007; Wamukonya & Davis 2001) have shown that use of solar energy brings in a lot of socio-economic benefits to the rural people.

In the study that was done by Gustavsson and Ellegard (2004) in Zambia on the impact of SHS on rural livelihoods, they found out that use of SHS was enabling the children in the area to study at night thereby improving their education, providing new possibilities for entertainment and socialization through radio and video at night, providing light for the home, saves money on lighting, extension of working hours at home and business, ability to do household chores easily at night such as cooking, reduction in emissions which also reduces acute respiratory problems and protects the environment, and a general improvement in living standards.

Jacobson (2007), conducted a study on solar electrification and social change in rural Kenya. In the study it was found that solar energy increased interconnectedness within the rural area as well as with urban counterparts through the ability to charge their mobile phones easily using solar electricity, increased entertainment and socialisation through TV viewing and radio, supports IGAs, extension of working hours, improved access to information through the radio and TV as well as mobile phones, improved education in the area by allowing children to study

at night adequately and general provision of lighting in the home which provides safety and security amongst other benefits.

Wamukonya and Davis (2001), conducted a study on the socio-economic impacts of rural electrification in Namibia where they made a comparison between grid, solar and unelectrified households. In this study they found that solar electricity improves household welfare, provides entertainment through TVs and enhances socialisation, enables children to study at night and hence improving their education, enables people to access educative programmes on the TVs and radios, extends length of working day, improves health, and lastly lighting provides safety and also enables adults to read books at night. However, in the study by Wamukonya and Davis (2001), they did not find solar electricity to have initiated or influenced any IGAs in the area.

These impacts listed above can be classified into five groups namely: Health, Education, Social, Environment and Income. Firstly, health impacts of solar electricity are due to the household's reduced exposure to hazardous indoor air pollutants (IAP) or emissions. People are also able to access health information programmes from the radios as well as TVs which enables them to embark on health practices and avoid catching diseases.

Secondly, the education impacts are due to the lighting that enables the children to study at night as well as do their homework in good time thereby getting better grades in school and excelling in education. Adults can also read at night. There is also acquisition of knowledge through the programs broadcasting on the TVs and radios.

Thirdly, social impacts encompass entertainment through television sets and radios, socializing at night due to lighting available as well as safety and security. In case of safety an individual is able to do things inside or outside the house properly as there is proper lighting that they are using thereby preventing injuries. The mobile phones enable transferring of information within rural setting as well as between rural and urban counterparts. Furthermore, TVs and radios enhance communication between rural communities and advertisers by transferring information from advertisers to the people about their products and service.

In terms of environmental impacts, solar energy protects the environment by reducing the amount of emissions into the atmosphere since it does not release any emissions during its life

time. Furthermore, use of solar energy replaces fossil fuels like kerosene, in lighting and refrigeration, which have emissions that damage environment and cause climate change.

The last impact is Income. Solar energy increases income levels in the household through savings (as they no longer purchase kerosene and other expensive lighting sources), revenue from mobile phone charging, extended hours of work in the home¹⁸ and business (increases sales volumes and hence more earnings) as well as improved health¹⁹.

Despite these clearly seen socio-economic impacts of solar energy, presented in the preceding paragraphs, other writers (Richter & Frings 2005) have argued that solar energy increases disparities between the poor and the affluent in rural areas. According to Richter and Frings (2005), rich and poor families stand on unequal footing regarding the use of electricity and therefore providing electricity simply amplifies disparities between them, thus making poverty visible without removing it. This unequal footing translates into differences in utilization levels between the poor and rich families where the latter are able to utilize fully the solar electricity and realize more benefits from it while their counterparts are not. These findings by Richter and Frings (2005) are similar to some that were found by Jacobson (2007). In the study by Jacobson (2007), it was found that the use of solar electricity in rural Kenya appeared to contribute towards differentiation and middle class formation. However, currently programs are in place (such as solar electrification by Barefoot College, India) that have targeted and supplied free SHS and start up accessories, such as phone chargers, to the poor to increase their capacity levels in the utilization of the solar electricity. This is being done to narrow disparities between the poor and the affluent in these areas.

In conclusion, utilization of solar energy can positively transform people's lives as evidenced by the number of socio-economic impacts it brings forward. The transformation is not only to the households concerned but the whole society as well.

¹⁸ It frees up some time that can be used for IGAs.

¹⁹ Improved health due to the absence of IAP as well as falls and injuries in the dark reduces medical bills and allocates more time and resources on other household activities and IGAs.

4.4 Solar energy (RE) and Climate change mitigation and adaptation

One of the important global conventions on renewable energy and climate change, the UNFCCC, emphasised the role RE can play in climate change mitigation and adaptation (United Nations 1992b). A similar emphasis was also made by the IPCC²⁰ in 2001 (IPCC 2001a). In line with this emphasis, numerous studies have been conducted on the subject matter. In this section, I will review some literature on how RE, more specifically solar energy, can be used in climate change mitigation as well as adaptation. These two issues will be reviewed separately.

4.4.1 Solar energy in climate change mitigation

The IPCC (2001a) defines climate change mitigation as an anthropogenic intervention to reduce the sources of GHGs or enhance their sinks. On the other hand, UNEP (2014) refers to climate change mitigation as efforts to reduce or prevent the emission of GHGs. Both definitions are applicable in this study. One of the studies showing how RE can be used in climate change mitigation was conducted by Pearce (2002) on solar PV. In this study, Pearce notes that use of PVs has more positive environmental impacts. He illustrated this using a 5 kWp PV system that could be placed on the roof of any typical home. Results from this study show that in a single year, use of this single PV would prevent: 3.3 tons of coal from being burned, 8.5 tons of carbon dioxide (CO₂) from enhancing greenhouse effect, ~50 pounds each of nitrous oxide (NO_x) and sulphur dioxide (SO₂) from polluting the atmosphere and causing acid rain, 2.5 pounds of particulates from causing a health hazard, 571 pounds of ash from being disposed of in landfills, and conserve over 5000 gallons of water. These calculations were based on electricity generation from coal. Pearce's work then clearly demonstrates that use of PVs to generate electricity mitigates climate change. When more PVs are used the greater the mitigation. Additionally, PVs have a long lifespan of 20-25 years official lifetime hence the propensity for incredible mitigation (Kamalapur & Udaykumar 2011; Pearce 2002).

Another study was conducted by Posorski et al. (2003), in which they wanted to find out if the use of SHS contributes to climate protection or climate change mitigation through reduced

²⁰The Intergovernmental Panel on Climate Change (IPCC) was established jointly by the World Meteorological Organization and the United Nations Environment Programme in 1988, in response to the widespread recognition that human-influenced emissions of GHGs have the potential to alter the climate system. See <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-intro.pdf>

GHG emissions. In this study, they compared the use of a single 50 Wp SHS against traditional lighting with petroleum lamps. The comparison showed that use of SHS had resulted into a GHG savings of around 9 tonnes of CO₂ equivalent GHG emissions within a 20-year period of use. From these results, they concluded that SHS that are used cost efficiently to substitute kerosene use reduces GHG emissions effectively, thereby mitigating climate change.

These two studies reviewed in this section therefore show that use of solar energy results into climate change mitigation. However, Drennen et al. (1996) in their study on solar power and climate change, which they did in 1996 using Zimbabwe as a case study, concluded that they did not see solar power to have a significant role in climate change mitigation in the near future. This conclusion could have been made based on the low utilization of PVs by the time their study was conducted, mainly because of high costs involved in acquisition of the PVs. However, currently use of PVs and other RETs is increasing as their prices are going down, and as such these will play a very significant role in climate change mitigation. The following figure illustrates growth of PV installed capacity since 1995 (a year before the study by Drennen et al was conducted).

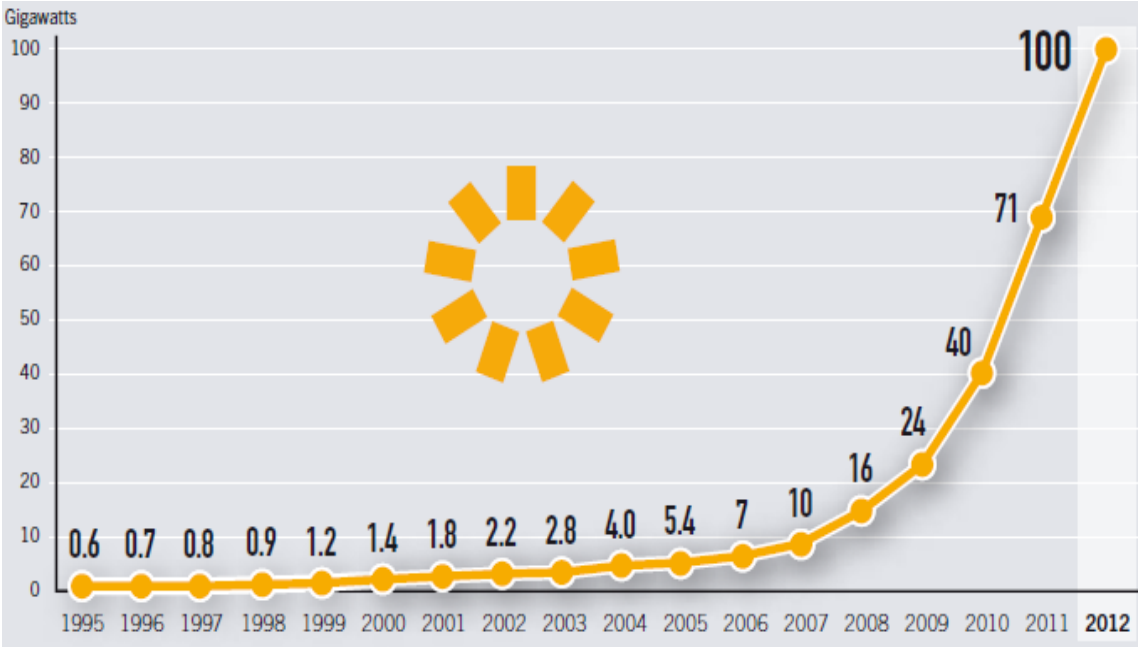


Figure 10: Solar PV Global Capacity 1995-2012 (REN, 2013b)

From the graph, it is evident that installed capacity of PVs has been increasing since 1995. Large increases have been achieved between 2009 and 2012 with a total of 76GW capacity

installed within this period. This disputes the argument raised by Drennen et al. (1996) about the significance of PVs in climate change mitigation. In this way I see their conclusion to be problematic and not applicable now. Increase in use of PVs subsequently reduces the amount of emissions released and as such mitigating climate change. Posorski et al. (2003), also emphasised that SHS or PVs can make a significant contribution to climate protection if their dissemination is in large numbers, which at the current trend as indicated in the preceding graph is achieving results.

4.4.2 Solar energy in climate change adaptation

The IPCC (2007) defines climate change adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. According to IPCC (2001b) the least developed countries (LDC) are the most vulnerable to climate change impacts that exacerbate existing environmental and resource stress and poverty. The high vulnerability of LDCs relates more to their low adaptive capacity than to the magnitude of any specific climate impacts (Venema & Rehman 2007). In this way it could be concluded that high priority area for least developed countries is climate change adaptation and not mitigation. However, climate change adaptation is area specific as the needs of one area would be different from the other. Furthermore, the link between climate change adaptation and RE is not as direct as that between RE and climate change mitigation. In this section I will present several studies that show how solar energy can be used in climate change adaptation.

One of such studies was conducted by Mosberg (2013) on a decentralized solar energy centre in Ikisaya village, Kenya. In this study, she found that the services being provided at the energy centre were helping the people in climate change adaptation. The Ikisaya energy centre uses solar PVs to generate power and provide the following services: Rental of portable LED-lanterns, mobile phone charging, computer services, typing, printing, photocopying, scanning, laptop charging, TV/Video viewing, and retail outlet for the sale of solar lanterns and small SHS. Mosberg (2013), states that the services offered at the centre have supported important coping strategies, such as enhancing access to casual employment, remittances, trade and business. These increase one's earnings which in turn enhances their adaptive capacity. Furthermore, the centre's mobile phone charging service has enhanced communication in the area and also enables people to save time as instead of walking long distances to talk to each other they can simply talk on the phone (Mosberg 2013). The time saved in travel can be used

on other productive activities. The TV/Video shows give people access to information that can be used to improve their livelihoods. However, she noted that not every member of the village was benefiting from the services being offered. Those who lived furthest from the centre were failing to access the services and thus their adaptive capacity was much lower.

Another study that shows how solar energy can be used in climate change adaptation was done by Vognild (2011). She explored the role of solar power supply in climate adaptation on Moushuni Island, India, whose inhabitants are dependent on agriculture. From the study, she concluded that provision of solar power on the island has helped the inhabitants to cope with the climate stresses that occur regularly on the island. Electricity supply was found to improve opportunities for diversifying income domestically, especially for women, due to the lighting which created extra time and better work conditions to carry out these activities in evenings, and also to visit each other to learn and carry out IGAs (Vognild 2011). Provision of lighting has therefore enabled the islanders to increase their income through diversification and extended hours of work. Vognild (2011), points out that increased opportunities for diversifying income can make the household less dependent on agriculture and therefore being less vulnerable to climatic challenges.

Venema and Cisse (2004), also conducted a similar study using a number of RETs including solar energy in 5 countries namely Argentina, Bangladesh, Brazil, Senegal and Zimbabwe. In their study they showed how decentralized renewable energy (DRE) projects such as SHS can be used in adaptation to climate change in LDCs. According to the study, solar energy (SHS) and the other DRE projects play this role in a number of ways some of which are through poverty alleviation and enhancing livelihood security. This was shown as follows: Firstly, access to the electricity enables people to engage in IGAs or diversify their livelihoods which raise their income and also alleviate poverty. Secondly, access to electricity reduces the prevalence of acute respiratory illnesses and other smoke related infections since electricity does not have emissions. Reduction in infections and other health risks such as waterborne diseases (since people have access to safe water pumped from underground) enables people to live a healthy and productive life which also aids in their livelihood security. These in turn enhances one's adaptive capacity to climate changes.

From the studies reviewed in this section, it can be concluded that solar energy play a significant role in climate change adaptation through poverty alleviation, enhancing livelihood security as

well as reduction of respiratory infections, amongst others. It can also be said that socio-economic benefits from solar energy utilization enhances the adaptation process. All these increase one's adaptive capacity to climate changes.

4.5 Improved cook stoves and climate change mitigation and adaptation

Improved cook stoves (ICS) are stoves designed to improve energy efficiency, remove smoke from the indoor living space, and raise the productivity of cooking (Köhlin et al. 2011). The introduction and promotion of ICS comes against the background that the traditional 3-stone fire (3SF), which is very common in the rural areas of developing countries, has more disadvantages to both the people and the environment including contributing to climate change through increased emissions from it. A number of studies have been conducted on the role of ICS in climate change mitigation and adaptation. In this section I will review some of these studies. The studies on the role of ICS in climate change mitigation will be reviewed separately from those on the role of ICS in climate change adaptation.

4.5.1 Improved cook stoves in climate change mitigation

One of the studies that show the role of ICS in climate change mitigation was done by Panwar et al. (2009). Their study involved a review on the scope of CO₂ mitigation through ICS and other RETs such as solar cookers. In this study they found out that combustion of biomass using ICS produces less emissions and can save about 161 kg of CO₂ emissions annually per stove. This shows that combustion of biomass using ICS reduces the amount of emissions released which cause climate change and hence mitigating climate change.

Adkins et al. (2010a), studied the fuelwood consumption of institutional "rocket"²¹ design ICS against 3SF in randomly selected school kitchens in the Sauri Millennium Villages Project site in Western Kenya. In the study, they experimented with various types of foods that are part of a school feeding program. The results showed that the rocket design ICS used less fuelwood compared to the 3SF on two types of food which required long time to be cooked with fuel savings of 48% and 42% respectively against the 3SF. From the results (fuelwood consumption) obtained in this study, Adkins et al. (2010a) used the IPCC's conversion factor

²¹ The stoves have vertically elongated combustion chamber (whose walls are made of an insulating material with low thermal mass) which controls airflow, combustion and mixing, and the stove design directs the heated air and gases closer to the pot, increasing heat transfer (Adkins et al. 2010a; Winiarski 2005).

of 1.747 tons of CO₂ emitted per ton of fuelwood burned (IPCC 2006) to predict that around 9 tons of CO₂ emissions may be avoided per year for each school that regularly uses this type of institutional rocket stove for cooking.

All in all, the results from these studies above show that use of ICS reduces amount of emissions released into the atmosphere which cause climate change. This then means that use of ICS mitigates climate change.

4.5.2 Improved cook stoves in climate change adaptation

Climate change adaptation is vital to the developing countries since according to IPCC (2001b) these are the most vulnerable to climate change impacts. Most of the people in the rural areas of developing countries use biomass for cooking on the 3SF which consume a lot of biomass thereby demanding its frequent collection. Since ICS are meant to consume less biomass when cooking, this will in turn lead to reduced number of trips done to collect biomass thereby freeing up some time that can be used for other productive activities. A number of studies that have been done to show how efficient ICS are in terms of biomass usage and time spent on cooking also show that ICS can be used in climate change adaptation. Some of these studies are presented below.

One of such studies was done by Umogbai and Orkuma (2011) at the University of Agriculture, Makurdi in Nigeria. In the study they used the traditional 3SF as a control when testing a locally made ICS. From the study, they found out that the ICS used an average of 69g of fuelwood to boil 1 liter of water in about 8 min (5 liters in 38 min) while 3SF used 326g of fuelwood to boil the same 1 liter of water in about 25 min (5 liters in 126 min). The study showed that average rate of fuelwood consumption (burning rate) was higher for 3SF (10.1g/min) than ICS (6.7 g/min) which meant that 3SF uses more fuelwood than ICS for the same task and same duration (Umogbai & Orkuma 2011). This then means that ICS reduce the number of trips that can be made to collect biomass for use in the household as they use less biomass for cooking.

Two similar studies were done by Adkins et al. (2010b) in two villages in Western Uganda and Western Tanzania. In these studies they wanted to evaluate the performance and usability of household biomass cook stoves under field conditions which involved cooking tests and qualitative surveys done in the actual kitchen. They compared the performance of manufactured ICS models based on the 'rocket' design with the traditional 3SF. In Uganda, the comparison

was on the performance of *Ugastove*²² and *StoveTec* stoves with the traditional 3SF respectively. The results from this Ugandan study showed that *Ugastove* stove achieved fuelwood savings of 46% while *StoveTec* stove attained a fuelwood savings of 38% against the 3SF respectively on a similar task. In Tanzania their study was on the performance of *StoveTec*, *Envirofit*²³ and *Advent stove* ICS, each of which was compared with the traditional 3SF. They tested the stoves by cooking *ugali* (maize flour paste) and beans on them respectively. The results from this Tanzanian study showed that when the stoves were tested by cooking *ugali* on them, *StoveTec* and *Envirofit* stoves attained fuelwood savings of 41% each while the *Advent* stove attained fuelwood savings of 25%. And when they tested the stoves by cooking beans on them, the results showed that the *Advent* stove attained fuelwood savings of 36%, *StoveTec* stove attained savings of 34% and *Envirofit* stove attained the lowest savings of 22%. This shows that use of ICS for cooking saves firewood. From the same study in Tanzania, around 60% of the respondents reported that they were able to cook food much faster using *StoveTec* and *Envirofit* stoves than the traditional 3SF. This then means that these people were able to save time in food preparation when using ICS.

From the studies presented above, it is clear that ICS use less biomass and also that an individual takes less time in cooking food when they are using ICS. This means that if a household uses ICS, the biomass collector(s) in that particular household will have spare time to do other productive activities as they will no longer be going to collect fuelwood and other biomass regularly and also that the one(s) preparing food will not be spending a lot of time preparing it. The time spared can be used to engage in IGAs (to increase household's earnings), relaxing (to rest the body), chatting with friends (enhancing social networks), attending community and local group meetings (to share ideas and learn new things) as well as perform other domestic chores such as cleaning inside the house and the surrounding which will lead to the household members living in a healthy environment. Apart from saving time in food preparation and collection of biomass, actual use of ICS is more comfortable than 3SF since

²² *Ugastove* stove is a metal and clay stove factory made in Kampala by the Uganda Stove Manufactures while *StoveTec* stove is a metal rocket stove designed by Aprovecho Research Center (USA), and manufactured in China (Adkins et al. 2010b).

²³ *Envirofit* stove model G3300 was designed by Envirofit International, USA and manufactured in India while *Advent* stove is manufactured by Advent Technologies, Tanzania (Adkins et al. 2010b).

the smoke is directed out of the kitchen and the cook will not suffer from red eyes or running nose, thus reduced stress in food preparation. All these enhances one's adaptive capacity to climate change, therefore the use of ICS enables climate change adaptation in the rural areas of the developing countries.

4.6 Pressure on biomass and options for more efficient use

The majority of population in developing countries lives in rural areas and heavily relies on biomass as a source of energy. It has been estimated that about 2.7 billion people worldwide, most of which are from the developing countries, rely upon direct burning of biomass for their daily energy needs (IEA 2010b, WHO 2011). According to Bhattacharya et al. (2000) and IEA (2006), biomass²⁴ accounts for more than 90% of the total rural energy supplies in developing countries. However, even though biomass occupies such a large percentage in the rural energy supplies of developing countries, IEA (2010) states that these people use traditional and inefficient combustion methods to convert the biomass to energy. Traditional use of biomass produces a number of disadvantages including increasing pressure on biomass resources. In this section, I will present the pressure being put on biomass and discuss options for more efficient use of the biomass to reduce the disadvantages.

Traditional use of biomass or traditional biomass is dominated by the traditional 3-stone fire (3SF). The 3SF is the traditional stove composed of three similar sized stones arranged in form of an equilateral triangle where biomass is put in between the stones and the fire is made at the centre (Jetter & Kariher 2009; Vaccari et al. 2012). These 3 stones are sometimes replaced by bricks, pieces of clay, big chunks of wood (which also double as fuel), iron tripods or cook-pots with three feet. The layout of traditional 3SF causes great heat dispersion due to no isolation of combustion chamber and this translates into an inefficient use of great amounts of wood and other biomass (Vaccari et al. 2012). This layout also results into inefficient combustion of the biomass. The inefficient use of biomass culminated with the high population that depends on it results into great pressure being exerted on it and a number of other disadvantages. A number of studies such as Adkins et al. (2010a), Adkins et al. (2010b), Malakini et al. (2013) and Umogbai and Orkuma (2011) show that 3SF consumes a lot of biomass thereby exerting more pressure on it.

²⁴ Biomass mostly used in the rural areas of the developing countries include fuel wood, charcoal, tree leaves, crop residues and animal dung. See IEA, 2010b.

In the study that was done by Malakini et al. (2013) in Malawi, they studied the performance and fuelwood consumption of two domestic ICS (*Chitetezo* stove and Rocket stove) available in the country against the traditional 3SF. The study was based on preparation of a typical Malawian dish²⁵ and they used *Cordyla Africana*, an indigenous firewood species which is commonly used for cooking in the rural areas of Malawi. This was to represent rural setting and usage of firewood. The results showed that Rocket stove used 201g fuelwood per kg of food (g/kg) cooked, *Chitetezo* stove used 259g/kg and the 3SF used 452g/kg (Malakini et al. 2013). Furthermore, in terms of efficiency, the results showed that the Rocket stove and *Chitetezo* stove were 55% and 43% more efficient than the 3SF respectively (Malakini et al. 2013). From these results it shows that the traditional 3SF used more fuelwood than the two ICS on the same task which also shows that the 3SF is inefficient.

The study done by Adkins et al. (2010a) has been briefly described in Section 4.5.1 while studies done by Adkins et al. (2010b) and Umogbai and Orkuma (2011) have been briefly described in Section 4.5.2. All these studies show that the traditional 3SF uses more biomass than the ICS on similar tasks.

All in all, the results from the studies above show that 3SF consumes more biomass than ICS on a similar task thereby making it inefficient. Since there are a lot of people in the rural areas of the developing countries that rely on the 3SF, this results into more pressure being exerted on the biomass and also an increase in the disadvantages²⁶ that arise from the reliance on it.

Following this inefficiency in the use of biomass and the associated disadvantages, a number of studies were conducted to find out how biomass can be used efficiently so as to do away with these. This also took into consideration that biomass will remain the primary source of energy for most households in the rural areas of the developing countries for a longtime to come. The main way that is currently being promoted in the rural areas of the developing countries to enable efficient use of biomass is through the use of improved cook stoves (ICS). Studies by Adkins et al. (2010a), Adkins et al. (2010b), Kishore and Ramana (2002), Malakini

²⁵ This dish was chosen because it is normally commonly consumed in rural areas as it is affordable by most rural people in Malawi (Malakini et al. 2013).

²⁶ Some of the disadvantages include poverty, respiratory infections, physical strain and environmental degradation through emissions and biomass harvesting.

et al. (2013), Panwar et al. (2009) and Umogbai and Orkuma (2011) show that ICS are more efficient than the 3SF in biomass consumption and time taken to prepare food. These studies showed that ICS use less firewood, produce less smoke and other emissions due to the high burning rate enhanced by the design of the stoves and also took less time to prepare the food. It was concluded from these studies that the ICS are more efficient than the traditional 3SF.

According to Kishore and Ramana (2002) an improved biomass cook stove can be able to save 700 kg of fuel wood per year as compared to 3SF. However, this figure may be high now as several improvements have been made to the ICS in the past 12 years since Kishore and Ramana's study was done in 2002. One notable improvement to the ICS is the Rocket stove which Malakini et al. (2013) in their study found that it used 55% less firewood than the traditional 3SF on the same task. This translates into less biomass being harvested and used thereby reducing pressure being exerted on it.

One other notable effect arising from inefficient use of biomass is the release of toxic emissions which cause respiratory infections as well as climate change. Bhattacharya et al. (2000), conducted an emission study on biomass when used on the traditional 3SF and found that incomplete combustion of biomass in the traditional cooking stove release carbon monoxide (CO), nitrous oxide (N₂O), methane (CH₄), polycyclic aromatic hydrocarbons (PAHs), particles composed of elemental carbon or black carbon, and other organic compounds. These substances are harmful to human beings as they cause various ailments and are also responsible for climate change. The study that was done by Panwar et al. (2009), which has been briefly described in Section 4.5.1, shows that ICS produces less emissions. This then shows that the coming in of ICS will help also to reduce all these emissions that are being released from incomplete combustion of biomass using the 3SF.

From the studies reviewed in this section, it has been seen that combustion of biomass using traditional 3SF is inefficient and wasteful in both time and biomass. The use of a lot of biomass results into more pressure being put on the resource as well as more emissions being released. It has further been seen that the introduction of ICS into the rural areas of developing countries will combat these and all other disadvantages arising from the use of traditional 3SF, and as such households should be encouraged to adopt them for use.

4.7 Gender differentiated roles on access to and control of energy types

Gender differences in the rural areas of developing countries determine which roles to be performed by men and which ones by women. Some of the most important roles performed in these areas include the acquisition, control and use of energy. In this section, I will present literature that shows whether or not there are gender differentiated roles in acquisition, use and control of the different types of energy in rural areas of the developing countries. For simplicity, the presentation will be divided into two parts: biomass and modern energy.

4.7.1 Acquisition, control and use of biomass

Traditional biomass is the main source of energy in rural areas of the developing countries, and it is mainly used for cooking, space heating and lighting. In terms of its acquisition, literature by FAO (1995), Wickramasinghe (2003), Bandyopadhyay et al. (2011), Kaygusuz (2011b) and Ding et al. (2014) shows that collection of biomass for domestic use has been primarily the responsibility of women in the rural areas of developing countries. This activity has traditionally been one of the women's main reproductive roles²⁷ in these areas. Women collect fuelwood or other forms of biomass so that they cook food or provide heating for the family in fulfilment of their reproductive roles. Wickramasinghe (2003) however points out that even though biomass collection for domestic use is primarily the responsibility of women, men lend a helping hand occasionally in the tasks they feel are 'heavy' and 'masculine' such as cutting down trees, chopping off tree branches as well as splitting wood. Ding et al. (2014), shows that men's involvement in the acquisition of firewood was due to increasing distances to collect firewood in the area they carried out their study. In addition to these, Clancy et al. (2002) points out that when energy has to be purchased, men enter the decision-making process, apparently because they are the primary bread winners in most households. In most rural areas, households will engage in purchasing fuelwood as a last resort, otherwise they try as much as possible to collect whatever biomass they can come across for free. All these show that involvement of men in biomass acquisition is very limited and just occasional. The following table (Table 3), from the study that was done on gender and health issues in the biomass energy cycle by Wickramasinghe (2003) in Sri Lanka, illustrates how involved men and women are respectively in the general tasks done during the acquisition of biomass.

²⁷ Reproductive role is described as domestic work done by women involving reproduction and maintenance of the labor force through childbearing and rearing responsibilities and general care and provision of the household and its members (Moser 1989).

Table 3: Involvement of men and women in household's biomass acquisition tasks

Task	Men (% range)	Women (% range)
Harvesting	25 – 30	75 - 80
Gathering deadwood	01 - 05	95 - 99
Trimming	20 - 25	75 - 80
Cross-cutting	30 - 35	65 - 70
Bundling	01 - 05	95 - 99
Carrying (head-loading)	01 - 10	95 - 99
Splitting	20 - 25	75 - 80

Source: Wickramasinghe (2003)

From the table above, it can be seen that the most common and regular tasks associated with the acquisition of biomass such as gathering dead wood off the ground, bundling and head-loading are done by women with very little help from the men. On the other hand, the 'masculine' tasks such as splitting, cross-cutting, trimming and harvesting show a higher involvement of men in the tasks, and this shows where the occasional help from men goes into. These results, as shown in table above, are typical of most rural areas of the developing countries. Overall, the table shows that women are dominating the biomass energy cycle.

In addition to women dominating in acquisition of biomass for domestic use, the study that was done by Brouwer et al. (1997) on responses of rural households to decreasing fuelwood availability in Malawi showed that children, more especially the girl child, were following the footsteps of their mothers. Girls were found to be helping their mothers in acquisition of biomass and thus coming second to their mother in level of involvement. This role of girls in acquisition of biomass for domestic use was also pointed out by Clancy et al. (2002), Biran et al. (2004) as well as IEA (2010b). In the study that was done by Biran et al. (2004) in Malawi and Tanzania on costs and benefits of children in firewood collection and use, girls were found to accompany their mothers to collect firewood on about 50% of their mothers' trips. However, the increasing firewood scarcity and distances covered to collect it has in most cases resulted into the girl child failing to go to school on some days so that they help in this task and hence affecting their literacy negatively and also prospects for a better job in future (Brouwer et al. 1997; IEA 2006). The following photo shows Malawian young girls carrying heavy loads of firewood from a forest reserve.



Photo: Buitenbos (2012)

Figure 11: Girls carrying firewood in Malawi

When it comes to the control of traditional biomass, studies by Wickramasinghe (2003), Mahat (2004), Kaygusuz (2011a) and Ding et al. (2014) show that women take a leading role in controlling usage of the traditional biomass in their households. These studies shows that women are managers of traditional biomass at household level and ensure that it is used reasonably as well as stored in a place that is secure and free from rain. Women's dominance

in control of traditional biomass could be because its usage falls within their reproductive roles and so they would want to ensure that it is well managed so that they are able to execute their roles without problems. According to Clancy et al. (2011), women remain managers of household energy and appliance use even if they did not make the decision to purchase it or pay for the energy, as is the case when energy has to be purchased.

Regarding use of traditional biomass, literature by Karekezi and Kithyoma (2002), IEA (2006), WHO (2006), Bolaji (2012) and Ding et al. (2014) show that women are the primary users of biomass in rural households of developing countries. In addition to women, studies by Brouwer et al. (1997), Mahat (2004) and Bolaji (2012) show that girls are also actively involved in using traditional biomass in the home, as they help their mothers with cooking. Furthermore, studies by Mahat (2004) and Matinga (2010) show that men are also involved in using traditional biomass when they cook food or heat water during the times their wives are ill, busy with other chores or have travelled. However this scenario is rare as usually older children in the household will be asked to perform these tasks during such times.

All in all, the preceding paragraphs in this section show that women are dominating in the acquisition, control and use of traditional biomass for domestic purposes. It has also been shown that men lend a helping hand occasionally in the acquisition and that children, most especially the girl child, are actively involved in acquisition and use of biomass in the homes. Men's use of biomass in the home is very minimal and usually rare. It can then be said that acquisition, control and use of traditional biomass in the rural households of the developing countries is gender sensitive due to the dominance of women in these tasks.

4.7.2 Acquisition, control and use of modern energy

Acquisition of modern energy involves spending money and usually comes as a huge cost to the rural households of developing countries. Its acquisition therefore would depend on who makes the decisions pertaining to how finances should be used and how finances are managed in the household. There are two ways pertaining to this.

The first way is when the finances are managed by the household head. In most households of the rural areas of developing countries finances are traditionally managed by men, who mostly are the bread winners. This then means that in such households men would make the decision to acquire the modern energy technologies. Studies by Clancy et al. (2002) and Malhotra et al.

(2004) point out that when energy and energy technologies have to be purchased, men make the decision as they are the bread winners and in charge of the finances in the households. However, even though such is the case in these male-headed households, Karekezi and Kithyoma (2002) and Pachauri and Rao (2013) show that women in those households influence such decisions as they are the ones who control or influence the household energy consumption patterns, but the final decision is made by the husband. In the cases where household head is a woman, decision to acquire modern energy technologies will be made by her since she is in control of the household's finances. Studies by Mahat (2004) and Clancy et al. (2011) show that in the households being headed by women, due to divorce, death or migration of the husband, such women will have a considerable say in decisions on the acquisition of modern energy technologies being the ones who are in control of the household's finances. This shows that decision to acquire modern energy technologies is usually done by the household head, mostly men and where women are heading the household then they make such a decision.

The second way is when the household's finances are managed by both the husband and wife. The study that was done by Matinga (2010) shows that in the households where finances are managed by both the husband and wife the decision to acquire modern energy technologies is done jointly by both.

When it comes to control of modern energy, literature by Clancy et al. (2011) shows that women are in charge of all forms of energy in the household including modern energy, even though they might not necessarily be responsible for the cost towards its acquisition or use as in case of electricity. Clancy et al. (2011), points out that women as managers of energy ensure that the household has access to energy by controlling its use as well as organizing its availability²⁸ in the home, even though they did not make the decision to purchase it or make the payments for its use. In addition to the women, the study by Mahat (2004) shows that men are also actively involved in managing the modern energy through repairs to the modern energy technologies, replacement of burnt bulbs as well as feeding and emptying biogas digesters, amongst others. This shows that both men and women are involved in the management of modern energy at household level.

²⁸ Includes also organising the purchase of lighting sources such as kerosene and candles in areas without electricity as well as cooking energy sources such as charcoal (even though the husband will be responsible for its payment).

In terms of use, studies by Matinga (2010) and Ding et al. (2014) show that acquisition of modern energy in the households is meant to ease the burden that women go through in the use of biomass (as well as reducing all other disadvantages they suffer arising from its use) as they fulfil their reproductive roles in their respective households. This means that women are the primary users of modern energy as soon as it has been acquired in their households as they fulfil their reproductive roles through the provision of heating, lighting as well as cooking food for their families. Studies by Kelkar and Nathan (2005) and Matinga (2010) also show men's involvement in the use of modern energy in their households. These studies put it clearly that men would cook food or do other domestic chores more often once a household acquires modern energy. This increase in the involvement of men is as a result of the ease of using the modern energy thereby reducing the gender gap in household chores.

From the preceding paragraphs on modern energy it can be said that acquisition of modern energy in rural households of developing countries is done by household head regardless of gender as well as jointly by both the household head and spouse in cases where they both manage household's finances. It has also been seen that men are actively participating in the use of modern energy in their households by helping with household chores more often. Finally, in terms of control, it has been seen that women take a leading role in its management as they are managers of all forms of energy in the household due to their reproductive roles. Men also assist in management as it is culturally believed that new technologies fall within their arena. Increased involvement of men in acquisition, control and use of modern energy shows that it is not gender sensitive as is the case with traditional biomass.

4.8 Approaches used

Literature shows that different scholars have used different approaches to study the subject under discussion in this paper. The three main approaches used so far have been Qualitative (Ahlborg & Hammar 2014; Sovacool & Drupady 2011), Quantitative (Zhao et al. 2013) and Mixed Methods approach (Blenkinsopp et al. 2013). All these researchers have had their own specific reasons for using these different methods. However, from the way these methods were used and results obtained, it is difficult to say which single method is better than the other. Choice depended on the researcher and nature of the study to undertake.

CHAPTER 5 - FINDINGS AND DISCUSSION

In this chapter I will present research findings and also discuss them. The aim of the study has been to find out the potential for using RE options in reducing vulnerability of rural livelihoods and also how efficient use of biomass can limit deforestation in Malawi and other disadvantages arising from its inefficient use. To this effect, an exploration of the Malawi energy policy 2003 has been made to look into how it addresses issues pertaining improving access to RE in the country, an analysis on socio-economic impacts of solar power usage in the study area has been done, and also a review on the pressure on biomass for domestic use in rural areas has been done and options for more efficient use of biomass and climate change mitigation explored. The data analysis and discussion has been done based on the themes that are relevant to the study according to the research objectives of this study.

5.1 Energy Policy in Malawi

This section presents the study findings on the exploration of the Malawi energy policy 2003 and how it addresses issues on improving access to RE in the country. A discussion on the same has been provided thereafter.

5.1.1 The Malawi National Energy Policy 2003

The Malawi National Energy Policy 2003²⁹ (*NEP 2003*) is the first ever integrated energy policy (IEP) for Malawi, designed to guide all developments in the country's energy sector. It incorporates all the five components that make up Malawi's energy supply system which are biomass, electricity, liquid fuels and gas, coal and other renewables (GOM 2003). As an IEP, its formulation took into consideration the integration of all five energy supply components in Malawi (which formed the basis for the formulation), the aspirations of the Malawi Vision 2020³⁰ as well as the Malawi Poverty Reduction Strategy Paper 2002³¹, and the existence of policies and acts from different sectors with differing objectives. In addition, bringing together all the country's five energy components in one policy was meant to bring harmony amongst

²⁹ The Malawi *NEP 2003* is the energy policy currently in use in the country.

³⁰ Malawi's Vision 2020 is based on a long-term multi-sectoral approach and provides the framework for national development goals and the policies and strategies to achieve them. It incorporates development issues from the Government, private sector and people of Malawi (GOM 1998).

³¹ The Malawi Poverty Reduction Strategy paper uses a multi-sectoral approach to achieve sustainable poverty reduction through empowerment of the poor (GOM 2002).

them by ensuring that policies and projects specified for one energy component or sub-sector are consistent with the goals, policies and projects for others (GOM 2003).

The long term goals for *NEP 2003* are to ensure that Malawi's energy sector (MES) is sufficiently robust and efficient to support government's socio-economic agenda of poverty reduction, sustainable economic development, and enhanced labor productivity; to catalyze the establishment of a more liberalized, private sector driven energy supply industry; and to transform the country's energy economy from one that is dependent on biomass to one with a high modern energy component in the energy mix (GOM 2003). It is hoped that the attainment of these goals will greatly change MES as well as the economy and the general living standards for the majority of the population. The *NEP 2003* is meant to be responsive to the development needs of the country (GOM 2003). Furthermore, the GOM put the question of poverty reduction at the center during the formulation of the *NEP 2003* where the provision of the modern, more efficient and cost-effective energy would enhance the promotion of opportunities through creation of jobs, provision of quality education, health and other social services, thereby transforming the socio-economic well-being of the people (GOM 2003). The policy goals are also in line with the Millennium Development Goals.

The major guiding principle of the *NEP 2003* is involvement of different stakeholders, (the private sector, public, government, as well as the international community) in the development of the country's energy sector (GOM 2003). Previously, Malawi's central government took a central role in energy issues but following implementation of the *NEP 2003* its role has been reduced from direct investment and control to policy formulation and governance (regulation) (GOM 2003). This has been done as a result of the liberal economic policies Malawi has been following since 1994 which reduces its control and involvement in other economic activities or investments, but rather should let the market decide. However, this change in central government's role was also done with a full recognition that markets do sometimes fail and do not always adequately respond to the State's social, economic, environmental and security concerns as such some form of State involvement is acceptable, but which needs to be properly defined, managed and channeled to avoid state-industry conflicts (GOM 2003). Furthermore, since the private sector is profit oriented and will only invest where the returns on investment (ROI) are guaranteed it will be difficult for it to provide electricity to the rural areas where the majority are poor as demand will be low hence negatively affecting the ROI and profits. This would explain the current level of GOMs involvement in the energy sector, more specifically

in REC where it is still able to invest even though the ROI is very low, as it is focusing on provision of social services and public infrastructure and not on making profits.

In order to ensure successful implementation of the policy's goals and objectives, the policy proposed to put in place a National Energy Implementation Plan (NEIP), Monitoring and Evaluation Framework (MEF) as well as a legal and institutional framework. The Legal Framework, includes, but not limited to: *Energy Regulation Act*; *New Electricity Act* to replace the Electricity Act 1998; *Rural Electrification Act*; *Downstream Liquid Fuels and Gas Supply Act*; *Renewable Energy Supply Act*; *Downstream Coal Supply Act* (GOM 2003). Under institutions, the key informant at the Department of Energy Affairs (DoEA) reported that the GOM established several institutions such as the Malawi Rural Electrification Programme (MAREP) Secretariat, Training and Testing Centre for Renewable Energy Technologies (TECRET), National Sustainable and Renewable Energy Programme (NSREP) Agency, as well as Malawi Energy Regulatory Authority (MERA) to look into various issues pertaining the implementation of the policy. The NEIP was meant to coordinate efforts from various energy sectors³² so as to ensure harmony in implementation of the policy, while the MEF was meant to check if the efforts being made in these sectors fall within the mandates of *NEP 2003* (GOM 2003). The responsibility of ensuring that the policy is implemented lies under the DoEA in the Ministry of Natural Resources, Energy and Environment. Among various other issues, the *NEP 2003* also addresses issues on increasing access to RE as well as efficient use of biomass, both of which form the basis of this study. How the policy addresses RE access issues will be presented in section 5.1.1.2 below.

5.1.1.1 The Malawi *NEP 2003* and Rural Electrification

The study found out that *NEP 2003* recognises the role rural electrification (REC) can play to meet its objectives of poverty eradication and rural transformation. GOM also sees REC as a way of increasing productivity in the rural areas (GOM 2003) thereby making the rural areas to be economically vibrant.

³² *NEP 2003* proposed that each energy sector should have its own National Energy Sector Implementation Plan (NESIP) which will show the current situation for each priority action, performance indicators, targets, implementing agency, human and financial resource requirements, and time-schedules in that particular sector (GOM 2003).

According to *NEP 2003*, the responsibility for REC falls under MAREP Secretariat, which is under the DoEA (GOM 2003). GOM, through MAREP secretariat is pursuing REC programmes using both grid and off-grid options. However, most of the REC carried out in the country so far has been through grid targeting areas of population concentration in the rural areas (such as the trading centres and rural growth centres), public institutions (such as police units, health facilities) and border posts (GOM 2003). According to the key informant at DoEA, REC programmes being carried out currently in the country using grid are done by government owned electricity company ESCOM.

Malawi's REC is based on a policy of minimising costs and tariffs by implementation of arrangements that are based on local participation and initiatives as well as that all REC plans are administered through MAREP Secretariat in the DoEA (GOM 2003). In order to successfully implement REC programmes, the *NEP 2003* put in place the Rural Electrification Fund (meant to be a dedicated and sustainable funding mechanism for REC where all funding would be channelled through) and the Rural Electrification Act (meant to be the legal basis for all REC programmes) (GOM 2003). Funds for REC programmes come from a number of sources. Key informant at DoEA stated that, *"Most notable sources of funds for REC are private sector; public sector through levies, such as petroleum levy and electricity levy where some of the money from them is used for REC, and donations from bilateral and multi-lateral partners; as well as Non-governmental organisations (NGO)"*.

Since REC has low ROI and provides very little incentive for private investors, the *NEP 2003* put in place a mechanism where GOM arranges some level of subsidy to different stakeholders and also adopts REC as a deliberate social policy in support of poverty reduction, rural transformation and productivity enhancement (GOM 2003). In this regard, GOM subsidises all plant and equipment for REC so as to offer the best prospect of developing local projects, minimising tariffs and promoting growth (GOM 2003). The subsidies are funded through the rural electrification fund and are meant to cover both grid and off-grid options. According to the key informant at DoEA, so far the largest user of this fund has been ESCOM as it embarks on the GOM initiated REC programmes using grid. The key informant further went on to say that, *"GOM embarks on REC as a way of providing the necessary public infrastructure and service to the rural poor, even though the exercise is costly on its part. This is being done as a social policy"*.

As one way of increasing capacity in power generation and also giving people a wider choice of service providers, *NEP 2003* put in place mechanisms that will see Independent Power Providers³³ (IPP) entering the energy market. These IPPs are allowed to develop their own generating capacity, including build, own, operate, and transfer (BOOTs), and to operate in the same way as private concerns in a competitive but regulated market (GOM 2003). *NEP 2003* allows these IPPs to embark on power generation using a variety of modes including but not limited to mini-hydro, micro-hydro, thermal, solar PVs as well as wind. According to the key informant at DoEA, most of these IPPs are to be location specific (decentralized) and mainly meant to provide power to the areas not touched by ESCOM including rural areas (thereby filling in the gap) and in some cases competing with ESCOM or each other for customers. Furthermore, it was envisaged that modes of delivery for IPPs involved in mini-hydro, micro-hydro, solar PVs and wind will be small and this will make them to be more location specific and hence ideal for REC as they can locate in remote areas and generate power for that area. Operations of all power providers, including IPPs, are regulated by MERA, the country's sole energy regulatory authority, which was established as a requirement in *NEP 2003*.

Apart from enhancing power generation capacity in the country, the coming in of IPPs on the energy market (enabled by liberalisation of the energy sector) was also intended to make the energy sector more efficient and vibrant. According to the *NEP 2003*, GOM aims to reform the electricity supply industry (ESI) through market restructuring³⁴ and promoting private sector participation (liberalisation) where the government sees competition and the private sector as key components in enhancing the efficiency and effectiveness in the energy sector (GOM 2003). *NEP 2003* thus recognises these roles liberalisation and competition play in service delivery as well as pricing and it envisaged that these would be good for REC as the rural poor will have access to cheap and efficient energy service. The key informant at the DoEA informed me that, “*On its part, in order to attract the IPPs into the rural areas, GOM offers subsidies and other incentives to the IPPs planning to invest and embark in the REC programmes*”. The

³³ The issue of IPPs was first introduced in the country through the *Electricity Act 1998* and refined in the *NEP 2003* since it had failed to register success in its original form under the Act (GOM 2003).

³⁴ As a way of liberalising the ESI, *the Electricity Act 1998*, quoted in *NEP 2003*, required all power providers (both public and independent) to have separate licensing for generation, transmission and distribution (GOM 2003).

combination of GOM subsidies and the competition is meant to guarantee low energy prices to the rural people and hence enabling more to access modern energy.

5.1.1.2 The Malawi *NEP 2003* and access to renewable energy

According to the *NEP 2003*, RE in Malawi covers energy from such sources as mini-hydro, micro-hydro, solar PVs, biogas as well as wind (GOM 2003). From this list, only biogas is currently not being used to produce electricity in Malawi. The electricity produced from the other RE sources is promoted as an off-grid option for REC³⁵ (GOM 2003). *NEP 2003* recognises that access to these (RE) sources and use of the same in the country is very low. This is despite of all the benefits that can be realised from use of RE, including REC. GOM then designed *NEP 2003* in a way to also address issues pertaining low access and usage of RE in the country (GOM 2003). Among some of the factors identified by GOM for the low access and usage of RE include lack of skilled technicians in the RE sector, presence of substandard equipment on the market, high initial costs as well as lack of awareness about the RETs (GOM 2003). GOM has therefore through *NEP 2003* come up with a number of ways to improve access to RE in the country.

As one way of improving access to RE, GOM liberalised the energy sector to enable a number of players enter the energy market in their different capacities and capabilities, thereby giving the customers a wider choice and improved service (GOM 2003). These players are GOM, IPPs and NGOs. According to the key informant at DoEA, the improvement of access to RE through liberalisation looked at coverage, reduction in prices as well as efficiency in the sector. In terms of coverage, it was believed that with more competing players on the market some will relocate in areas away from other competitors thereby reaching those who were not previously reached, thus wider coverage. It was also believed that competition would bring in efficiency in service delivery and reduced prices, as the providers fight for customers.

Since liberalisation of the energy sector was seen as one way of improving access to RE, GOM also noted that the involvement of a number of players on the energy market could bring in more problems if left unchecked. To this effect the government moved in again through *NEP*

³⁵ Even though RE is ideal for REC, ESCOM (currently doing REC) does not use it as it does not deal with issues concerning RE whether its promotion or generation (GOM 2003).

2003 to address such potential problem areas so as to harmonise operations of all involved in the sector, improve their efficiency and at the same time ensuring improved access to RE. In order to do this GOM embarked on institutional and capacity building. The key informant at DoEA stated that, *“one of the things that GOM did in order to improve access to RE was to engage in institutional and capacity building. This institutional and capacity building was also meant to have well-functioning institutions in the sector that will cater for all developments including ensuring that all those involved in the sector are operating according to what the GOM and the NEP 2003 stipulates as well as help in improving their efficiency”*. Following this a number of institutions were established. One of such institutions is NSREP³⁶ Agency. *NEP 2003* points out that GOM established NSREP Agency as a semi-autonomous body under DoEA and it was mandated to serve as a focal point for the implementation of Other Renewable Energy Sources Supply Industry (ORESSI) reform programme, particularly the market priming activities (GOM 2003). NSREP was funded by UNDP and as a national energy programme it aimed at increasing the sustainable use of, reliance on and access to the country’s RE resources (UNDP 2000). In this way, NSREP Agency provided guidance in the reforms being undertaken in the RE sector aiming at improving access to RE.

The second institution established by GOM through *NEP 2003* to improve access to RE is TECRET. The key informant at DoEA pointed out that, *“TECRET is a training and testing centre for RETs and it is operated by Mzuzu University-a public university. It aims at building capacity in RETs which will enhance efficiency in personnel as well as the quality of RETs in the country leading to an improvement in access”*. According to *NEP 2003*, TECRET is mandated to train and accredit RET technicians as well as to test and certify RETs in collaboration with the Malawi Bureau of Standards (MBS) and MERA (GOM 2003).

According to the informant at DoEA, it was necessary to establish TECRET and train RET technicians as some of the personnel involved in the RE sector, most especially Solar PVs, did not possess any skills and that resulted into poor installation, damage to customer’s equipment, lack of maintenance and loss of money on the part of the owner. The informant went on to say that the problem of unskilled technicians came about due to lack of training in the RE sector

³⁶ The National and Sustainable Renewable Energy Programme (NSREP) was prepared by DoEA in 1997 and launched in 1999, while the NSREP Agency was formed in 2003 following the launch of *NEP 2003* (GOM 2003; UNDP 2000)

and it became worse with the entrance of several energy players on the market. Training at TECRET was to ensure that personnel handling RETs is accredited, thereby guaranteeing quality service and satisfaction. The key informant at DoEA further informed me that, “*GOM decided to establish TECRET as a testing centre to control quality and standards of the RETs in collaboration with MBS as there was a proliferation of substandard RE products on the market, most especially Solar PVs, which failed to deliver as required. This proliferation of substandard RETs was because Malawi had no codes of practice and system standards for RETs*”. According to the informant, some of the traders were importing substandard materials to maximise profits as they are cheaper at source than the high quality ones. Failure by these substandard materials to deliver as expected resulted into customer dissatisfaction and also chasing away of potential customers. Establishment of TECRET was therefore meant to sort out these problems and help in improving access to RE.

Another way that GOM planned to improve access to RE is through public awareness campaigns or information dissemination programmes. *NEP 2003*, state that GOM shall engage in civic education on issues related to different energy sub-sectors including available technology as well as facilitate access to such information by various stakeholders and the public (GOM 2003). The information provided included how the technologies work, where to get them and benefits realised, amongst others. Apart from the civic education, *NEP 2003* also requires GOM to offer courses related to RE in the formal education (GOM 2003). It was envisaged that by engaging in these, the public will be able to acquire knowledge enough to make informed decisions on RE, and this knowledge would also enhance its marketability.

Since high initial cost was regarded as one of the factors affecting access to RE in the country, GOM through *NEP 2003* brought forward a number of ways this could be sorted out so that access to RE is improved. The GOM planned to establish a loan guarantee fund to be managed by a private fund manager; encourage commercial banks to provide loans for RET suppliers and end-users; and provide Fiscal Incentives in the form of exemption from import duty and import surtaxes for all RETs systems (GOM 2003). According to *NEP 2003*, these were also to enhance market priming of the technologies. The removal of duty and import surtaxes was to reduce the initial cost while the loans were to facilitate payments for those who could not afford paying in cash at once. Furthermore, GOM also planned on using liberalisation to reduce the costs as competition usually brings down prices. These would then ensure that more people can access the RETs, hence improving accessibility.

All in all, improving access to RE in the country involved GOM coming up with mechanisms through the *NEP 2003* to remove barriers in the RE sector. These barriers are classified as institutional, financial, technical, informational, normative and human capacity (UNDP 2000). GOM also came up with policy instruments that aimed at addressing specific issues in the RE sector as is also the case with all other energy sectors.

5.1.1.3 Policy instruments aimed at improving access to solar energy in Malawi

The *NEP 2003* does not outline specific policy instruments that deal with improving access to solar energy in the country that GOM planned to follow. It deals with issues concerning all RE sources, including solar energy, as one entity called Other Renewable Energy Sources (ORES). According to the key informant at DoEA, *NEP 2003* does not address solar energy separately but rather as one of the RETs and as such policy instruments covering improving access to ORES also cover solar energy since it falls within this grouping. However, not all policy instruments covering RETs or ORES are applicable to solar energy. The following paragraphs present the most relevant policy instruments to solar energy from the list of instruments aimed at improving access to ORES in the *NEP 2003*. These policy instruments have been put into three categories, for simplicity and relevance, according to KPMG (2012) and REN21 (2013a). The categories are: *Regulatory Policies and Targets, Fiscal Incentives and Public Financing.*

Under the category of *Regulatory Policies and Targets*, GOM through the *NEP 2003* has only one policy instrument it plans to use to improve access to RETs. This policy instrument is called *RE targets*. Under this policy instrument, GOM set RE targets it intended to achieve in the use of RETs in the country in a particular period. The table below illustrates the targets.

Table 4: Energy Mix Projections 2000 - 2050

	2000	2010	2020	2050
Biomass	93.0	75.0	50.0	30.0
Liquid Fuels	3.5	5.5	7.0	10.0
Electricity	2.3	10.0	30.0	40.0
Coal	1.0	4.0	6.0	6.0
Renewables	0.2	5.5	7.0	10.0
Nuclear	0.0	0.0	0.0	4.0
TOTAL	100%	100%	100%	100%

Source: GOM (2003)

From the table above, year 2000 represents actual figures or true picture on the ground in terms of energy usage when the planning was made while the rest of the years represents targets GOM planned to attain. These targets were to act as a guide for GOM in its quest to improve accessibility and usage of all RETs, including solar energy. The table shows that *NEP 2003* does not have specific targets for Solar PV installations in the country, but combines all RETs. But even though this is the case with *NEP 2003*, a study of project document for a RE program that was jointly run by UNDP, DANIDA and GOM called Barrier Removal to Malawi Renewable Energy³⁷ (BAREM) showed that project implementers had planned that Solar PV installations in the country be increased from about 5 000 systems in 1998 to at least 33 000 systems by 2015 (UNDP 2000). This in essence means that some targets for solar PVs were set by GOM though it did not show in *NEP 2003*.

Under the category of *Fiscal Incentives*, GOM has four policy instruments aimed at improving access to RETs, solar energy inclusive. These policy instruments deal with the high initial costs involved in purchase of solar equipment by reducing the cost and also lessening the acquisition process. The first policy instrument in this category involves provision of *tax exemptions*. Under *tax exemptions*, GOM offered to remove duties and taxes from all RETs. According to *NEP 2003*, GOM will remove all import duties and surtaxes as its contribution to reducing first costs (GOM 2003). GOM used to charge a 10% duty and a 20% tax on Solar PV modules, charge controllers and lights and a 62% duty on batteries (UNDP 2000). This resulted into high price consumers have to pay for the solar equipment and as a result not being affordable to most of the people in the country as they are poor. Removal of taxes and duties was meant to reduce the initial costs thereby making it more affordable and hence improving accessibility.

The second policy instrument under *Fiscal Incentives* is the provision of *subsidies*. Under this, GOM planned to provide *subsidies* on all ORES including solar equipment and solar related services and these subsidies are intended for both the end users and suppliers (GOM 2003). According to the key informant at DoEA, subsidies are meant to make the final product very affordable to the end user as a portion of the price is paid by the GOM and as for the suppliers, the subsidies are meant to help them meet other business-related expenses or to reduce their

³⁷ The program, run from 2000 to 2005, was intended to identify and remove all forms of barriers that exist in the solar PV sector so as to improve its accessibility and usage in Malawi's rural and peri-urban areas (UNDP 2000).

operation costs which would translate into offering low charges as GOM has paid part of it for the end user. However, according to key informant at DoEA, these subsidies are not applicable to everyone in the country but are meant only for GOM or DP selected low-income beneficiaries in the rural areas.

The third policy instrument under *Fiscal Incentives* is called *Investment Incentives*. This policy instrument involves provision of loan and loan guarantees by the government to RET suppliers. According to *NEP 2003*, GOM shall provide loan guarantee fund to be managed by a private fund manager as well as facilitate provision of commercial credit facilities by commercial banks for RET suppliers (GOM 2003). According to key informant at DoEA, the loans obtained will help suppliers offer a diverse range of products and also maintain a healthy stock inventory of solar equipment, thus being able to meet demands on the market, as well as opening up new business centers in an expansion drive to seek new markets. Opening up of new markets, to reach out to people in areas that had no access to these services, and product diversification will result in improving accessibility to solar energy.

Tax breaks is the fourth policy instrument GOM planned to pursue under *Fiscal Incentives*. In *tax breaks*, the government allow investors not to pay tax for an agreed number of years from the date of business establishment. The money that would have been used as tax is then ploughed back into the business to boost its operations. This is to enable the businesses get more established. According to *NEP 2003*, GOM planned to promote use of affordable alternative energy sources through tax breaks as one of fiscal incentives for RET industries (GOM 2003). However according to the key informant at DoEA, *tax breaks* are not applicable to every other company investing in RETs as is the case with *tax exemptions*.

Under the category of *Public Financing*, GOM has two policy instruments to guide it through improving access to RETs. The first policy instrument being pursued under this category is called *Public Investments (PI)*. *PI* refer to investments done by GOM with own funding or with DPs and sometimes DPs only. According to *NEP 2003*, GOM will continue the electrification of public institutions through its on-going MAREP using both grid and off-grid options (GOM 2003). The key informant at DoEA stated that, “*GOM’s continual solar electrification of public institutions and villages, after liberalisation, is a way of providing public services or investments to the rural communities and also a way of showing the public that electrification using solar PVs work and thus promoting the solar PVs*”.

The second policy instrument being pursued by GOM under *Public Financing* is called *Micro-Credit Financing*. In pursuant of this instrument, *NEP 2003* states that, GOM shall provide loan guarantee fund to be managed by a private fund manager as well as facilitate provision of commercial credit facilities by commercial banks for RET end-users (GOM 2003). According to the key informant at DoEA, this financing is coming in to assist the rural households be able to acquire the service while at the same time not disrupting their day-to-day lives or straining themselves financially since they are poor. This financing would then increase the accessibility of solar PVs in the country.

All in all, *NEP 2003* recognizes the benefits that energy industry reforms under liberalisation would bring to the country's REC programme. It also sees the role of IPPs and use of RETs as more appropriate in penetrating remote areas as these two would normally be location specific and decentralized. To tap on these benefits and successfully implement REC, GOM put in place a number of policy instruments and attractive incentives to lure IPPs into this programme. It also put up policy instruments to attract consumers to the use of solar energy. In both cases, GOM aimed at improving accessibility to solar energy and the target was the rural poor so that they should be able to access it with ease. This increase in accessibility would also help GOM achieve its goals of poverty reduction, rural transformation and increased rural productivity.

5.1.2 Implementation of the *NEP 2003* to improve access to solar energy

Implementation of *NEP 2003* is an on-going process. Since inception of the policy eleven years ago, its implementation has experienced both achievements and challenges in all the five energy components it is dealing with as an IEP. This section presents the successes or achievements attained so far and also challenges being faced in implementation of the policy to improve access to solar energy in the country. The presentation will be based primarily on policy instruments presented in section 5.1.1.3 and to a minor extent on other ways GOM intended to improve access to RE presented in section 5.1.1.2.

5.1.2.1 Achievements made in the implementation of the policy

A number of achievements have been registered so far in the implementation of *NEP 2003* to improve access to solar energy. The following are the achievements made so far.

Following *Regulatory Policies*, GOM set RE targets it intended to achieve in the policy. It also set targets for solar PV installations in the country under the BAREM project. However, figures achieved so far show that GOM has not done so well in pursuant of this policy instrument. For instance, according to key informant at DoEA, the country had registered a total of 11 000 stand-alone solar systems at the time of this study in 2013 (up from 5 000 in 1998), against the projected 33 000 systems by 2015.

Under the category of *Fiscal Incentives*, GOM has at the time of this study managed to register some achievements on two out of the four policy instruments it had planned to pursue. Firstly, GOM has managed to provide subsidies to selected low-income consumers to enable them acquire the SHS or solar electricity at a very low price as much as possible. One notable case, according to the key informant at DoEA, is the GOM's solar electrification of six villages across the country in 2007 at the rate of one village per district. The districts covered in this project were Nkhata Bay and Mzimba (Northern Region), Nkhotakota and Ntcheu (Central Region) and Chiradzulu and Thyolo (Southern Region). The project used a hybrid system which involved both solar and wind where electricity was being generated at a central point and the households were connected from this central point using a mini-grid. Each beneficiary was required to pay 10% of the installation cost and the remaining 90% subsidized by the GOM. Apart from GOM offering subsidies to the low-income end-users for acquisition of solar energy, international organizations have also offered subsidies for solar electrification following *NEP 2003*. Barefoot College of India which provided SHS to the area under study and other two districts in the country (at 100% subsidy) is a good example of such international organizations. At the time of this research it was not known if any company or supplier had received subsidies from GOM for the solar electrification.

Secondly, GOM has managed to provide *tax exemption* (as a fiscal incentive) to all suppliers and consumers of solar equipment, as well as all other RETs, by removing import duty fees on all RET equipment being imported into the country. Key informant at the DoEA stated that, "*GOM waived off import duty on all solar equipment as well as all other RETs coming into the country so as to reduce their costs. However, even though these are duty free, the importer still has to pay value added tax (VAT) currently at 16.5% of the purchase price*".

In the category of *Public Financing*, GOM has managed to make achievements in both of the two policy instruments it had planned to pursue in improving access to solar energy in the

country. Firstly, GOM managed to make available *Micro-Credit financing* for solar end-users to enable them acquire solar equipment and have it installed. The key informant at DoEA stated that, “*GOM entered into an agreement with Standard Bank Malawi Limited, a commercial bank, where people would obtain loans for acquiring solar equipment. The loan was guaranteed by the GOM and the beneficiary was required to use a registered RE company for supply and installation of the equipment*”. This loan, operated as a revolving fund³⁸, was particularly meant for people in the rural areas to enable them acquire SHS and it carried low interest rates. The low interest rate, according to the key informant at the DoEA, was done in consideration that the target group was low-income consumers. The informant further went on to say that this facility has enabled a lot of people, more especially the civil servants in the rural areas, to acquire solar PV systems for their households. Civil servants represent a larger proportion of the formal work force in the rural areas and usually get information more quickly than other people in the same area due to the strong communication links that exist between them and their district offices. However, actual figures on how many households benefited from this facility are difficult to obtain.

Secondly, GOM has managed to solar electrify some villages and also public institutions such as police stations, health centers, schools and agricultural stations in other rural areas as *Public Investments* to provide social services to the people. However, even though this solar electrification is a form of *public investments*, the electrified units also serve as Solar PV demonstration projects to enhance public awareness of solar PVs. In this way, these units serve a dual purpose. The key informant at DoEA stated that, “*GOM installed solar systems in public institutions such as health centers, schools, police stations and border posts as well as a number of villages across the country to provide power to such places and also to demonstrate to the public that solar PVs work*”. Apart from GOM, other international organizations such as UNESCO have also been involved in solar electrification of public institutions. According to UNDP (2000) these projects serve as demonstrations of practical applications of PV lighting in Malawi and addresses both demand and supply side issues in use and provision of PV systems through visible, tangible and affirming demonstration.

³⁸ Money for the revolving fund was sourced by Malawi Environment Endowment Trust (MEET) and the commercial bank was used to provide the service to the beneficiaries.

In addition to the achievements made with the policy instruments as described above, GOM has also made achievements in other activities it had put in the *NEP 2003* to help improve access to solar energy in the country but are not policy instruments. Firstly, GOM established TECRET at the Mzuzu University to operate as a training and testing center for RETs in the country. This was intended at building capacity as well as have appropriate standards for RETs. According to key informant at DoEA, TECRET works hand in hand with MBS in developing standards for RETs and is currently working mainly on Solar PVs and other solar equipment. The key informant further stated that, “*TECRET and MBS have so far developed standards for solar water heaters, solar refrigeration as well as solar panels*”. These standards are meant to guide importers of solar equipment as well as enforcing agencies to put to an end proliferation of low quality equipment which has a very short life span, among other problems. TECRET has also trained and accredited RET technicians in the country.

Secondly, GOM established NASREP Agency as one way of building institutional capacity. According to the key informant at DoEA, NASREP Agency has been providing much needed guidance and coordination in the RE industry and this has been vital in implementation of the RE segment of *NEP 2003*. Other institutions established include MERA (a body which regulates the whole energy sector) and MAREP Secretariat (responsible for REC).

All in all, the research shows that GOM has managed to attain some achievements in the implementation of the *NEP 2003* to improve access to solar energy. It has been seen that the government has removed barriers that existed in the creation of a market or accessibility and use of solar PVs in the country. According to the key informant at DoEA, GOM used BAREM project’s consultations to identify barriers and addressed them when writing the RE component of the *NEP 2003*. This has made it possible for GOM to make successes in the RE sector. According to the project document, BAREM emphasized on Solar PVs even though it was initially for all RETs because GOM had put solar PV as a priority RET (UNDP 2000). However, even though barriers have been removed and some achievements attained, this research found out that most of the rural people still do not have access to solar energy, indicating that there are some challenges being faced in the sector.

5.1.2.2 Challenges encountered in the implementation of the policy

In this section I will present the challenges that are being faced in the implementation of the policy to improve accessibility to solar energy in the country.

The first challenge concerns the credit facility that GOM provided through Standard Bank Malawi Limited to low-income consumers to enable them acquire solar equipment. According to key informant at the DoEA, this facility is no longer available as the fund failed to sustain itself due to the failure by some people to repay the loans they obtained. The informant went on to say that when GOM, through MEET, was making available money to the bank for this facility, it was agreed that the fund would be a revolving one and as such would be self-sustaining. However, failure by other people to repay their loans meant that money was taken out from the fund without being replaced hence its depletion and thereby denying others in need of the facility from being served. In addition, the research also found out that this failure to pay back the loans has also affected businesses negatively as sells have gone down. The key informant at the DoEA said that, *“the revolving fund helped the accredited businesses to sell more products as more people were being financed by it”*. Therefore, failure to repay the loans became a challenge to sustenance of the fund as well as improving access to solar energy.

The second challenge concerns the *tax exemption* facility that GOM put on solar equipment coming into the country. When GOM introduced this facility the importers were expected to extend the benefits of not paying duty to the consumers by charging reduced prices to reflect the tax exemption. This research has however found that this is not the case. The key informant at DoEA stated that, *“this tax exemption facility has not been very successful since most of the importers or retailers are not passing on the benefits to the consumers. The prices that the retailers are charging on the equipment does not reflect the tax exemption facility on them”*. This shows that the retailers are still charging high prices on solar equipment despite the tax exemption facility they are enjoying.

Another challenge being faced concerns GOM opening up importation of RE or solar equipment into the country to everyone, whether business entities (accredited or not) or individuals as end users. This has resulted into those not conversant with solar issues to be involved in importation of the equipment. This becomes a challenge as the quality and standards of the solar equipment, set by GOM through TECRET and MBS, is being compromised by these importers as they import anything they find on the market so long as the price is favorable

to them. The key informant at the DoEA stated that, “*individuals and other non-accredited businesses are importing poor quality, and even banned solar panels, into the country. They have no knowledge about required standards of equipment to be imported*”. Worse still, according to key informant at the DoEA, most of these sell their low quality solar equipment at prices similar to those with correct standards on the Malawi market, thus people paying more for poor quality products. In this way, allowing everyone to import solar equipment into the country without restrictions on standards erodes efforts GOM is putting to improve access to solar energy by using high quality equipment.

The fourth challenge concerns *public investments* where selected public institutions have been solar electrified by GOM as well as DPs. The key informant at the DoEA stated that, “*some solar systems have been abused and tampered with by staff in these institutions, after hand over, and as a result of this the life span of the equipment is compromised. Most of them stop working after just a very short period of time in service at the facility.*” This defeats the public awareness campaign about the practicality of solar PVs and also the provision of lighting to these facilities.

Another challenge concerns the lack of a specific RE strategy in the country. According to the key informant at the DoEA, Malawi does not have a stand-alone RE strategy which would have been very detailed and hence being able to tackle each RE sub-sector in depth. The informant noted that other developing countries such as Uganda and Mozambique have such strategies and that has helped them to make big advances in the RE sector, compared to Malawi. According to the key informant at the DoEA, Malawi is currently using an IEP and an IEP leaves out some details which would have been very helpful in implementing improvements in a particular energy component.

5.1.3 Discussion

This section is a discussion of the results presented above (sections 5.1.1 and 5.1.2) on the exploration of the *NEP 2003* and how it addresses issues pertaining improving access to RE (solar energy) in the country.

In terms of the nature of the *NEP 2003*, the study has revealed that it is an IEP and covers all the country’s energy supply components. Its formulation integrated the country’s five energy

supply components as well as ideas from Malawi Vision 2020, the Malawi Poverty Reduction Strategy Paper 2002 and other existing policies and acts from different sectors. This integration was meant to ensure that *NEP 2003* takes on board energy concerns from all sectors across the country as well as GOM's development agenda. This would then make *NEP 2003* more relevant and also be one of the instruments that will enhance development in the country. However, this integration has also made the policy fail to tackle each of the five energy components in detail thereby lacking in other important areas. The generalization has also resulted into an error where other energy sectors have not being given enough attention in the policy while others have been given a lot of attention.

The study has also revealed that the long term goals for *NEP 2003* is to make the country's energy sector efficient and vibrant and be able to support GOM's effort in developing the country. GOM recognised the role efficient energy can play in poverty reduction as a result it put focus on poverty reduction when formulating this energy policy. To this extent the policy is to ensure that the country transforms from total dependence on biomass fuels to higher usage of modern energy. Modern energy can be used in a variety of applications and it was envisaged that by migrating to modern energy, this form of energy will enhance the socio-economic status of the people through job creation and opportunities to embark on IGAs as well as improved education, health and other social services. This means that *NEP 2003* is meant to ensure the country transforms and develops its energy sector so as to improve people's living standards.

In order to make the energy sector more vibrant and efficient so as to be able to achieve GOM's goals, the study shows that *NEP 2003* allows for the involvement of different stakeholders in the sector as well as its liberalisation. It also requires GOM to reduce its involvement in the energy sector from direct investment and control to policy formulation and regulation. This means that the sector's direct investments are left to other stakeholders. However, the study also shows that GOM still retains some form of direct investments in areas where the private sector would not go due to low ROI such as rural areas (REC). GOM is doing this to make it possible for modern energy to be provided even to low-income consumers in rural areas thereby meeting its goals of poverty eradication. The study also shows that liberalisation of the sector has resulted into a number of energy players entering the country's energy market. However, this has resulted into a number of problems one of which is proliferation of sub-standard equipment and unskilled technicians on the market.

The study has revealed that *NEP 2003*, being a poverty reduction oriented energy policy, recognises the importance of REC and the role it can play in ensuring that the policy is successful in meeting its goals in the rural areas. The majority of Malawi's poor live in rural areas and as such in order to make meaningful strides in poverty eradication and rural transformation energy services for these people need to be changed. This means that *NEP 2003* looks at REC and uses it as a way of reaching out to the majority of the country's poor with modern energy and at the same time transforming their social and economic lives and also making the rural areas economically vibrant by increasing productivity.

In order to attract private investors into REC, where ROI is low, the study shows that GOM arranged to provide subsidies to them on all their plant and equipment that they will use in REC. Funding for the subsidies and all other GOM initiated REC programmes comes from the Rural Electrification Fund, which is operated by GOM. The study shows that all REC programs in the country are the responsibility of MAREP secretariat, one of the institutions set up to help in implementation of the policy. However, the study did not find investors who have benefited from these REC subsidies, it only found villages.

In terms of access to RE in the country, the study has revealed that GOM recognised that there is low access to it and as such the section of *NEP 2003* that deals with ORES addresses issues on how access to RE can be improved, including solar energy. However solar energy, which is the most common form of RE in the country, is one of such energy sub-sectors which have not been given enough attention in this energy policy. This is also despite the policy recognising the importance of solar energy in REC and the benefits that will be attained from it which includes rural transformation and poverty eradication.

In order to improve access to solar energy, the study has revealed that GOM came up with a number of ways through the *NEP 2003*. These include liberalisation of the energy sector, institutional and capacity building, public awareness and a variety of policy instruments that were meant to address specific issues in the sector. Some of these policy instruments have produced good results while others have so far performed miserably, thereby requiring a review of such instruments.

The study has also revealed that implementation of the policy to improve access to solar energy has registered successes in other areas and also experienced challenges in others. In one of the

achievements, the study shows that the country had at the time of this study increased the number of stand-alone solar systems by 6 000 (up from 5 000 in 1998 to 11 000 in 2013). Even though these specific figures do not appear in *NEP 2003* they still fall under set targets since they were done to improve access to solar energy in the country and solar energy falls under RE which has set targets in the policy. However, this is far below the set target by BAREM project of at least 33 000 solar PV systems installations by 2015. Looking at the rate of solar PV installations done so far, it is very unlikely that the remaining 22 000 solar systems from BAREM's projection can be installed in the next few months so that by 2015 the target of 33 000 is achieved.

Other successes made include provision of *subsidies* to selected low-income consumers and also *tax exemptions* on solar equipment to all suppliers and consumers of such. Provision of subsidies (full or part) has assisted selected households in the rural areas to have solar electricity. This shows that subsidies have contributed towards improving access to solar energy in the country. Removal of import duty fees or tax exemptions on solar equipment is meant to reduce the price end-users pay for it, thereby improving its accessibility as more people will be able to afford it. The study however shows that this has not been mostly the case as suppliers continue to charge higher prices despite the tax exemption facility they use.

GOM has also managed to provide loans and loan guarantees to low-income consumers in the rural areas to enable them to purchase the solar equipment. The study shows that more people have benefited in the rural areas from this facility. However, most of the beneficiaries have been the civil servants because of their ability to access information easily from the GOM through their respective district offices.

The study also shows that GOM has solar electrified some villages and public institutions across the country as a way of providing power to such points and also as a way of promoting public awareness. These have helped in demonstrating to the rural people that solar energy exists and works thereby making them to think of having their own. Once people have seen the practicality of these PV systems and the benefits users are getting from them, they get motivated to have one in their household. This motivation then increases demand, which is good for the suppliers. So public awareness through solar PV demonstrations in the solar electrified public institutions and villages is benefiting both the consumer and the supplier.

The last achievement made so far is that the country has now a training and testing centre for RE (TECRET) which is at the Mzuzu University. The study has revealed that GOM established TECRET, which has worked closely with MBS, to establish standards for solar equipment brought into the country, among other functions. This was done to make sure that all equipment brought into the country is of better quality and that it will be able to deliver as expected. The study however shows that despite having these standards there is still a proliferation of low quality solar equipment on the energy market in Malawi. This shows that the two institutions, MBS and TECRET, do not have enough capacity to check and enforce compliance on the standards of imported equipment or it could also mean that people are not aware of these standards hence importing ignorantly.

In terms of challenges faced, the study shows that repayment of loans obtained has been a problem and this has affected negatively the sustainability of such loan schemes. This is in reference to the now defunct scheme which was being operated by Standard Bank Malawi Limited on behalf of GOM. Other people who were in need of this facility have not been assisted since it is no longer in operation due to that it run out of money and became defunct. In addition to this challenge, the study also shows that the benefits from tax exemptions that solar equipment dealers or traders enjoy are not passed on to the end users and as such the prices remain high. This makes it difficult for most of the low-income consumers to acquire the solar equipment. It also defeats the purpose of GOM in removing the taxes. It would then be concluded that the retailers are simply reaping off both GOM and the consumers by not reducing the prices to reflect the duty fees they did not pay on them. As a result of this behavior, these unscrupulous traders are compromising government's efforts to improve accessibility to solar energy in the country as prices of solar equipment remain high.

The study also shows that opening up of the importation of solar equipment into the country to anyone has exacerbated the problem of proliferation of low-quality solar equipment into the country. This is because most of these people have no knowledge about the required standards for solar equipment in the country. Some of the importers also do it deliberately since this low-quality equipment is cheap at the source but when brought into the country it is sold at a price similar to those with the required standards, as the study has also revealed, thereby making more profit. This low-quality equipment performs poorly and as such putting off both current and potential customers.

Another challenge being faced concerns *public investments*. The study shows that once the solar equipment is handed over to the local management of the institution it is poorly handled and eventually gets damaged. This defeats both the purpose of public awareness and provision of social service. It becomes a challenge in improving access to solar energy as a lot of people visit the facilities and know that the solar electricity was not used for a long time at the facility. It would be difficult to convince them to have solar systems in their households as their picture of solar electricity is that of something with a very short lifespan, based on what they have witnessed at the facility.

The last challenge identified in the study is the nature of *NEP 2003* itself. The study shows that being an IEP it does not address other issues in detail as such leaving gaps. Furthermore, the country does not have a specific RE strategy which would have supplemented the policy in such areas it is failing to address. A sectoral strategy addresses issues for that particular sector in detail. This however does not mean that an IEP is not important but rather it should also be accompanied by specific sectoral strategies to ensure that no issue is left out.

In reference to the SLF, the *NEP 2003* is in the transforming structures and processes part of the model. The policy formulation involved different types of institutions and organizations which included those from the public and private sector as well as the civil society. It also involved making references to other policies and acts or legislations in the country. This was done because all of these affect livelihoods and determine how we live and as such it was done to ensure that the policy to be formulated will impact on the people positively. The implementation of *NEP 2003* also involves the same and this has resulted into the policy being able to register some successes as well as transforming the Malawi's energy sector for the better. By transforming the country's energy sector, it shows that the policy is determining the people's livelihoods and its outcomes.

All in all, formulation of *NEP 2003* was to transform Malawi's energy sector where provision of efficient and cost effective energy was seen as a way towards developing the country as well as eradicating poverty. The policy recognises that REC is the answer to transforming lives of the majority of the people in the country, since the majority live in the rural areas. And to successfully do that the policy also recognises the role that stand-alone RETs, most especially solar energy, can play in REC. Implementation of the policy to improve access to solar energy in the country has registered both successes and challenges. It has been seen from the

discussions that these challenges are an impediment to the promotion of solar energy. It is therefore feared that if these challenges are left unaddressed they might erode the gains that have been attained in improving access to solar energy in the country.

5.2 Solar energy impacts

The study embarked on finding out the impacts of using solar energy in the study area with emphasis being placed on the socio-economic impacts. However, during the studying of these socio-economic impacts, other notable impacts (indirect impacts) were also identified. These will be looked at in the discussion section of the solar energy impacts.

5.2.1 Socio-economic impacts of solar energy

This section presents the study's findings on the socio-economic impacts of solar energy in the study area. These results are similar to those that Gustavsson and Ellegard (2004) and Jacobson (2007) found in their respective studies on solar energy, as presented in literature review of this study (chapter 4). For ease of presentation, I have put these socio-economic impacts into five categories namely: Income, Health, Education, Environment and Social.

5.2.1.1 Income

This research has found that SHS in the study area are providing economic benefits to the households using them as well as the SEs. The following are the main ways how these economic benefits are being attained by these two groups.

Firstly, when the participants were asked if access to solar electricity creates an IGA, 91% of them indicated that it does while the remaining 9% said it did not. The 91% who responded positively to the question went on to mention various IGAs they are doing because of access to solar electricity. For clarity, I have put the various ways they mentioned into two categories: IGAs initiated by solar electricity and IGAs enhanced by solar electricity.

IGAs initiated by solar electricity refers to those IGAs which were started in the study area as a result of the existence of solar electricity. This research has found that electricity from SHS has enabled other SHS owners to venture into IGAs, most common of which is mobile phone charging with 91% of the respondents involved in it. The figure below illustrates the various IGAs participants have ventured into, which have been initiated by SHS.

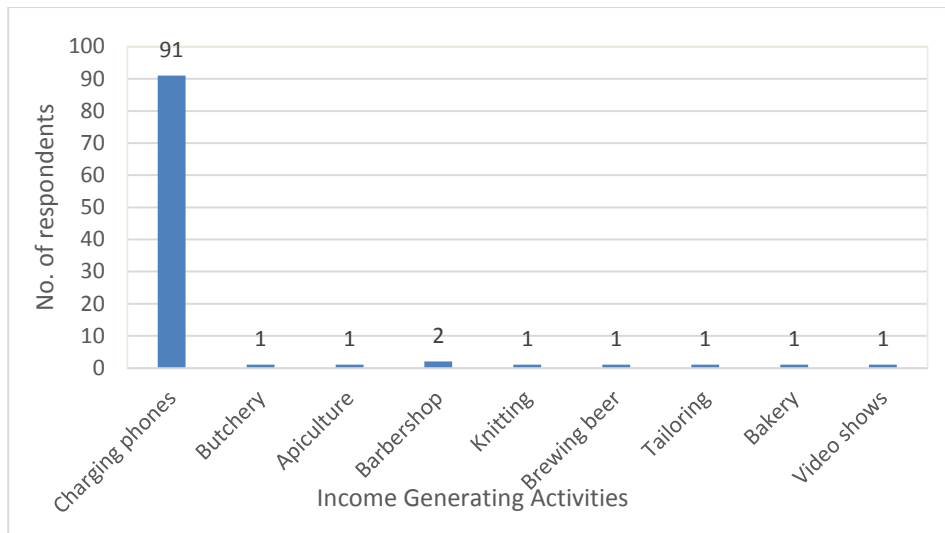


Figure 12: Various IGAs initiated by SHS in the study area

The figure above shows that mobile phone charging is dominating as an IGA. When asked how much people pay to have their phones charged, participants gave me three answers: MK30.00, MK40.00 and MK50.00 per mobile phone respectively. The following figure illustrates number of participants charging a particular fee.

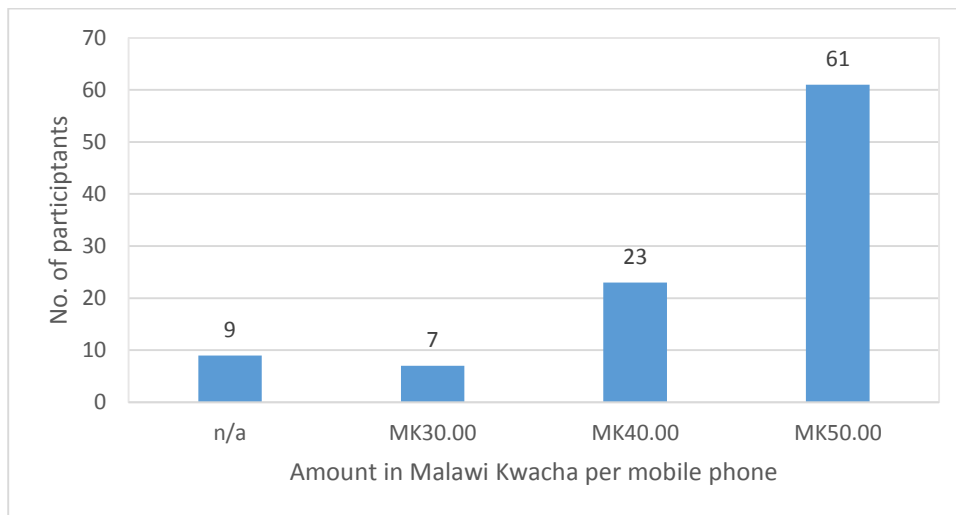


Figure 13: Number of participants charging a particular fee

In terms of number of mobile phones charged per day per participant, the numbers given varied widely. The following figure shows number of mobile phones charged per day per participant in the study area.

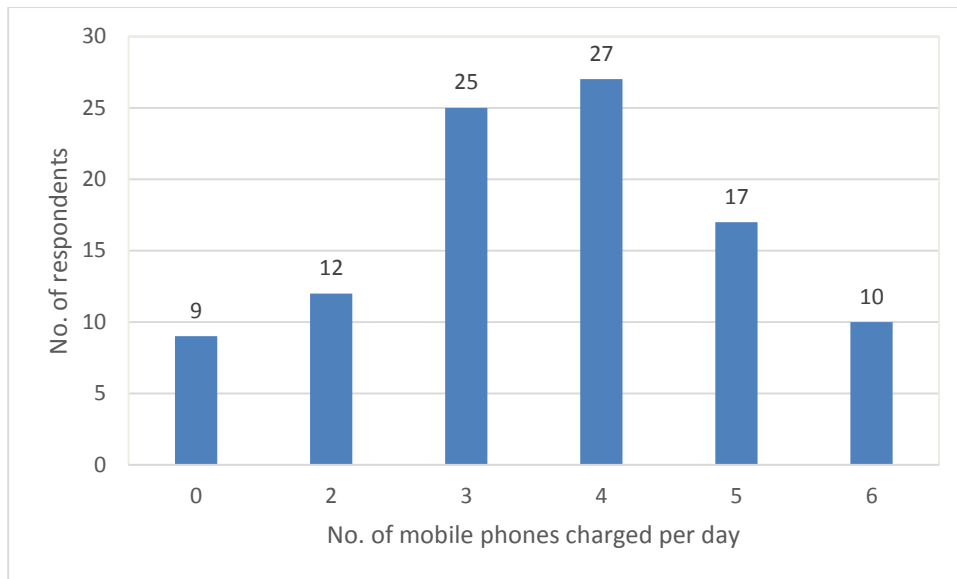


Figure 14: Number of mobile phones charged per day by a participant

From the figure above, minimum number of mobile phones charged is 0 (representing participants who do not use their SHS to charge mobile phones) and the maximum is 6 with a mean of 3.52 mobile phones.

The following figure (figure 15) illustrates the amount of money earned per day by each participant using SHS to charge mobile phones. This has been reached at by multiplying the number of mobile phones charged per day by the charging fee per mobile.

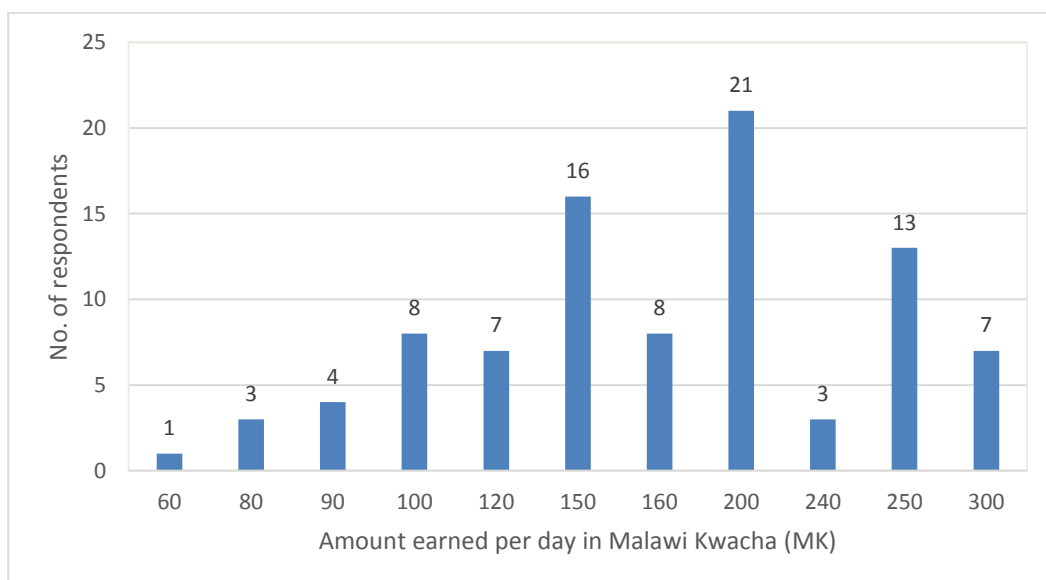


Figure 15: Money earned by a participant per day from mobile phone charging

From the figure, minimum amount earned per day is MK60.00, maximum is MK300.00 and the mean amount is MK159.00.

In order to determine the level of significance of earnings from mobile phone charging to the household's total monthly income, percentage of mobile phone charging earnings in the total monthly income and also percentage of other sources of income in the monthly total income were calculated. This was also used to compare the contributions from both (earnings from mobile phone charging and other sources of income) in the household's total monthly income. The following table details the statistics obtained from the two variables.

Table 5: Percentage contributions of mobile phone charging and other sources of income to household's monthly income

		% solar income to monthly income	% other income to monthly income
N	Valid	100	100
	Missing	0	0
Mean		23.83	76.17
Median		23.08	76.92
Std. Deviation		13.28	13.28
Minimum		.00	47.06
Maximum		52.94	100.00

(Source: Own Field Work, 2013)

From the table above it shows that percentage contribution of mobile phone charging earnings to household's total monthly income ranges from 0.00 (minimum) to 52.94 (maximum) while that of other sources of income ranges from 47.06 (minimum) to 100.00 (maximum). 0.00% contribution of mobile phone charging earnings to household's total monthly income as well as 100.00% contribution of other sources of income to household's total monthly income represents those who do not use SHS to earn money from it through mobile phone charging. Thus those who do not earn money from mobile phone charging (0.00% contribution to monthly income) have a 100.00% dependence on the other sources of income on their household's total monthly income.

The following figure (figure 16) illustrates the distribution of participants in various percentage categories of mobile phone charging monthly earning contributions towards household's total monthly income.

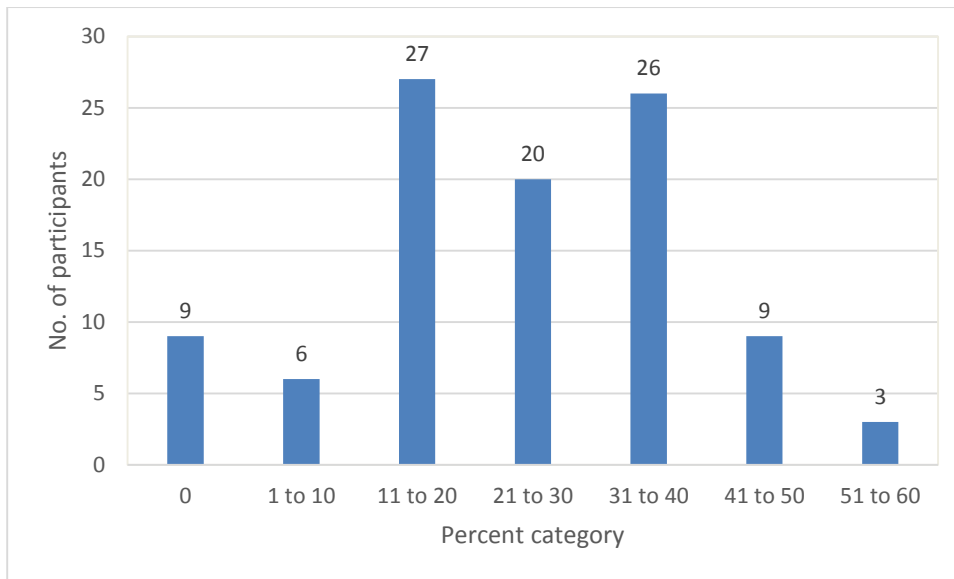


Figure 16: Percentage contribution of mobile phone charging to household's total monthly income

Figure above shows that 58% of the participants get more than 20% of their total monthly income from mobile phone charging.

This research also found out that while other households have been using all the money earned from mobile phone charging to meet essentials in their homes, others have been saving part of it and used it as capital to embark on other IGAs. 5% of the participants explained that they were able to start other IGAs using earnings from mobile phone charging that they were saving. These IGAs include butchery, barbershops and tailoring shop.

IGAs enhanced by solar electricity refer to already established businesses in the study area whose operations have been boosted by the coming in of solar electricity. When the participants who operate businesses in the study area were asked how solar electricity has impacted their businesses, they informed me that it has extended hours of business into the night. One of the participants, a tea room operator in the area for eight years now, had this to say, *"I am able to operate my tea room way into the night while other tea rooms have closed for the day because I have adequate illumination from SHS. This lighting also attracts customers as they would want to take their tea in proper and smell-free lighting. Now I am able to make more money in the tea room than before I acquired the SHS"*. 7% of the participants were already operating businesses in the area before SHS arrived. The following figure (figure 17) presents various IGAs enhanced by solar electricity in the study area.

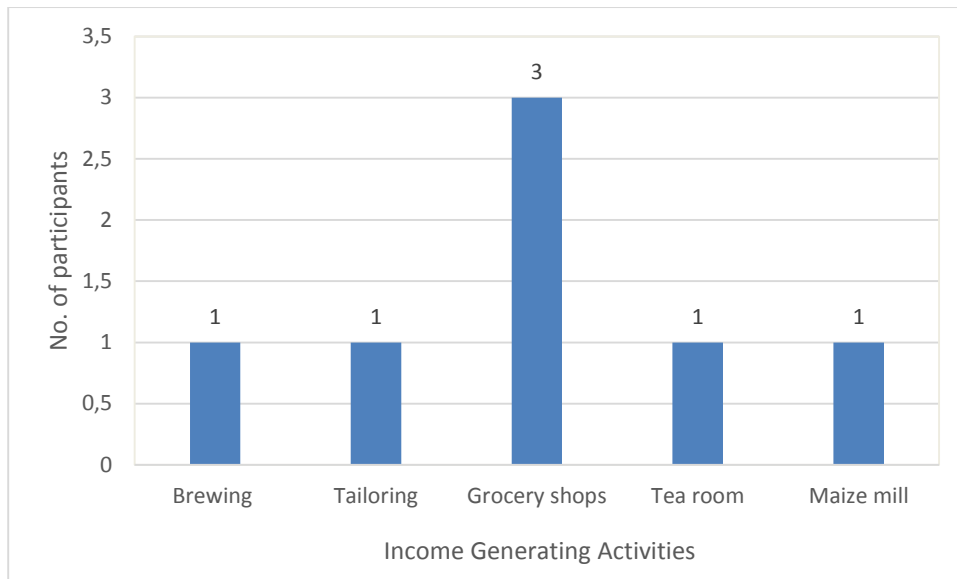


Figure 17: Various IGAs enhanced by SHS in the study area

It should be pointed out that all the other IGAs indicated in figure 12 (except mobile phone charging) as well as figure 17 are not run on their own, but done together with mobile phone charging. This means that while other participants have only mobile phone charging as an IGA others will have it and any one of the other IGAs presented in figures 12 and 17.

The second economic benefit realized from the use of SHS, identified in this research, comes from the savings made since kerosene and other inefficient and expensive lighting systems are no longer being used. All the participants (100%) informed me that ever since they started using SHS they stopped purchasing kerosene, candles and other lighting devices as it was no longer necessary to have them since SHS provides adequate lighting. Furthermore, the other sources of lighting proved to be very expensive to obtain. The following table presents the amount of money being spent on SHS, kerosene, candles and torch batteries per month in the study area as of the date of the study.

Table 6: Money spent per month on various lighting sources in the study area

Lighting source	Size of family	Quantity	Amount/month (MK)
SHS	Any	1 unit	200.00
Kerosene	• 5 members	1.5 liters	1 500.00
	• 8 members	2.0 liters	2 000.00
Candles	• 5 members	12 candles	1 200.00
	• 8 members	16 candles	1 600.00
Torch batteries	• 5 members	2 two-battery torches	1 600.00
	• 8 members	3 two-battery torches	2 000.00

(Source: Own Field Work, 2013)

The third economic benefit from the use of SHS identified in the study area deals with the SEs. According to the SEs, the SHS installation work they did in the two villages as well as the maintenance works they are currently doing on them entitles them to a monthly allowance of MK3000.00³⁹ each for their time. This money is paid by the VSC and is obtained from the monthly contributions of all SHS recipients. The SEs further said that in addition to the regular work done in the two villages, they are also able to do private jobs⁴⁰ at Salima boma and the surrounding districts and towns, as well as cities where they earn more money (than their regular job). The following table (table 7) illustrates the rates charged by the SE when they do private jobs. They charge per bulb fixed.

³⁹ In 2009 this was equivalent to \$21.13 (at the rate of \$1.00 to MK142.00) while at the time of study this was equivalent to \$7.32 (at the rate of \$1.00 to MK410.00).

⁴⁰ The money earned here is paid direct to the SEs and not through VSC.

Table 7: Current rates charged by SE on private jobs

	Rates in MK	
	Rural	Urban
New installation	1000.00 per bulb	<ul style="list-style-type: none"> • 10 000.00 for 1 to 2 bulbs • 15 000.00 for 3 bulbs • 20 000.00 for 4 bulbs • 30 000.00 for >4 bulbs
Re-installation	1000.00 per bulb	<ul style="list-style-type: none"> • 7 000.00 per bulb (wiring done in tubes inside the wall) • 3 500.00 per bulb (wiring done on the wall)

(Source: Own Field Work, 2013)

One SE explained that she had done new installations for up to 20 bulbs in several villages of the surrounding districts in the 12 months period preceding this study earning MK20, 000.00 and also 9 bulbs in urban areas in the same period earning MK45 000.00. This translates to a monthly average of MK5 417.00, which is 180% higher than their monthly allowance. The SE further went on to say that in a good year she makes more than this.

5.2.1.2 Health

This research also found that there are a number of health benefits that the households using SHS in the study area are having.

The first health benefit deals with respiratory infections. When the participants were asked to mention any benefits they have realized in their households from use of SHS, 44% mentioned a reduction in respiratory illnesses in their homes due to absence of smoke in their houses. When asked to mention any changes participants (spouses) have noticed in their respective household heads since they started using SHS, 24% mentioned improved health as smoke inhalation in the house no longer exists. Again, when participants (household heads) were asked to mention any changes they noticed in their spouses since they started using SHS, 31% mentioned improved health due to absence of smoke in the house. As for changes noticed in their children arising from use of SHS, 24% of the participants mentioned improved health due to absence of smoke in the house.

The second health benefit is derived from the dissemination of messages through radio, TV, and mobile phones that help to prevent both communicable and non-communicable diseases. Participants in the study area reported that they are able to get vital health information from the radios and TVs through regular health programming as well as announcements or breaking news items whenever there is an outbreak or an impending one. Sometimes these disease outbreak announcements are even sent through mobile phones. The messages are meant to alert them of the coming danger as well to teach them how to prevent themselves from being infected. They said this is possible because of the use of solar electricity to power these gadgets. The participants informed me that this has been of help to the community as they have been able to avoid contracting some diseases.

Thirdly, all participants (100%) informed me that adequate illumination in their houses from the SHS is also a health benefit to them since disease causing insects such as mosquitoes and other small animals such as rats, cockroaches, scorpions and several others tend to disappear from such houses as illumination reduces their hiding chances and rate of survival. An informant told me that they used to have a lot of rats in their home but following acquisition of SHS which provides good illumination in the house the rats have disappeared. He however noted that they still get one or two rats but these are not resident in the house but suspect they come from either the kitchen outside or cereal granary where there is no lighting. Another informant said that, *“Illumination in our homes also chases away mosquitoes which cause malaria. And in addition to this we are also able to kill mosquitoes in our home by hand since we can see them flying around as we have adequate illumination from solar electricity. Mosquitoes love darkness and whenever we have lights on they hide and thus reducing their mobility and also their bites on us”*.

5.2.1.3 Education

This research also found out that people in the study area are benefiting from the use of SHS in terms of education. The first way this benefit is being attained is through the use of lighting from SHS to study and do school assignments at night. Participants informed me that their children are able to study adequately at night as they are using the lighting from SHS and this helps them to know more and achieve success in their academic work. When the participants were asked if they noticed any changes in their children ever since they started using SHS, 74% mentioned improved grades and performance in school and they attributed this to the use of SHS which enables them to study at night adequately.

In addition to children from households owning SHS being able to study at night, this research also found that neighboring children to these households are also allowed access to it for study. One of the SEs informed me that households that have SHS allow their neighbor's children to come at night and study together with their children. This was also concurred by the participants. One participant had this to say, *“Our children are now getting good grades in school as they have adequate lighting to study and do other school work. Before we acquired SHS it was difficult for them to study due to inadequate illumination and at the same time kerosene and candles which were more practical⁴¹ to use for studying were expensive and usually used sparingly so that the quantity available should give us more days”*. Households without SHS use the lighting sources shown in figure 18⁴² below hence their children having difficulties to study at night.



Figure 18: Some lighting devices before acquiring SHS and still used in households without SHS

⁴¹ This is comparing the two to firewood and grass torch which are very difficult to use as sources of lighting.

⁴² These are also some of the lighting sources that were being used by households currently using SHS before they acquired the SHS.

In the picture: top right is grass torch, bottom right is kerosene lamp without glass top and very common in most households (sometimes it is made from used cocoa, coffee or milk tins), bottom left is kerosene with glass top, and top left is the candle.

Head teachers of the primary schools in the study area informed me that they noted that there was an improvement in school performance of their pupils for the past four years, with most of them passing the various school tests and also actively participating in class. They said this improved school performance is also reflected at both the zonal and national examinations where their pupils are performing better now. The head teachers further went on to say that the number of pupils being selected to secondary schools has also improved in the area. They attributed this improved performance to the use of SHS which provides adequate lighting for study and do additional school work at home at night. The figure below illustrates the numbers of pupils selected to secondary schools from two primary schools in the study area.

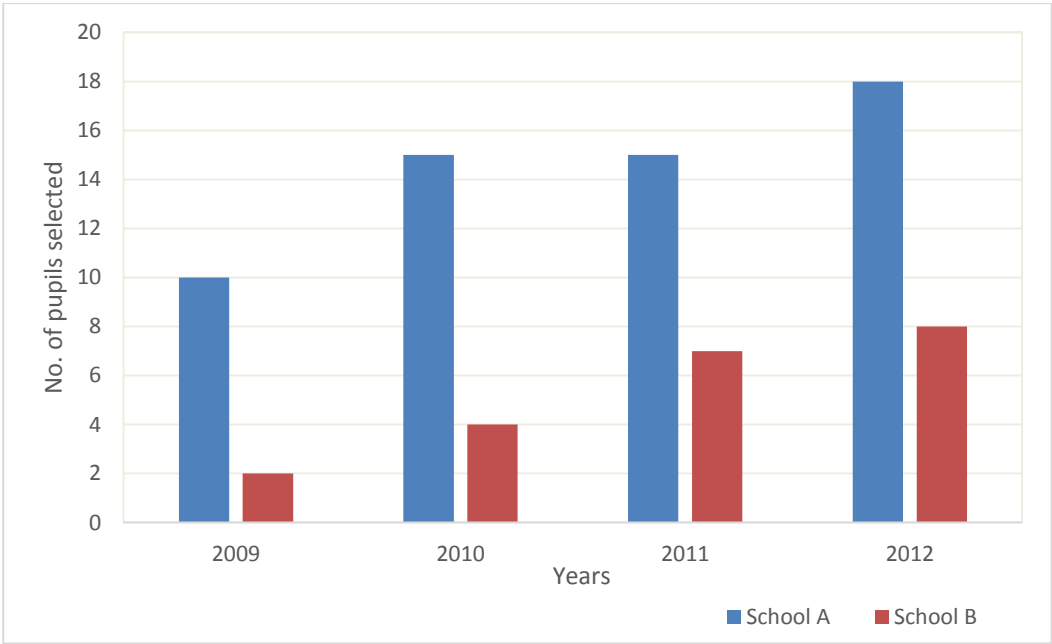


Figure 19: Secondary school selection performance from two primary schools

The head teachers also informed me that the teacher-pupil relationship in their schools has improved in the recent years. One head teacher had this to say, *“There has been improvement in the number of pupils bringing to school completed home works as they have access to solar lighting either directly in their homes or from neighbors and this has improved the schools’ teacher-pupil relationship. Completion of school work is seen as one of the attributes of a disciplined pupil and this results into a good working relationship with their teachers”*.

Another education benefit from SHS in the study area is by using the solar electricity generated from it to power radios, TVs and mobile phones from which they are able to access vital information. Participants informed me that they are able to listen to educative programs on the radios, mobile phones (since most of the participants have mobile phones with in-built radios) or watch them on TVs and some of these programs are tailor-made for rural people and address specific issues pertaining to rural people's welfare. As for TV programmes, the participants informed me that they visit video show rooms in the two villages to watch.

5.2.1.4 Environment

This research has also found out that use of SHS in the study area is good for the environment. When the participants were asked to mention any benefits they have realized from the use of SHS in their households, 59% mentioned clean lighting due to the absence of smoke from it. To this effect it shows that the use of solar power for lighting has resulted into reduced emissions in the study area as solar electricity does not produce emissions.

5.2.1.5 Social

This research also found out that use of solar power in the study area is bringing in social benefits to the participants. The following are the main ones.

The first social benefit is that people are able to work at home way into the night as they have good illumination from solar electricity. When participants (spouses) were asked to mention any changes they noticed in their respective household heads ever since they started using SHS, 21% mentioned ability to work at night without problems as one of the changes. When the same question was directed to household heads, 25% mentioned the same. They attributed this ability to the adequate illumination from SHS. According to the participants, this enables them to be more productive by finishing more tasks. One informant said that, *"when we are working in the day we always have peace of mind knowing that we can even work at night if need arises or if we are not able to finish our jobs since we have solar lighting"*. Women participants said that they are able to wash cooking utensils and plates used during evening meal in the same night due to the solar lighting and this helps to keep their houses clean.

However, this extension of working time may seem as a reduction of resting time for these people but according to them this is not the case as it has given them more freedom to do their activities and complete them as well as have peace of mind. One informant had this to say, *"Extension of working hours gives us peace of mind when we are resting knowing that we have*

completed the tasks. How can we rest comfortably when we have pending tasks to be accomplished? You always think of the work that you have failed to finish that day and be more stressed". This shows that even though working more means a reduction in resting hours, for most of these people they would rather complete their tasks and rest comfortably with peace of mind, which is very vital to them, and the SHS is enabling them to do this.

Secondly, the participants informed me that people in the study area are able to gather around at night watching TV or listening to the radio while they chat. According to them, these gatherings provide much needed entertainment to relax after a hard day's work and this is possible since there is solar electricity which provides power for the radios or TV as well as illumination. An informant had this to say, *"Neighbors usually gather at a household that has a radio and listen to it at night or sometimes we visit the video show room in the village. Both these are powered by solar. This provides a good platform for socialization after a day's work and also a means of relaxation"*.

Thirdly, participants informed me that they are also able to access vital information through radios, TV and the mobile phones they are using. One of the shop owners in the area had this to say: *"The advertisements carried on radios and TV help me and other fellow business people in this area to know which traders to deal with when we go to Salima boma to buy goods for restocking in our shops. We are also able to know generally what is happening in the country"*. Participants also said that they let each other know about emergencies, meetings, opportunities and other events in their villages through mobile phone calls. This to them has transformed the way they used to access information before they acquired SHS.

The fourth social benefit is that households using SHS do not experience any fire accidents arising from lighting sources. Participants informed me that ever since they started using solar electricity they have never experienced any fire accident in their houses caused by lighting sources. One participant said, *"My bathroom was burnt down one night as I had gone to bath with a candle as a source of lighting. When wind blew the candle fall down and the grass I had used to construct the bathroom caught fire and that was it"*. Another participant recalled how beddings in his children's bedroom caught fire as the tin kerosene lamp had burst (since it got too hot) and kerosene fell on the beddings catching fire from the lamp's wick which was still burning. With the use of solar electricity, participants are saying such cases are now history since solar electricity does not have any naked flames.

Another social benefit that the participants in the area are having from use of SHS is that the solar lighting provides security and ensures safety to household members. Participants informed me that use of SHS provides much needed security at night as the lighting deters dangerous animals from getting close and attack them. Another participant explained that they feel safe when they walk around in their houses or outside since the lighting enables them to see where they are going and what is ahead of them and as such they cannot bump on to something and be hurt. When participants were asked to mention lighting system they use for security at night, they mentioned solar lights fixed on the verandah as well as the solar lantern. The following figure illustrates the ways how SHS are used to provide security in the respondents' households.

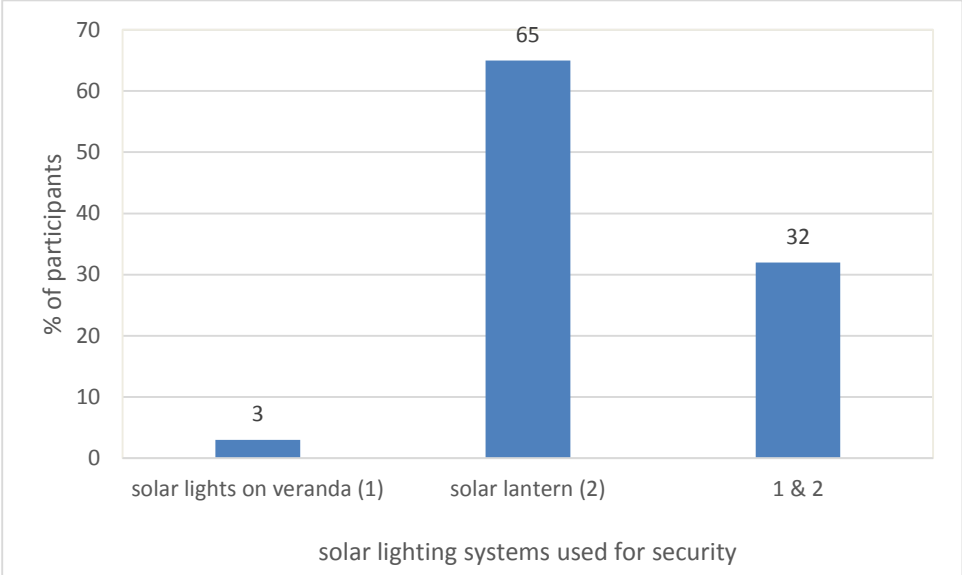


Figure 20: Solar lighting systems used for security in the study area

Lastly, SEs informed me that people without SHS are able to charge their mobile phones within a short distance from their homes thereby saving on time and using time saved to do other meaningful things. The SE noted that since households using SHS are spread out in the two villages this has helped villagers to easily access them and charge their mobile phones.

This section has presented the results of the socio-economic impacts of solar energy in the study area. The following figure provides a summary of the socio-economic impacts of solar energy in the study area following the five categories mentioned.

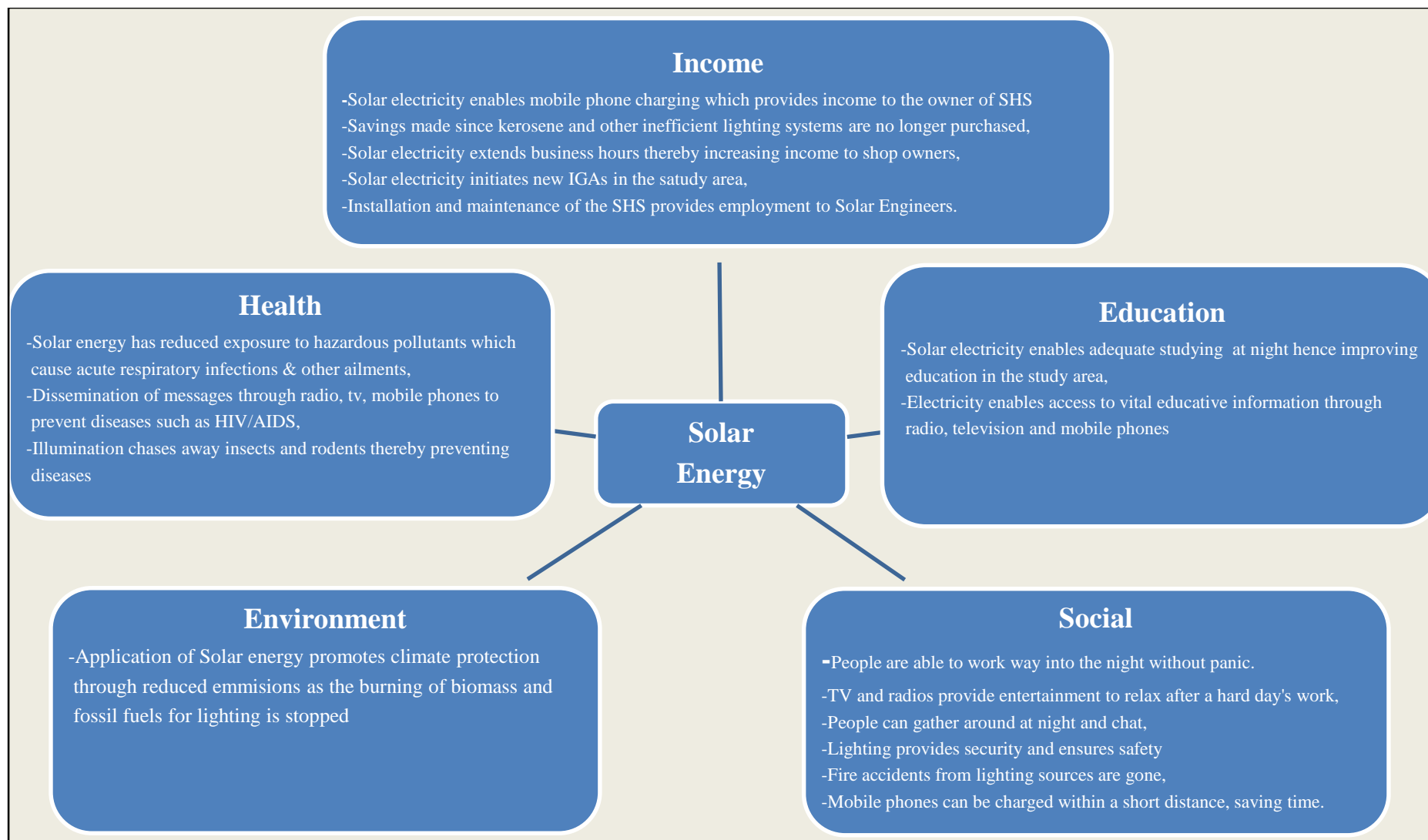


Figure 21: Summary of socio-economic impacts of solar energy in the study area

All in all, the use of SHS in the study area has reduced people's vulnerability to climatic changes by providing the people with skills and knowledge (education), livelihood options and diversification (IGAs), savings (since they no longer purchase kerosene), stronger social networks and healthier life. All these will reduce people's vulnerability to climate changes by increasing their adaptive capacity to such.

5.2.2 Discussion

This section discusses the study's findings on the socio-economic impacts of solar energy in the study area, as presented above. The discussion will also include the indirect impacts being attained from the use of solar energy in the area.

5.2.2.1 Socio-economic impacts of solar energy

The study has shown that use of solar energy in the study area has brought various socio-economic impacts to the respondents as well as members of their households. It has been seen that the income or earnings, health and social life of the respondents and their families have been improved through using SHS. It has also been seen that education in the area has been improved and also that use of solar electricity aids in climate change mitigation through reduction in emissions. Most of these results are similar to what Gustavsson and Ellegard (2004), Jacobson (2007) and Wamukonya and Davis (2001) found in their respective studies on the impacts of solar energy in rural areas.

However, all these three studies did not identify or mention installation and maintenance of the solar electricity or SHS to be a source of employment for the personnel involved in these such as the SEs in the study area. My study has shown that installation and maintenance of SHS in the study area provides employment to the four people working as SEs in the two villages thereby guaranteeing them an income at the end of the month, either from the regular monthly allowance they are entitled to in the study area or from private jobs.

In the study by Jacobson (2007), it was found that use of solar electricity in rural Kenya appeared to create differentiation and middle class formation. This was because according to this study in Kenya most of the productivity gains of using solar energy were being captured by the rural elite or middle class who were able to utilize fully the solar energy. Similarly, Richter and Frings (2005) argued that solar electricity increases disparities between the poor and the elite in the rural areas as the elite are more able to utilize fully solar energy. My study has found otherwise. In my study it has been found that even the poorest of the beneficiaries

are able to engage in IGAs by using solar energy and thus earning an income on daily basis. The most common IGA initiated by solar electricity in the two villages is mobile phone charging where 91% of the participants are involved in and assured of income every day. In the study it was also found that some of the so called poor people amongst the participants were actually making more money from this IGA than the elite within the same group. This shows that in the study area use of solar energy did not increase the disparities between the poor and the elite but rather tried to narrow them down. Differentiation in the study area is also being avoided by narrowing down of the gap.

Furthermore, while the study by Jacobson (2007) showed that the role of solar electricity in IGAs or economic productivity was modest, my study has found that the role of solar electricity in IGAs in the study area is big and very significant. The study shows that 58% of the participants get more than 20% of their monthly income from mobile phone charging as an IGA. This shows how important use of solar electricity is in the income earning capacity of these households.

From the results and discussion above, it is evident that solar energy is doing an immense job transforming people's lives in the study area. In reference to the SLF, it has been shown that solar energy enhances the social capital, protects both the physical and natural capital, aids in building human capital, as well as builds and improves an individual's financial capital. All these assets are interrelated and this further shows how instrumental solar energy can be in achieving sustainable livelihoods and also enhancing adaptive capacity to climate change.

5.2.2.2 Solar energy and climate change mitigation and adaptation

The study's results on the socio-economic impacts of solar energy, presented in section 5.1.1, have also shown that solar energy can be used in both climate change mitigation and adaptation. The use of solar energy in climate change mitigation and adaptation is falling under indirect impacts in this study since it is as a result of the socio-economic impacts. The following section is a discussion of how solar energy can be used in climate change mitigation and adaptation in the study area. These will be discussed separately.

In terms of climate change mitigation, the study has revealed that a SHS does not produce smoke or any other emissions when it is generating electricity or being used and hence making solar electricity a clean source of energy. The lighting sources (biomass and fossil fuels) which

the participants used before acquisition of SHS produced a lot of smoke and other emissions such as CO, CO₂, SO₂, and NO₂ all of which have a devastating impact on the environment leading to climate change. This shows that the lighting sources which were used by these participants before acquisition of SHS were environmentally damaging.

When the participants stopped using these fuels for solar energy as a source of lighting that switch led to a reduction⁴³ in emissions in the area, thus mitigating climate change. These results are similar to what Posorski et al. (2003) found in their study. Posorski et al. (2003), conducted a study to find out if use of SHS contributes to climate change mitigation. In their study they found out that when SHS are used to substitute kerosene and petroleum they reduce GHGs effectively. This is also similar to the study area where the participants have substituted kerosene for SHS. This then means that use of solar energy through SHS is enabling climate change mitigation in the study area. However, the study also shows that the numbers involved are small since it is just a fraction of the population (135 households) in the study area that is involved in this mitigation.

In terms of climate change adaptation, the results from this study show that use of solar energy can help in climate change adaptation in the study area. The study has shown that use of solar energy in the study area has improved the earnings or incomes, health, education, as well as social life in the participants' households. This is similar to the results that Mosberg (2013), Vognild (2011) and Venema and Cisse (2004) found in their respective studies on how use of solar energy can result into climate change adaptation in rural areas. In their studies, they found out that solar electricity increased peoples' earnings and productivity, improved access to information, reduced respiratory illnesses as well as enabled socialisation, all of which increases one's adaptive capacity to climate change.

However, all these three studies did not find education as capable of enhancing one's adaptive capacity to climate change. My study finds that education can enhance adaptive capacity to climate change through the provision of relevant knowledge in formal as well as civic education that will equip people with skills on how to adapt to climate change. Use of solar electricity

⁴³ 'Reduced' because other people in the two villages are still burning kerosene and biomass for lighting.

will enable these people to read more and acquire more knowledge on this phenomenon, thus reducing their vulnerability.

From this discussion, it can be said that use of solar energy in the area proves to be an important tool in both climate change mitigation and adaptation. It is able to protect the environment as well as improve the living standards of the participants as well as members of their households.

5.3 Biomass use for domestic purposes

The study also sought to review the pressure being put on biomass from domestic use by looking at whether there has been any change in acquisition and use of the biomass in the last twenty years. Further, the study explored options for more efficient use of biomass to reduce increased pressure on it and also mitigate climate change. This section provides the study findings regarding these issues.

5.3.1 Pressure on biomass for domestic use

All participants in the study area indicated that they depend on biomass for cooking. They mentioned firewood, charcoal and crop residues as the forms of biomass they use for cooking. However, when the participants were asked to mention the main source of energy they use for cooking, 83% of them mentioned firewood while 17% mentioned both firewood and crop residues. Furthermore, 93% of the participants mentioned to be using crop residues at one time or the other but it is only the 17% that regard it as one of their main sources of energy for cooking. This also applies to charcoal where 62% of the participants said that they use it for cooking but went on to say that they use it only when other options (firewood and crop residues) are not available and sometimes as a supplementary to either of the two forms and hence it is not a full time source of energy to them and cannot qualify to be regarded as a main one. Others further said that they can go for months without using charcoal, but would have it in the home in case there is need to use it. The following figure illustrates the main sources of energy used for cooking in the study area.



Figure 22: Main sources of energy used for cooking in the study area

In the figure above, picture on the left is firewood in bundles⁴⁴ and on the right are maize cobs. Maize or corn cobs are the main crop residues used for cooking in the study area. Other crop residues, used to a smaller extent, are dried stalks of maize, tobacco and cotton.

When the participants were asked about the source of their firewood, they mentioned several sources but natural forest and participant’s own garden were the two most dominant sources. The figure below illustrates where the participants obtain their firewood.

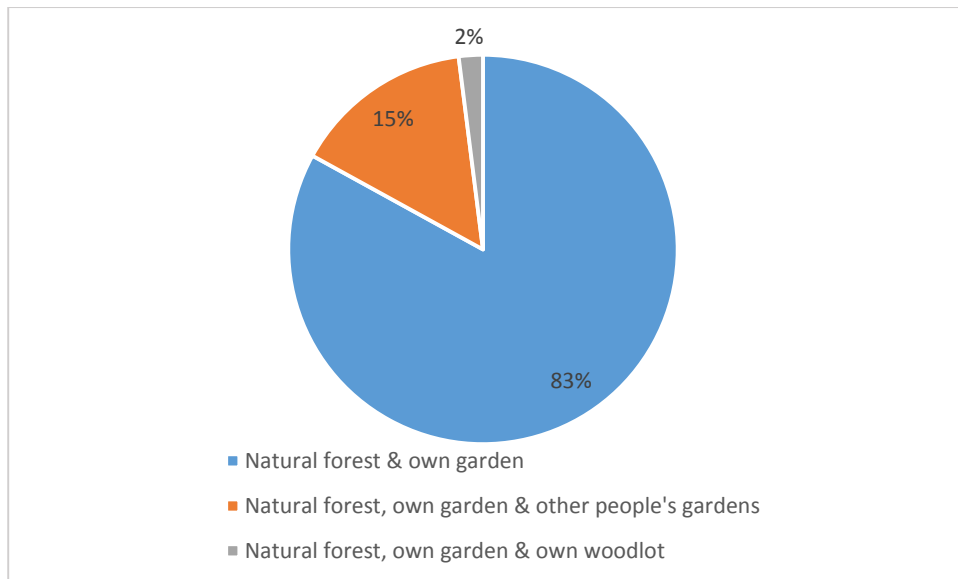


Figure 23: Sources of firewood in the study area

⁴⁴ Each bundle weighs approximately 25kgs

From the preceding figure it can be seen that all participants (100%) obtain their firewood from natural forests and own gardens. Own garden in this case refers to gardens they are currently cultivating on where they cut off branches of trees in them as well as bushes. Natural forests refers to indigenous trees growing naturally in traditional, customary or public lands.

When the participants were asked about how much firewood they collect in a month, their answers varied widely. The minimum amount collected was 75kg, while maximum was 400kg and a mean amount of 163.75kg. The following graph details the amount of firewood collected per participant on a monthly basis. These figures are the total amount collected by the participant from all their respective sources in a month.

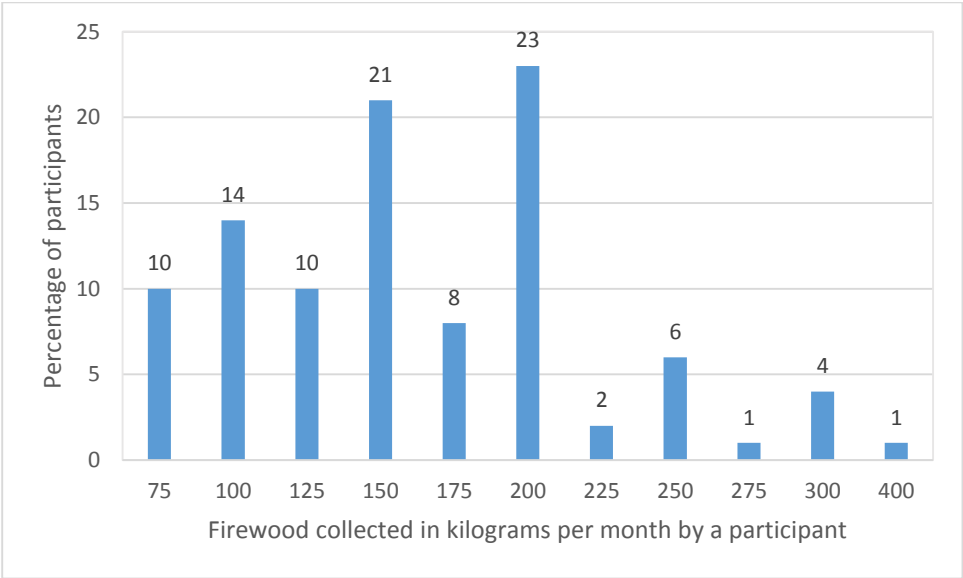


Figure 24: Amount of firewood collected per month in kg per participant

When participants were asked to mention the stoves they use for cooking, 73% mentioned traditional 3SF only while 12% mentioned ICS only. 15% of participants mentioned that they use both stoves. The following graph (figure 25) illustrates these results.

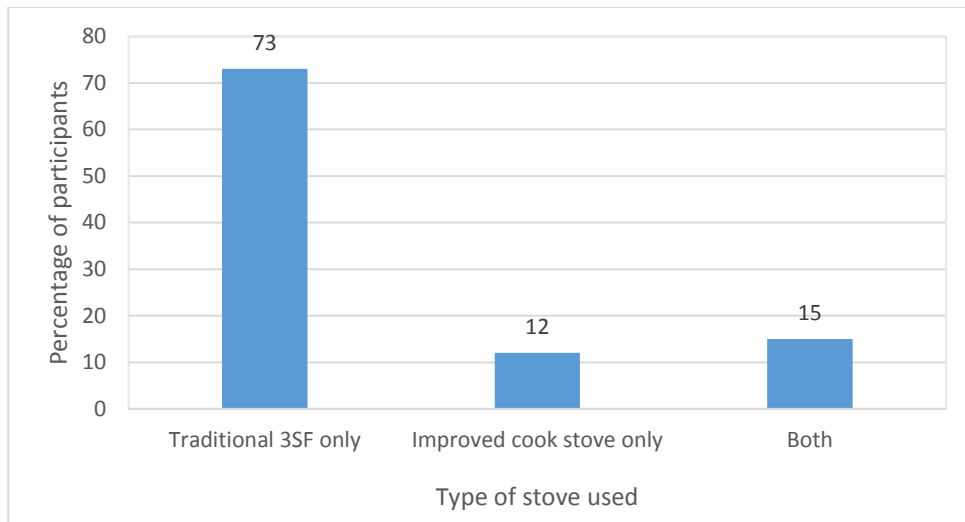


Figure 25: Types of cooking stoves used in the study area

The graph above shows that overall the study sample has 88 participants who use traditional 3SF and 27 participants who use ICS. The figure below illustrates the two types of stoves being used in the study area.



Figure 26: Traditional 3-Stone Fire and Improved Cook stove

In the figure above, picture on the left is a traditional 3SF and on the right is a double pot ICS. There is also a single pot version of ICS in the study area.

The research further found out that there were noticeable differences in the amount of firewood used between participants using traditional 3SF and those using the ICS. The following table illustrates thus.

Table 8: T-Test group statistics

Have you ever used any improved cook stoves?		N	Mean
firewood collected (kg/month)	Yes	27	125.00
	No	73	178.08
firewood used (kg/month)	Yes	27	103.70
	No	73	147.95

(Source: Own Field Work, 2013)

The table above was calculated by treating the participants using traditional 3SF only (73%) as one group while those who use ICS only (12%) as well as those using both⁴⁵ (15%) as one group, giving 27%. Specifically, the results show that those using ICS collected 125kg/month and used 104kg/month on average while those using 3SF on average collected 178kg/month and used 147kg/month.

During the research I noted that some participants were giving me different quantities in the amount of firewood collected and amount used. When I asked the participants concerned to explain why they had such differences, they informed me that they sell some of the firewood they collect. One informant had this to say: *“I collect more than I need in a month and sell the surplus to those who are in need of it, in that way I make money from the firewood scarcity in our village”*. In total, 29% of the participants mentioned that they sell their surplus firewood. This 29% is made up of participants using traditional 3SF as well those using ICS.

When the participants were asked whether there have been changes in the acquisition of biomass in the study area for the past twenty years, 100% of them said yes. The participants informed me that they noticed changes in both the availability and usage of the biomass, especially firewood. For ease of comparison I split the twenty years into two 10 year periods

⁴⁵ Participants using both stoves indicated that ICS is their main stove and use 3SF occasionally to supplement the former.

of 1994⁴⁶ – 2003 and 2004 – 2013. In terms of availability, the participants informed me that during the first 10 year period firewood was in abundance and was found close to their houses at a distance of about 1km or less. They went on to say that they had a wide variety of trees to choose from the best firewood to use. As for the last 10 year period, they said they noticed that firewood was no longer closer to their homes and had started travelling longer distances to obtain it. The following figure illustrates current distances covered to collect firewood.

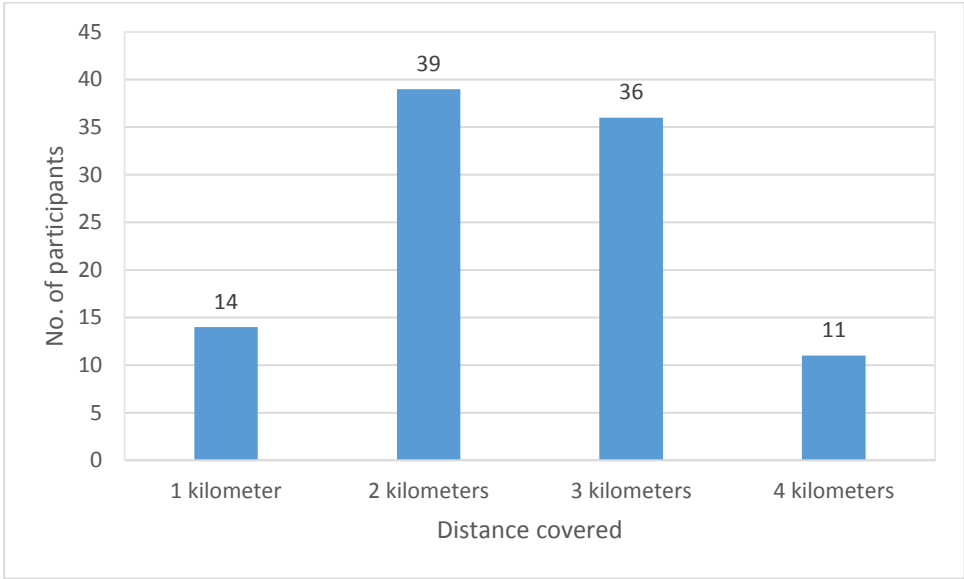


Figure 27: Distances being covered currently to collect firewood

Increase in distances taken to collect firewood resulted into an increase in the amount of time taken to collect the firewood as well. The following graph (figure 28) illustrates the amount of time being taken currently in fuelwood collection.

⁴⁶ The years 1994 and 2004 are significant in Malawi’s history so it was easier for the respondents to relate to them and remember how it was during that time. 1994 was when first multiparty general elections after referendum were held, while 2004 was when the second multi-party era president was elected into office.

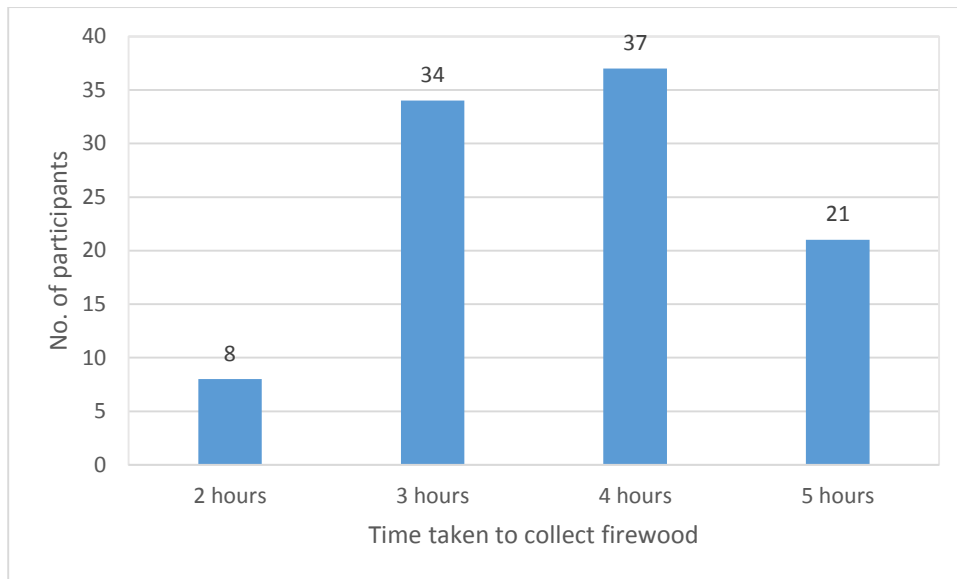


Figure 28: Time taken currently to collect firewood

In terms of usage, the participants informed me that the abundant supply of firewood during the first 10 year period resulted into careless usage on their part. They mentioned that households were only using the traditional 3SF and usually did not put the fire out after using it. In the last 10 years, the situation changed. The participants said that due to scarcity of firewood they started using it carefully so that it lasts long and even went as far as putting off the fire when not in use. Other participants went on to say that this was the time other households started thinking of acquiring ICS (being promoted on the radios and also by NGOs) as well as using other forms of biomass in addition to the firewood. The other forms were used on their own or with firewood as is the case shown in the picture of 3SF in figure 26 above.

All in all, this section has presented the research results pertaining to pressure being exerted on biomass, more especially firewood, in the study area. It has been seen that all participants in the study area are dependent on biomass (firewood and crop residues) for cooking and the majority of them use traditional 3SF.

5.3.2 Options for more efficient use of biomass

The study also explored options for more efficient use of biomass. This was done in order to find means to reduce increased pressure on it (as shown by results in section 5.3.1 above) and also mitigate climate change. This section presents the findings.

The T-test that was done in this study (Table 8 above) to ascertain whether there are noticeable differences in amount of firewood collected and used between participants using traditional 3SF and those using ICS revealed that there are indeed differences between these two groups. The results show that the differences for both firewood used and firewood collected are statistically significant ($p < 0.01$) between these two groups. Simply put, the results show that traditional 3SF uses more firewood than ICS on similar tasks.

Participants (15%) using both the ICS and 3SF informed me that they save a lot of firewood when they use ICS than 3SF on the same task. They went on to say that ever since they started using ICS they noted that the amount of trips they make to collect firewood has been reduced. This was echoed by the participants who only use ICS (12%).

In addition to using less quantities of firewood, the participants also reported that ICS releases less smoke. This is attributed to the limitations on number of pieces of firewood that can be used per single time on the ICS (Figure 27). Since the ICS limits the number of pieces to 1 or sometimes 2 per load, the participants informed me that they make sure that the firewood used is very dry to enable it burn on its own. The absence of moisture in the firewood results into perfect burning and reduction in emissions released. This then means that usage of ICS results into reduced smoke and other emissions. One of the participants using 3SF had this to say: *“Because of scarcity of firewood and limited choices, we just put on the fire whatever piece of firewood we find. Some of it dry and some not so dry so long as we are able to provide the stove with more firewood. The moisture contained in some of the firewood results into a lot of smoke produced in the kitchen”*. Other participants chipped in by saying that 3SF’s demand for more firewood, in the midst of firewood scarcity, forces them to use some trees which are naturally dangerous and produce equally harmful smoke. Users of ICS said they manage somehow to choose which ones to burn, but it is very difficult with the scarcity.

Since the number of ICS users is small in the two villages, I asked the 73 participants not using the ICS if they would be interested to have one in the near future. 72 of them (representing 72% of the total sample) said yes while only 1 (representing 1% of total sample) said no. The table below show the reasons for their response in either case.

Table 9: Reasons for willingness to use ICS or not in future

Response	Reason	# of participants	% total sample
Yes	1. Uses less firewood thus saving trees	37	37
	2. Produces less smoke good for health	5	5
	3. 1 & 2 above	19	19
	4. Reduced trips collecting firewood	9	9
	5. Cost effective when operational	2	2
No	1. It is expensive to build one	1	1

(Source: Own Field Work, 2013)

The reasons in table above show that these participants have full knowledge about the benefits of using ICS in their household, even though they do not use one. When asked where they learnt about these benefits, some of the participants informed me that they have a neighbor who uses ICS so they know the benefits they are enjoying from using it. Others said that they heard about the benefits first from the radio and then confirmed with fellow villagers using the ICS. When asked why they are not using ICS despite these benefits they already know, they informed me that at the moment they find it expensive and cannot afford one. Other participants said that they had wanted to get one but the time they had the money the people⁴⁷ who were trained to build ICS in the two villages had been contracted to install them somewhere by a certain organisation so they ended up using the money.

When the participants who are not using ICS were asked to elaborate on what they meant by ICS being expensive, they informed me that they have to buy a 50kg bag of cement, collect river sand, buy (if they do not have their own) atleast 50 kiln baked bricks of size 4.5mm by 9mm, purchase 7 steel inner rings as well as pay the artisan. They went on to say that most of the cost for installing the ICS comes from the bag of cement since it is expensive. The following table (table 10) shows breakdown of the cost towards installing a single pot ICS in the area understudy, as at the time of this study.

⁴⁷ Programme for Basic Energy Conservation (ProBEC) implemented by German Technical Cooperation Agency (GTZ) trained 5 people in each of the two villages understudy to be local artisans of ICS.

Table 10: Itemised cost of a single pot ICS installation

ITEM	QUANTITY	COST (MK)
Labor	1 artisan	1 000.00
Cement	50 kg bag	6 500.00
Steel rings	1 set of 7 rings	1 000.00
Bricks	50	250.00
	TOTAL COST	8 750.00

(Source: Own field work 2013)

Despite the benefits that the users of ICS are experiencing from it, I asked them if they face any problems with these stoves. The following are the problems that were mentioned: Firstly, it is labor demanding as big pieces of firewood have to be cut into smaller pieces (so as to fit the stove opening as well as for the moist ones to dry). Secondly, it is not ideal for larger families as it mainly handles smaller pots. Lastly, one has to be careful when using it for fear that it might break due to poor workmanship or other factors arising from improper usage and which will require more money for maintenance.

From the results presented above it is clear that ICS is efficient and environmentally friendly. It has been seen that it uses less firewood and also releases less emissions than traditional 3SF. However, the number of users in the study area is still small.

5.3.3 Discussion

This section is a discussion of the results obtained in the study pertaining to the pressure being exerted on biomass for domestic use and also options for more efficient use as presented in sections 5.3.1 and 5.3.2.

The study shows that 100% of the participants depend on biomass for cooking, where 83% of them use firewood as the main source of energy while 17% use crop residues and firewood as their two main sources of energy for cooking. Use of charcoal is occasional since they have to buy it while crop residues are mostly seasonal (found after harvest). The 17% who regard it as main source together with firewood use the maize cobs as they shell the maize from their granaries, which can be done throughout the year so long as they have maize in them. The study therefore shows that firewood is the main source of energy for all the participants. These results,

showing high dependence on biomass, are similar to the findings of Bhattacharya et al. (2000) and IEA (2006).

In terms of sources of firewood, the study has revealed that the main sources are natural forest and participant's own garden. However, since they obtain firewood from their gardens only when branches or bushes tamper with crops then this would not be a regular source because in the event that this is not the case then it means they would not obtain firewood from the garden. This shows that natural forest is the primary source of firewood in the study area.

The study has further revealed that 73% of the participants use 3SF while 27% use ICS. Those who use 3SF have been shown to collect and use more firewood than their counterparts. This echoes what Adkins et al. (2010a), Malakini et al. (2013) and Umogbai and Orkuma (2011) found in their studies, as reviewed in Chapter 4. All these researchers found in their respective studies that ICS use less firewood than the 3SF on the same task.

In terms of changes in acquisition and use of biomass in the study area, the study has revealed that there have been changes regarding these two issues over the past twenty years. As for acquisition, the study has shown that there has been a decline in the availability of firewood closer to participants' homes and this has resulted into participants having to walk longer distances now to acquire firewood. This depletion has been due to the careless usage of firewood when it was in abundant (as revealed in section 5.3.1) as well as use of 3SF by the majority in the study area. In addition to these, the area has also experienced a population increase in the past twenty years primarily due to births which has further increased demand for firewood. Population increase results into more pressure being put on available limited resources as everyone tries to get a part of the resource. This has further triggered unsustainable harvesting of the trees for firewood since the rate of harvesting is much higher than natural replacement rate of these indigenous trees. In terms of use of biomass, the study has revealed that there has been a change now in that participants are using the firewood more carefully than before. This has been due to its scarcity and need for people to use firewood collected for a longer time. This has further resulted into other participants installing ICS as well as employing other techniques such as putting off the fire when not in use and also use of other forms of biomass together with firewood so that they save on the firewood.

The study has also shown that other participants (29%) collect more firewood than they need so that they sell off the surplus to others. However, these participants indicated that selling firewood is not a regular activity or IGA but they would do it when there is pressing need for more money to satisfy other needs. The firewood is mostly sold to the beer brewers as well as those who have failed to collect on their own due to other problems. These participants explained that they sell their firewood from home and the price for each bundle is MK300.00. This activity, even though the participants claimed that it is not regular, results also into pressure being exerted on these forests so as to satisfy these people economically.

According to the SLF by DFID, which is guiding the analysis of these results, this reliance on firewood by the participants shows that they are depending solely on the natural capital for their energy needs. However, the way they are using the natural capital is precarious. The trees are being harvested unsustainably resulting into depletion and degradation of this resource as evidenced from the increasing distances taken now to collect firewood. Furthermore, the study also revealed that participants are now spending more time collecting firewood, with 58% of them spending more than 3 hours on the task each time. This time could have been used for other activities that can enhance someone's life. This means that reliance on firewood culminated with increasing scarcity hampers the participant's chances of pursuing other livelihood strategies as more time is taken by it.

Apart from those collecting firewood, other villagers are also turning these forests into sources of financial capital by cutting down trees for making charcoal as well as collecting firewood for sale, as is the case with 29% of the participants. This is further depleting the resources and also degrading the environment.

The study has also shown that other forms of biomass such as crop residues (maize cobs and stalks, tobacco and cotton stalks) are also used in the area as a source of energy for cooking. This practice results in trade-offs in agricultural productivity since these residues should have decomposed and help naturally in improving soil fertility and structure, which are essential in crop production. Since these are removed from gardens then the soil gradually degrades resulting into lower yields. According to SLF, land is a natural capital and if it is degraded it cannot be able to provide for the population that depends on it. In the study area, most of the people are peasant farmers and as such the loss of value of their land will negatively impact on their livelihoods.

The effects that are faced from the use of firewood such as respiratory illnesses, physical strain and injuries negatively affect the human capital as an individual will be down with illness. This prevents one from performing tasks that would improve their lives. In the study area such illnesses would reduce the number of man hours women can put on their farming, consequently reducing productivity, food availability and nutrition levels in their households.

In terms of efficient use of biomass, the study has shown that those who use ICS in their households use less firewood than those using 3SF. This means that ICS is efficient in biomass consumption. This translates into reduced time spent on collecting firewood and other biomass as well as a reduction in the disadvantages arising from both its collection and use.

The saved time on collecting firewood can be used to do other tasks that will enhance one's livelihood. In addition to time saving, reduction in ailments means that the participants will have the ability to be more productive and accomplish more tasks as they are not sick often. These benefits increases one's ability to go through shocks.

Despite the benefits that are realised from the use of ICS, the study found out that only a few people in the study area (27% of the sample) use the stove. The participants informed me that the main reason for the stove's low usage is that they find it expensive, with most of the cost coming from the 50kg bag of cement required. However, during the study it was found that the bag of cement is enough for two single pot ICS. This means that for two households planning to install a single pot ICS each then the cost is reduced as they share the cement thus becoming relatively affordable. Other notable reasons for the low roll out of these ICS would be pertaining to the problems that its users face. During the study users complained that ICS is labour demanding as they have to chop larger pieces of firewood to fit the openings in the stove and also that it does not handle larger pots, which are typical of most of the households in the area due to large families. They said if they have to use pots that can fit properly on the stove then they have to cook a meal twice which to them is time wasting. This would explain why most of the larger families still use 3SF despite the benefits of ICS.

From the results, it is evident that the efficient⁴⁸ way of using biomass is through ICS. In reference to SLA, this stove has an ability to protect both the human capital (through reduced labor and exposure to emissions) as well as the natural capital (through reduced amount of biomass collected). It also has an ability to enhance social capital (by giving people more time for social networking and building up skills). In this way it shows that use of ICS helps in improving the livelihoods of the users.

All in all, the pressure that is being put on biomass has more effects on both the people and the environment. It has led to unsustainable use of the forest resource (as people harvest the firewood in larger quantities) thereby degrading the forest reserves. It is also causing respiratory illnesses due to emissions released from the fire as well as other physical ailments arising from the collection. Furthermore, reliance on biomass is reducing productivity in the gardens due to degraded soils following removal of crop residues as well as reduced time spent on the farm since firewood collection is now taking more time. All these reduce one's ability to go through shocks and other changes hence being more vulnerable. It can then be said that the pressure that is being put on biomass in the area (arising from reliance on it) is, both directly and indirectly, causing the participants to be vulnerable to climatic changes.

The use of ICS has not only proven to be an efficient way of using firewood and other forms of biomass but also one that would reduce the pressure being exerted on the biomass. In the face of dwindling resources, including forests, it is of utmost importance to use the remaining resources in a sustainable and efficient manner. It has also been seen in the study that the use of ICS provides the users with time at hand to do other chores in the home that would help in transforming their lives thereby making them less vulnerable. Finally, the ICS has been seen that it produces less emissions thus aiding in climate change mitigation. More people should be encouraged to adopt this stove so that its gains can be multiplied at a large scale and probably effectively reverse the current trends in biomass collection and use as well as the disadvantages arising from such. It would also help to give people an opportunity to have sustainable livelihoods which will make them less vulnerable.

⁴⁸ Efficiency in a sense of using less time and biomass to accomplish cooking tasks.

5.4 Gender differentiated roles on access to and control of energy types

In Malawi, traditionally, gender differences determine which tasks to be performed by women and which ones by men. Since energy is fundamental for the maintenance of human species, its acquisition, control and use could be determined by the society’s traditions as well. This research sought to find out if the acquisition, control and use of the different types of energy used for cooking and lighting in the study area is also gender differentiated. In this section I will present research findings pertaining to this.

5.4.1 Acquisition, control and use of biomass

All participants in the study area informed me that they use biomass for cooking only and not heating or lighting. They said that they do not use it for heating since the area is hot and as for not using it for lighting it is because they use SHS. The study (section 5.3.1) further revealed that 100% of the participants use firewood as their primary source of energy for cooking. Other forms of biomass used for cooking in the study area are crop residues and charcoal.

In terms of acquisition, when participants were asked to mention household members responsible for acquisition of the forms of biomass they use in their homes, their answers varied depending on the form. Firstly, in terms of firewood collection, 42% mentioned spouse, 25% mentioned household head and spouse while 14% mentioned household head only. The following figure details the responses:

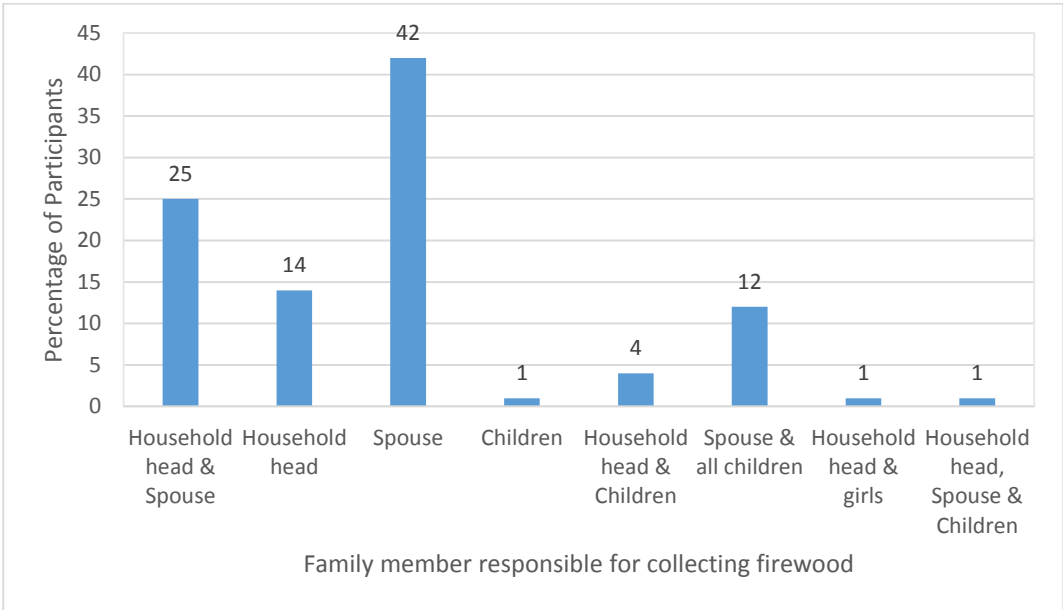


Figure 29: Participant’s household member(s) responsible for firewood collection

In the graph above, spouse refers to the wife while household head mentioned in the second column from left with 14% of the participants refers to female headed households.

Secondly, when participants were asked to mention who was responsible for collecting crop residues in their households, 50% mentioned both the spouse (wife) and children, 17% mentioned spouse (wife) only and 10% mentioned household head only. The figure below illustrates the details.

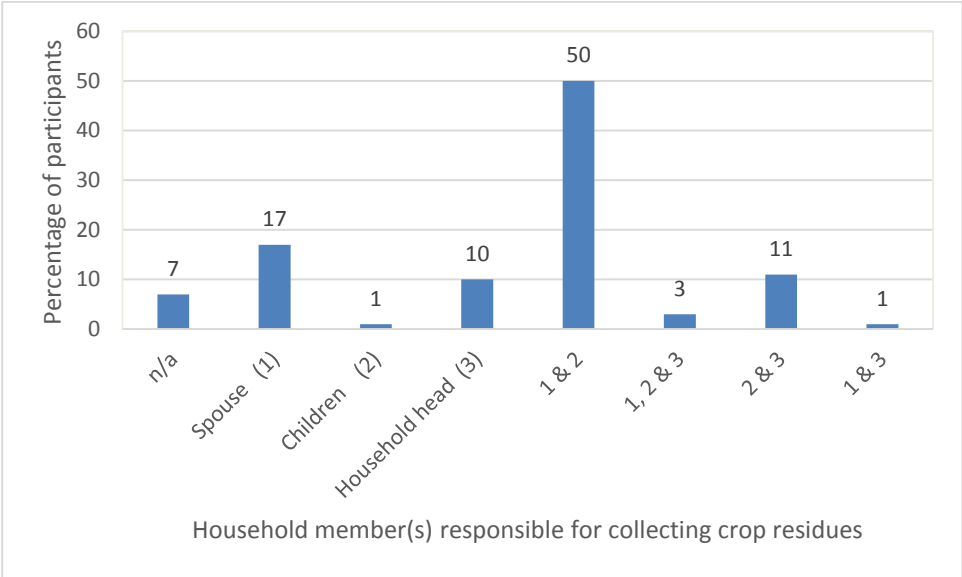


Figure 30: Participant's household member(s) responsible for collecting crop residues

Thirdly, in terms of charcoal acquisition, 35% of the participants mentioned that both the household head and spouse in their households are responsible for its acquisition while 23% mentioned only household head. The following figure illustrates the details.

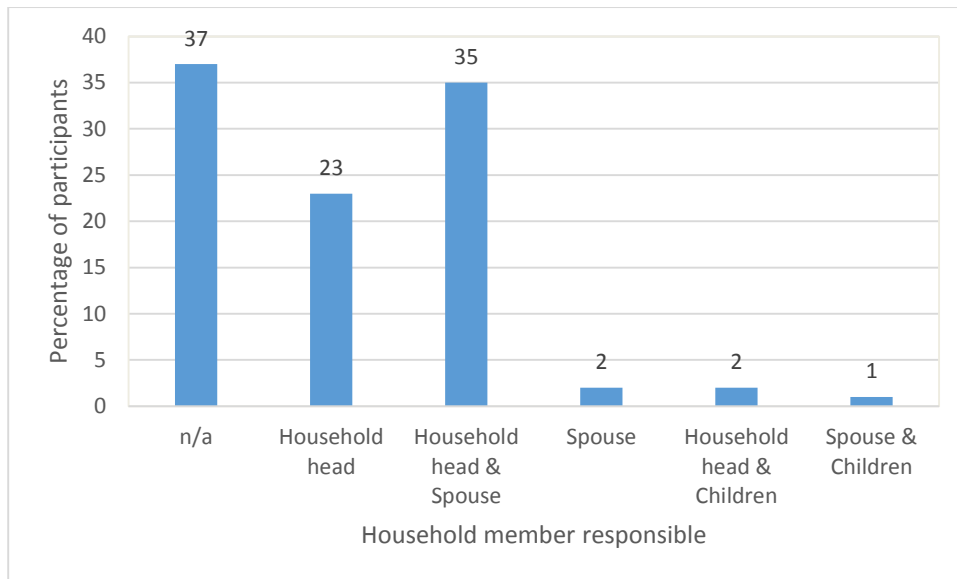


Figure 31: Participant's household member(s) responsible for acquiring charcoal

In the figure above household head stands for both male and female household heads. When the participants who use charcoal (63% of the sample) were asked about the source of the charcoal they use, all mentioned that they purchase it from local charcoal makers either at the market or the makers bring it to their homes to sell them.

In terms of controlling the usage of forms of biomass acquired in the household for cooking, 60% mentioned spouse (wife). The figure below illustrates the divisions.

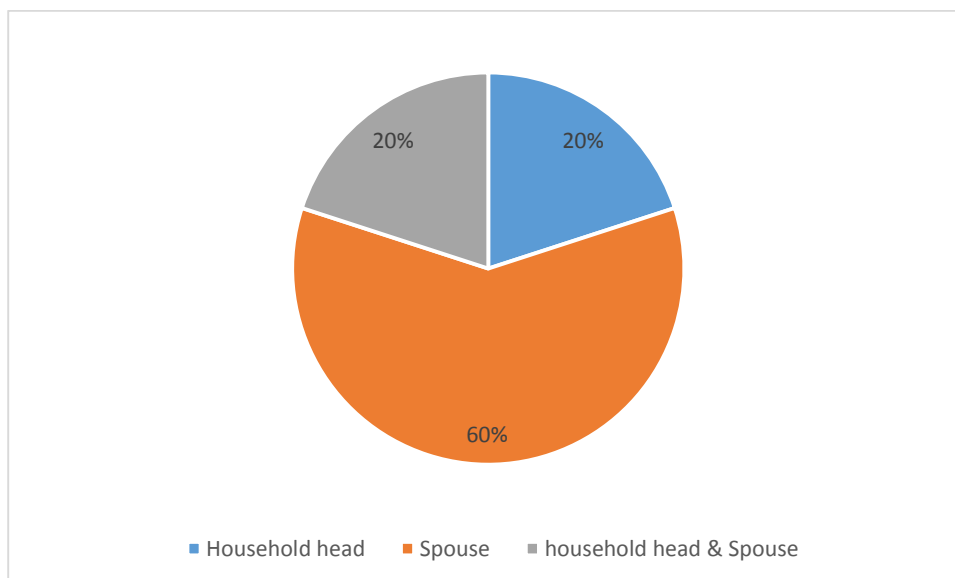


Figure 32: Biomass usage control in the participant's household

Lastly, in terms of who uses biomass in the household for cooking, 98% of the participants mentioned women while 58% mentioned children. Women in this instance includes both female household heads and spouses. The figure below illustrates the responses.

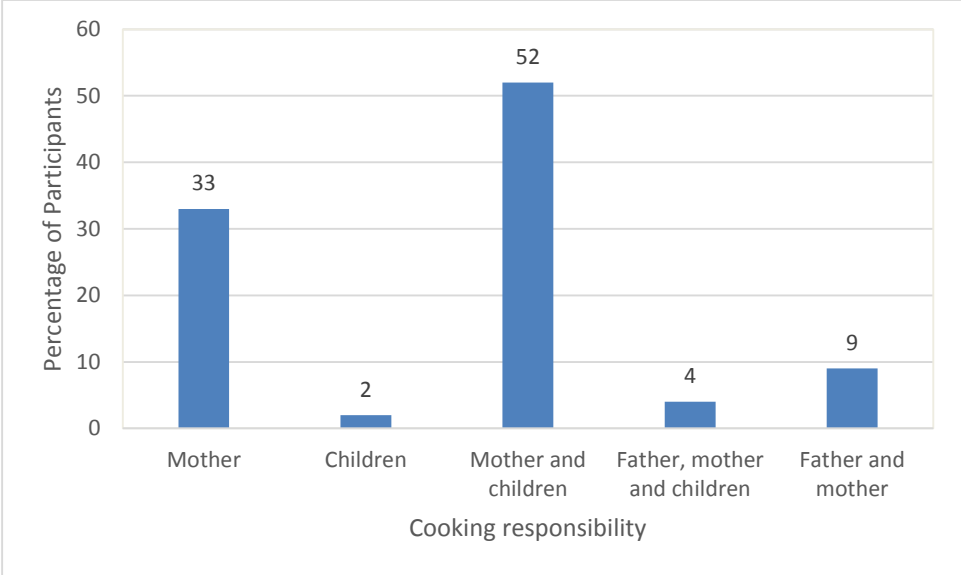


Figure 33: Participant’s household member(s) who uses biomass

5.4.2 Acquisition, control and use of solar power

All participants in the study area informed me that the only source of lighting they use is the solar electricity from their SHS. In terms of acquisition, the study (section 3.2) has revealed that the participants acquired the SHS for free from Barefoot College, India. The SHS were given to either household heads (male or female) or wives (with full consent of the husband).

When participants were asked about who was responsible for solar lighting in their homes, 52% mentioned household head while 45% mentioned both household head and spouse. Others mentioned spouse only and child only respectively. The following figure illustrates the details from their responses.

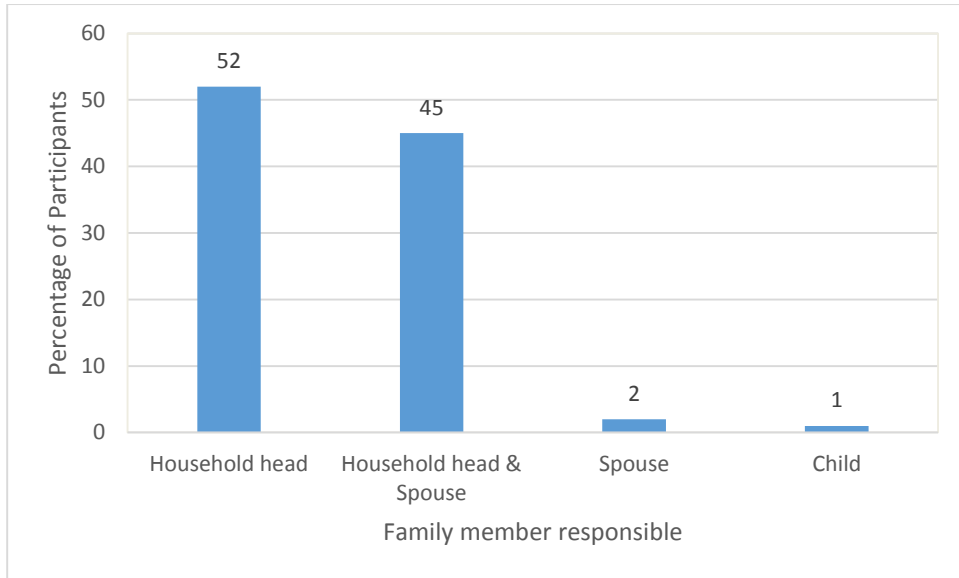


Figure 34: Lighting energy responsible household member

In addition to finding out who takes care of solar lighting in the households, I also wanted to find out who controls its usage or who decides on how much lighting energy to use in the home. On this issue, 64% mentioned household head while 35% mentioned both household head and spouses. The figure below illustrates the details.

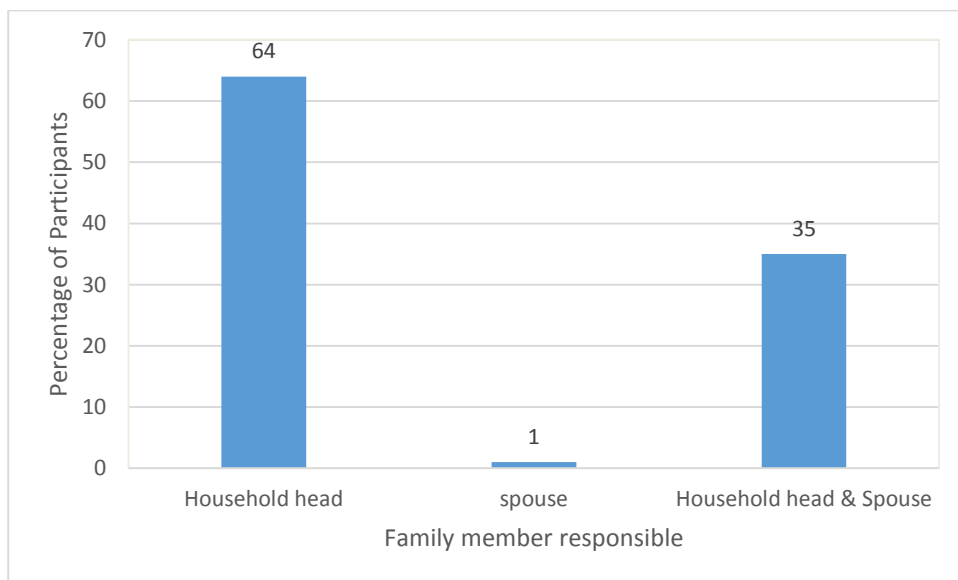


Figure 35: Control of solar energy for lighting in participants' household

5.4.3 Discussion

This section discusses the study results on gender differentiated roles on access to and control of biomass and solar energy. The discussion will follow the presentation of the results above.

The results from this study, as presented in the preceding section, show that women in the study area are dominating in the acquisition of biomass for domestic use. These results are similar to what Wickramasinghe (2003), Bandyopadhyay et al. (2011), Kaygusuz (2011b), and Ding et al. (2014) found in their respective studies. In their studies, these researchers found out that collection of biomass for domestic use in the developing countries is primarily the responsibility of women and as such they dominate in this role. The study has also shown involvement of children in the acquisition of firewood and in the study area and this is similar to what Brouwer et al. (1997) and Biran et al. (2004) found in their respective studies. In these studies they found out that girls assist their mothers in acquisition of firewood and usually accompany them when they are going for such tasks.

The study has further shown that men in the study area are involved in the acquisition of firewood and this is similar to the results of the studies that were conducted by Wickramasinghe (2003) and Ding et al. (2014). The study by Wickramasinghe (2003) found out that men are involved in the acquisition of firewood by doing the tasks that are felt to be masculine, while the study by Ding et al. (2014) found out that men are involved in the task due to increasing distances in collection of firewood and they use mechanized animal-drawn transport for the task. However, even though my study shows that there is an increase in distances that women cover to collect firewood in the study area, my study did not find that the involvement of men in collecting firewood in the study area was because of this increase in distance, but rather performing the occasional and masculine tasks.

Even though these studies above show involvement of girls (Biran et al. 2004; Brouwer et al. 1997) as well as involvement of men (Ding et al. 2014; Wickramasinghe 2003) in the acquisition of firewood, they all show that these perform this task to help the women in their households and the primary responsibility of acquisition of firewood still remains with the women. This is also what my study has found.

The study has also revealed that acquisition of charcoal in the study area is dominated by the household heads. These are both male and female household heads. The reason for the household heads to dominate in this is that acquisition of charcoal involves making payments to the charcoal maker and since household heads control finances in their respective households then they are in a better position to decide to acquire it. Even if the household heads delegate

purchase of something, they are still regarded as the ones who have purchased it since money for the transaction came from them.

In terms of control or management of biomass, the study has shown that women are taking a leading role in the control of all forms of biomass in the study area. These results are similar to what Wickramasinghe (2003), Mahat (2004), Kaygusuz (2011a) and Ding et al. (2014) found in their respective studies. Their studies show that women are the managers of all forms of biomass in the rural homes of the developing countries. However, while these four studies emphasize the role women play in managing biomass in the home, my study shows men in the study area are also playing a significant role in managing biomass in their households even though this is done as a means of helping their wives who retains the primary responsibility of managing biomass in the household.

When it comes to the use of biomass, results from this study show that women are dominating in this activity in the study area. These results are similar to what Karekezi and Kithyoma (2002), Bolaji (2012) and Ding et al. (2014) found in their respective studies. In these studies they found out that women are the primary users of biomass in the rural households of the developing countries. Furthermore, this study has shown that children, especially the girls, are also involved in the use of biomass in the study area. In addition to the women and children being involved in the use of biomass in the study area, the study also shows that some men in the study area are involved occasionally in the use of biomass. This echoes results that Mahat (2004) and Matinga (2010) found in their respective studies. In these studies they found out that men would use biomass when preparing food when their wives are ill or have travelled.

In terms of solar acquisition, the study shows that it was acquired for free and was given to either household heads (male and female) or wives. Since acquisition did not require spending money there was no need for the decision to be made by the one who controls the finances (in most cases the household head) as is the case when money has to be spend on its acquisition. However, the study shows that most of the recipients were household heads.

When it comes to the person responsible for solar lighting in the participants' households as well as control of its usage, the study shows dominance of household heads. This shows that both men and women are actively involved. These results are different from what Clancy et al. (2011) and Mahat (2004) found in their respective studies. While the study by Clancy et al.

(2011) puts emphasis on women as the managers of all forms of energy in the household, including solar energy, and the study by Mahat (2004) shows that men are actively involved in managing energy when it comes to modern energy, my study shows that in the study area both men and women are actively involved when it comes to solar energy management at household level. This then shows that in the study area, gender is not an issue when it comes to solar energy, as long as you are the household head.

In terms of who uses solar energy in the household, the study shows that all household members use it, regardless of gender. The study has revealed that both men and women are embarking on IGAs using solar electricity and also that both use it for lighting in their homes. This is different from the studies by Ding et al. (2014) and Matinga (2010) which point out that women are the primary users of modern energy as soon as it is acquired in the home and that acquisition of modern energy is meant to ease the burden women go through in the use of biomass. My study finds that women are not the primary users of solar energy in the study area but rather both men and women.

From the results presented and discussions made, it shows that gender differentiated roles in acquisition, control and use of the different types of energy in the study area are mainly noticeable in biomass and not solar energy. In the study, women have been dominating in the acquisition, control and use of firewood and crop residues while when it comes to solar energy both the household head and spouse were responsible. Charcoal was an exceptional form of biomass in the study in that its acquisition was primarily dominated by household heads while control and use was dominated by women. It can therefore be said from this study that while biomass that is free is very gender sensitive pertaining to its acquisition, use and control in the home (with women dominating), the modern energy sources such as solar power are not. Furthermore, where the acquisition of biomass involves spending money (as is the case of charcoal in this study) then it becomes gender neutral as household heads (male or female) who control finances in the home take a leading role while women (household heads and spouses) still dominate its control and usage.

In reference to SLF, this division of labor based on gender which has seen women dominating in acquisition, control and use of biomass means that female members of the society are more exposed to the disadvantages that arise from these tasks. This affects negatively both the social and human capital. While women are burdened by these disadvantages, men on the other hand

are not. Solar energy has shown that it is gender neutral and that men are more involved in performing household chores. This shows that while biomass affects negatively the social and human capital, solar energy enhances it.

CHAPTER 6 – CONCLUSION & RECOMMENDATIONS

6.1 CONCLUSION

This thesis has investigated the potential for using RE options and efficient use of biomass in reducing the vulnerability of rural livelihoods and also how these can limit deforestation in Malawi. The issue of reduced vulnerability has been addressed by looking at how use of solar energy and efficient use of biomass in the study area improves people's adaptive capacity to climate change. To accomplish the study's main goal, the study was guided by three specific objectives and five research questions. Since the study's core was on livelihoods, the Sustainable Livelihood Framework developed by DFID in 1999 was used to help in analysing all this. This section, whose structure intends to reflect whether the study's objectives have been met or not, provides a summary of the study findings and concluding remarks. These will be done by looking at each of the study's research questions on its own.

6.1.1 Summary of findings

What is the national policy on improving access to RE in Malawi?

The study found that the *NEP 2003* is an IEP which covers all the five energy sectors in the country of which RE is one of the sectors. Furthermore, under the RE section of the *NEP 2003*, the policy does not address each of the RE components separately but rather handles all renewables as simply one unit.

The study also found out that in order to improve access to RE in the country, the policy allowed GOM to establish various institutions and legal frameworks, embark on capacity building as well as liberalisation of the energy sector. In addition to these, GOM through *NEP 2003* also came up with policy instruments.

Lastly, the RE section of *NEP 2003* addresses issues on how access to RE can be improved in the country, but it does not specify how access to each component of the RE sector can be improved. This makes it to fail address specific issues for the various sectors in detail and in a more tailor-made manner.

To which degree has the policy been implemented to achieve improved access to RE options in rural areas in Malawi?

In regard to this research question, the study has found that implementation of *NEP 2003* to achieve improved access to RE options in the rural areas of Malawi has attained some successes and also faced challenges.

Some of the successes attained so far include establishment of institutions such as TECRET and NASREP Agency, liberalisation of the energy sector, the development of standards for solar water heaters, panels and refrigeration by TECRET and MBS, removal of tax on all RET imports into the country as well as solar electrification of selected public institutions in rural areas with a dual purpose of provision of power and public awareness. The study finds that these have helped to improve access to RE in the country to a certain level.

In terms of challenges being faced, the study found the following: Failure of GOM to come up with a successful financing mechanism for RE end users in the country that would enable more low-income consumers to easily acquire RETs; tax exemptions on all RETs into the country does not necessarily benefit the intended group as benefits are not passed on to them by traders, thus prices remain high; the solar equipment that was installed in public institutions under public investments is abused the moment it is handed over to local management and hence failing to live up to the intended goal and also chasing away potential users; and lastly, opening up importation of solar equipment into the country to everyone has resulted into low standard equipment getting into the country which does not last long thereby making potential customers fail to appreciate it hence pushing them away.

Overall, the study finds that *NEP 2003* has managed to improve access to RE in the country to some level and also that the challenges being faced in its implementation are hampering efforts to register higher levels of improved access to RE in the country and it is feared that these might erode successes that have been attained so far.

What is the impact of RE options on men's and women's livelihoods?

The study has found that the use of solar energy in the study area has transformed people's lives socially and economically. It has been revealed that use of solar electricity in the study area has improved the health of respondents as well as that of the members of their households, increased their incomes, improved levels of education in the study area, improved their social life and also contributes towards climate change mitigation. The improvement in health, income, education and social life has resulted into an improvement in people's adaptive capacity to climate change. It can then be said that use of solar electricity in the study area has reduced the vulnerability of rural livelihoods to climate change.

Has there been a change in the acquisition and use of biomass for domestic purposes in the last twenty years?

The study has found that there has been a change in the acquisition of biomass for domestic purposes in the last twenty years in the study area. The respondents reported an increase in time and distance taken to collect firewood as well as use of some tree species which were not used previously for firewood because of their nature, all of which indicates scarcity of firewood in the study area.

In addition to this, the study also found that respondents have changed the way they use biomass. They are now putting off the fire from all biomass left after use, use other forms of biomass together with firewood, and those who can afford have also managed to install and use ICS in their households all of which is aimed at saving firewood. It can then be said that the study has also found that increased scarcity of firewood in the study area has resulted into people having to adjust the way they use it and all other forms of biomass and are now using it carefully as well as combine with other forms of biomass so that it lasts long.

How do gender roles reflect on use and control of types of energy?

The study has found that in the study area gender differentiated roles are more pronounced in the acquisition, use and control of traditional biomass while in modern energy they are not pronounced. This shows that biomass as their main source of energy is more gender sensitive while modern energy is gender neutral. The study also found out that where source of energy is to be purchased, either biomass or modern energy, the household head either male or female takes charge, thereby showing gender neutrality. Lastly, traditional biomass burdens women with a lot of work (collection), ailments (associated with collection and use) and other disadvantages unlike men whose involvement with it is very rare.

6.1.2 Concluding remarks

From the presentation and discussion of the study findings in chapter 5 as well as the summary of study findings in section 6.1.1 above a number of conclusions can be drawn. Firstly, it is clear from the study that GOM, through *NEP 2003*, is making efforts to improve access to RE in the country as it recognises the role that RE can play in REC as well as what both can do in poverty reduction and rural development in the country. Secondly, it is also evident from the study that the use of solar energy in the study area has positively transformed respondents' lives as well as that of their household members which in return has increased their adaptive capacity

to climate change. Thirdly, use of ICS has also been seen to improve people's adaptive capacity to climate change as well as limiting deforestation. Fourthly, use of solar energy as well as ICS has also been found to mitigate climate change. Lastly, it is also evident from the study that traditional biomass is more gender sensitive than modern energy in terms of acquisition, control and use and also that there have been changes in the acquisition and use of biomass in the last twenty years in the area. The study has therefore been able to show that use of RE options, such as solar energy, as well as efficient use of biomass through ICS in the rural areas of the developing countries results into improved adaptive capacity and hence reducing people's vulnerability to climate change. It has also shown that efficient use of biomass limits deforestation. This means that the study has been able to meet its objectives.

However, the study did not find any contribution by solar electricity use towards limiting deforestation in the study area. This is because solar electricity is only used for lighting in the study area and biomass still remains the main source of energy for cooking.

The findings for this research are important and this research can be useful in a number of ways. The study area is made up of poor people (subsistence farmers) who are dependent on rain-fed agriculture for a living and thus being more vulnerable to climatic challenges. The SHS that were provided to the respondents in these two villages of Chitala and Chimonjo, Salima district, five years ago have proven that they are capable of transforming people's livelihoods positively hence reducing their vulnerability to climate change as has been the case with the respondents. When these have been applied to other rural areas in Malawi or other developing countries, with similar setting, they can also be able to reduce people's vulnerability to climate change. Furthermore, since traditional biomass remains the main source of energy for cooking in most of the rural areas of developing countries, this research has shown that use of ICS can help to reduce deforestation and other disadvantages arising from traditional biomass use. It has also been shown that use of ICS enhances people's adaptive capacity to climate change. Similarly, when use of ICS has been increased in the rural areas it can lead to more trees being saved and also protecting the environment. It is therefore possible that insights from this research can be relevant to other similar contexts.

My research has therefore shown that renewable energy, when used for REC, as well as efficient use of biomass can contribute significantly to climate change adaptation in the rural areas of the developing countries by increasing people's adaptive capacity. It is essential

therefore that GOM and its development partners put in place mechanisms that would enhance access to RE as well as efficient means of combusting biomass amongst the rural poor so that their vulnerability to climate change is reduced as they are constantly threatened by it due to their dependence on rain-fed agriculture. If more poor people in the rural areas use these the greater the chances of avoiding massive human suffering from climate change.

Finally, I have managed to be as thorough as possible in my thesis in terms of description of methods, context, theory and findings to help other researchers or ordinary readers to easily use my research or transfer it to other contexts.

6.2 RECOMMENDATIONS

Following the findings of this study, the following recommendations have been made that can help increase access to and usage of RE and ICS in the area as well as the whole country and other developing countries. Some of these recommendations are based on the suggestions that were made by the respondents.

- Malawi should have a stand-alone National RE Policy which would be able to address each of the components in Malawi's RE sector on its own. This will enable such a policy to handle issues regarding various components of RE in a more specified and detailed manner, unlike the case with current national energy policy, the *NEP 2003*. It will also be able to come up with tailor-made strategies for each component, for instance a component might be affected by a set of barriers different from other components as such the way of tackling such barriers will have to be more specific to that component. This will eventually lead to successes in that component as well as a combined success of the whole Malawi RE sector.
- The GOM should set up proper and well organized RE financing mechanisms to enable people access RE easily. However, this financing should not be run by the government, but rather it should just provide seed capital to a dedicated fund and hire an agent or commercial bank to run it on its behalf. It should be run differently from the defunct scheme where the GOM's approved low-income consumers were handled differently from the rest of the bank's customers. The bank hired should run the financing mechanism the way it does with all its other loans in terms of tracing and handling loan defaulters. This will ensure that everyone is paying back the loans they obtained and

then the money collected made available to other low-income consumers in need of it. The fund should also be self-sustaining and the bank hired to run it should be bound to ensure that they will run it without seeking for extra funds from the government. This will ensure its sustainability and continuity for years to come. However, before setting up this scheme, there is need to conduct a research to look into why other beneficiaries of the defunct GOM initiated RE financing mechanism for low-income RE end-users failed to repay their loans or generally why it collapsed. Findings from this will help the GOM and all other concerned parties to come up with effective RE loan schemes for the low-income consumers.

- Since most of the REC projects using off-grid stand-alone technologies have been implemented using solar electrification through subsidies, and might continue to be so for some time as solar electrification is the strong alternative to grid electrification in REC, GOM and other stakeholders should start putting in place a pay-as-you-go (PAYG) system for such solar electricity projects as a way of moving away from subsidies. This will help them to save money but also to reach out to a lot of people. Subsidizing of SHS is not a sustainable solution to help in improving access to solar electricity and all other renewables as governments or other funding agencies have to constantly look for new funding for another set of subsidies. Solar PAYG system involves lending out solar lanterns that have a capacity to provide illumination as well as charge mobile phones to households for a number of days. Fully charged lanterns are lent out for a small fee from one central point where the roof of the building will have solar panels to charge all the lanterns. When the lantern runs out of power they bring it back to the center for charging and also to pay for and collect another lantern. If solar PAYG system is put in place, it will be self-sustaining as the fees paid by service users will be used to fund the program's operations, maintain damaged units as well as buy more equipment for the service. In addition to being self-sustaining, it will also help low income households to have access to solar energy without subsidies as they use what they can afford to pay for. It also brings a sense of responsibility in that they will use the electricity carefully so that it should take them more days before they pay for another service. Ability of PAYG system to sustain itself will help organizations involved in RE as well as GOM to come up with programs that will generate money on their own without having to look for additional funding to such programmes.

Furthermore, the extra money generated will also help in reaching out to more people with new energy investments.

- There is need for GOM through MBS and TECRET, the two agencies responsible for RET standards in the country, to put trained personnel on all entry points into Malawi such as airports and border posts to check on the quality and standards of solar equipment being brought into the country. This is to help solve the problem of bringing into the country sub-standard equipment by unaccredited businesses and individuals. These are able to have their sub-standard equipment on the Malawi market because there is no one to check and enforce standards at the entry points of these into the country. This shows that there is lack of capacity in this area. The trained personnel put on such points will check and enforce compliance with the required standards by everyone. Furthermore, these two agencies as well as DoEA should also invest in public awareness campaigns to let people know the required standards of solar equipment to be brought into the country, so that no one should play ignorance to such matters.
- GOM and all other stakeholders should continue installing solar electricity in public institutions (under public investments) as a way of showing the public that solar power works, but the local management should be told in strictest terms that they have to take good care of it. It should also be mandatory for the local management to have a committee running and monitoring the equipment installed at their facility to ensure that no one abuses it. The committee should include selected members of staff and community leaders (since the facility is in their community), amongst others. These installations of solar electricity in public institutions help to reach out to a lot of people in the rural areas with a message that solar electricity exists and it works. Most of the people in the rural areas of the developing countries have never seen how solar power works. Demonstration of technology is a powerful marketing device but if poorly handled can also be a disincentive.
- As one way of doing away with loans as well as subsidies, the GOM and other stakeholders should consider introducing lay-by services or schemes for RETs and ICS. This will involve potential beneficiaries having to pay for the new technology that they will acquire in small amounts and finishing the payment before collecting it for use at home. The payments will be made to an accredited service provider or their

authorized agent at the local area. This takes away the hustle of having to chase for loan defaulters as people are obliged on their own to finish their payments as quickly as possible and enjoy the benefits of the new technology.

- Since lack of spare parts and high quality equipment on the market is posing as a threat to the solar electrification project in the study area, CCODE should work hand-in-hand with Barefoot College of India to source these from India. This is because it has already been seen in the study area that the parts that came with the solar equipment from India lasted a long time. However, these items sourced from India will not be given for free to the SHS users. CCODE will give them to the VSC who will sell on its behalf in order to recover the money used to obtain them from India. In this way the users will have access to high quality equipment and spare parts and at the same time CCODE will be able to recover the costs for such.
- GOM should review the policies it is following now that aim at attracting private investments in the energy sector and more precisely REC. This is because ever since *NEP 2003* was implemented, which allows for the participation of the private sector in the Malawi's energy market including REC, the involvement of the private sector has been very minimal. Review of such will help the GOM to come up with very relevant energy investment policies that will not only increase the involvement of the private sector in the energy industry but will also help GOM achieve its development goals. However, review of such policies might not be enough if there is no political will to provide an enabling environment for their implementation. In this way GOM should ensure that it is also providing an enabling environment for the private investors to flourish in the country's energy sector which will in turn see more rural people accessing modern energy thereby transforming their livelihoods.
- In case of ICS, women should be involved in the planning at the local level and should also be asked about their cultural and family values and preferences when it comes to energy use and not just pushing it on them. These values and preferences should be taken into consideration when designing the energy project for them. This will assist in adding a local flavor to the project and increase its acceptability. Other energy projects have failed because of lack of involvement of the beneficiaries in the planning stages

as well as failure to consult them on their energy needs and preferences. The ICS project in the study area has not made much success more especially on the larger families. If the women from these families were involved in the planning stages then the stove design would have taken on board family sizes. Furthermore, whatever technology that is proposed or which they will receive should be closer to what they have been using already and should not be seen as something that is from 'outside this world' which might cause some resistance and even failure of the whole project.

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APPENDICES

Appendix 1: Household interviews questionnaire

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

HOUSEHOLD QUESTIONNAIRE

A. GENERAL INFORMATION

S/No	Item	Name
1.	Questionnaire No.	
2.	Name of respondents (optional)	
3.	Village name	
4.	Solar engineer's name	

1. Household characteristics

Respondent's identity	Sex	Age (years)	Marital status	Education level	Occupation
1. Household head 2. Spouse of household head	1. Female 2. Male		1. Married 2. Single 3. Divorced 4. Widow/widower 5. Separated	1. None 2. Primary 3. Secondary	1. Farmer 2. Permanent job 3. Temporary job 4. Business 5. Retired 6. Any other

2. Indicate the total number of family members in each category

	1	2	3	4	5	6
Age (years)	Below 10	11 - 20	21 - 30	31 - 40	41 - 50	>50
Males						
Females						

3. Number of children attending school

Education level \ Gender	Kindergarten	Primary	Secondary	Tertiary
Males				
Females				

B. ECONOMIC STATUS OF THE HOUSEHOLD

4. What economic activities is your family involved in?

Item	List type of crops / business
Cash crop cultivation	
Food crop cultivation	
Livestock	
Business	
Others (specify)	

5. What type of dwelling do you have? (Brick, mud, straw, etc.) _____

6. Who owns the dwelling?
 1. Renting 2. Owned permanently by occupant

7. What assets does the household possess? (Indicate how many in each case)

Type	Car/ Motorbike	gen. set	bicycle	cart	radio	TV	lamp	mobile	solar units	Hoes	Panga knives
#											

8. What type of animals does the household possess and how many are in each group?

Type	Cattle	Goats	Sheep	Pigs	Chickens	Others specify
Total #						

9. How much do you earn per month (MK)? Both farm and off farm earnings.
 1. <10 000 2. 10 001 – 20 000 3. 20 001 – 30 000 4. 30 001- 40 000 5. >40 001

10. Do you get any remittances from other family members? 1. Yes 2. No
 11. If yes, how much remittance do you receive per month? _____
 12. How much land do you own (acres)? 1. <5 2. 6 – 10 3. 11 – 15 4. >16

C. GENERAL HOUSEHOLD ENERGY USE PATTERNS

13. Can you describe the means of lighting you used in your household before acquiring solar? _____

14. Describe the problems you faced with these sources of lighting.

15. Can you describe life in your household before you started using solar energy?

16. What is the main type and source of energy you use for:

Activity	Type of energy	Source	Responsible	Monthly cost
Cooking				
Lighting				

17. Who decides on and controls the following (*tick the most appropriate*)

Responsible \ Item	Type of energy to use		How much to use	
	Cooking	Lighting	Cooking	Lighting
1. Household head (HH)				
2. Spouse of HH				
3. Other (specify)				

18. How much money was spent on the acquisition of solar equipment:
 MK _____

19. What do you use solar power for? _____
20. Are there any benefits that you have realized in your household from the use of solar power?
21. What changes do you see in your household's members ever since you started using solar in 2009?

Household member	Changes noted
Household head	
Household head spouse	
Children	

22. Do you face any technical problems when using solar power? 1. Yes 2. No
23. If yes, would you please state these problems

24. What do you do when you encounter such problems? _____

25. Do you get timely maintenance service from the village solar engineers? 1. Yes 2. No
26. If not, what are the problems? _____

27. Does access to solar electricity create an income generating activity? 1. Yes 2. No
28. If yes, which one(s)? _____

D. ENERGY USED FOR COOKING

29. Who cooks for the family? *Tick the most appropriate*

Father	Mother	Children	Others –specify

30. Where is the cooking place located? *Tick the most appropriate*

Outside the house and is shaded	Outside the house and without shade	Others-specify

31. Which type of stove and fuel do you use for cooking and how do you rank the performance of the stove (compared with the other stoves you use)?

	Traditional stone fire	3	Improved stove	Charcoal stove	Paraffin stove
Fuel type					
Use Rank					

Rank: 1 = least, 2 = moderate, 3 = highest

32. Fuel collection

Type of fuel	# of times collected/wk.	Distance from home (km)	Time spent on the activity	Who collects it
Wood				
Charcoal				
Crop residues				
Others (specify)				

Drudgery of using firewood

33. Where _____ is _____ firewood _____ collected?

34. How much firewood do you collect in a month? _____ bundles (25kg/bundle)

35. How much firewood do you use for cooking in a month? _____ bundles (25kg/bundle)

36. What are the main problems that occur to the firewood collector?

Problem \ Frequency	Daily	Weekly	Monthly	Others (specify)
Headache				
Neck ache				
Backache				
Bruises				
Wild animals encounter				
Sexual harassment				
Physical strain				

37. What are the main problems that occur to the family due to firewood use? _____

38. Apart from cooking, what else do you use firewood for? _____

E. ENERGY FOR LIGHTING

39. Do you need lighting for your work at night? 1. Yes 2. No

40. If yes, which activities need lighting at night? _____

41. How often do you go out to relieve yourself at night? _____

42. Which lighting system do you use for security at night? _____

43. What problems emanate from lack of proper lighting at night?

F. HEALTH RELATED PROBLEMS

44. What are the common illnesses people in your household suffered in the past year?

	Type of disease/illness	Indicate how often (<i>tick the most appropriate</i>)			
		>4 times a year	2-3 times a year	Once a year	Never at all
1	Flue / running nose				
2	Sore throat				
3	Red eyes/ itching				
4	Coughing				
5	Asthma				

45. What do you think are the main causes of these illnesses?

46. Do you think the coming in of solar will reduce any of these illnesses above?

1. Yes 2. No

G. KNOWLEDGE ON SOLAR ENERGY

47. Where did you hear about solar energy? _____

48. Mention any solar systems which you had ever used? _____

49. How do you rate the cost of using solar units against the other sources of energy?

1. Very low 2. Low 3. Moderate 4. High 5. Very high

50. If you were given a chance to choose among several sources of energy for lighting, what are the chances for solar energy to be selected? (*tick most appropriate*)

	1 st choice	2 nd choice	3 rd choice
Choice rank			

51. What would be the reasons for your choice?

52. If you were to recommend RETs to other people, would you recommend solar energy?

53. What would be the reason(s) for your answer?

H. WILLINGNESS TO PAY FOR RENEWABLE ENERGY (SOLAR)

54. If you were given a solar home system or any other solar unit, how would you prefer to pay for it? 1. Cash 2. Installments 3. Hire/rent 4. None / given freely

55. In case of installments, please state how long? _____

56. How do you think solar energy will change you and your family's life? Explain.

G. ENERGY SAVING TECHNOLOGIES (IMPROVED COOK STOVES)

57. What do you do to save on firewood?

Option	Tick most appropriate
1. Put off the fire when not in use	
2. Use of energy saving stove	
3. Use of crop residues & firewood together	
4. Others (specify)	

58. Have you ever used any improved cook stoves? 1. Yes 2. No

59. If yes, what are the benefits of using improved cook stoves?

60. Do you know improved charcoal stoves? 1. Yes 2. No

61. Do you use improved charcoal stoves? 1. Yes 2. No

62. If yes, how do you rate the efficiency of the improved charcoal stove you use?

63. Do you have plans to use energy saving stoves in future? 1. Yes 2. No

64. In either case why? _____

THANK YOU

Name of the interviewer: _____

Signature: _____ **Date:** _____

Appendix 2: Guide for interviews with Solar Engineers

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

KEY INFORMANT INTERVIEW GUIDE: SOLAR ENGINEERS

1. Can you describe how you got involved in this project
2. Could you explain the background to the solar project in this village, thus
 - i. How did it start and when?
 - ii. How many households were involved in the initial stages and how many now?
 - iii. What is the nature of the solar equipment that was received?
 - iv. How many households received the SHS?
 - v. What was the requirement for one to get the solar home system?
3. What were the reasons for CCODE to embark on this solar project?
4. How is the management of the project structured?
5. What has been the response of the villagers towards solar energy?
6. What are you doing to ensure that more people access solar energy in these villages?
7. If you were to recommend RETs to other people, would you recommend solar? Please explain the reason for your answer.
8. What are the successes of the solar electrification project in this village?
9. What challenges is the solar project facing in this village?
10. What is the relationship between:
 - i. You and the solar users?
 - ii. Solar users and non-solar users?
11. What do the people of this village want about solar in terms of the nature of the equipment, availability of spare parts and servicing?
12. What challenges do you face as a solar engineer in this village?
13. What have been your achievements as a solar engineer in this village?

***** Thank you very much*****

Appendix 3: Guide for interview with Chief District Forestry Officer

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

KEY INFORMANT INTERVIEW GUIDE: DISTRICT FORESTRY OFFICIAL

1. What is the current version of the National Forest Policy of Malawi that the country is using?
2. Has there been any amendments done to it, and why?
3. What are the objectives of this policy?
4. In your assessment do you think these objectives are being met in Salima district?
5. If not, what would be the reasons for the failure?
6. What problems does your office face when implementing the policy in the district?
7. What are the causes of deforestation in Salima district?
8. What is your office doing to combat deforestation in the district?
9. What problems do you face when combating deforestation in the district?
10. Would you say your efforts in combating deforestation in the district have been a successful or not?
11. What would be the reason for your answer above?
12. What do you think should be done to reduce the high levels of deforestation in the district?

*******Thank you very much for your time*******

Appendix 4: Guide for interviews with forestry officials

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

KEY INFORMANT INTERVIEW GUIDE: NATIONAL FORESTRY OFFICIAL

1. What is the current version of the national forestry policy that the government of Malawi is using?
2. Has there been any amendments done to it, and why?
3. What are the objectives of this policy?
4. In your assessment do you think these objectives are being met in the country?
5. If not, what would be the reasons for the failure?
6. What problems does your office face when implementing the policy in the country?
7. What are the main causes for deforestation at a national scale?
8. What is your office doing to curb the deforestation in the country?
9. What problems do you face when doing your job as a national forestry office?
10. Would you say your efforts in combating deforestation in the district have been a successful or not?
11. What would be the reason(s) for your answer above?
12. What do you think should be done to reduce the rate of deforestation in the country?

*******Thank you very much for your time*******

Appendix 5: Guide for interview with Director of Renewable Energy

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

KEY INFORMANT INTERVIEW GUIDE: DIRECTOR OF RENEWABLE ENERGY

1. What is the current version of the National Energy Policy (*NEP*) that Malawi is using?
2. What does the *NEP* say about improving access to renewable energy in Malawi?
3. To which degree has the policy been implemented to achieve improved access to renewable energy options in rural areas in Malawi?
4.
 - a. What challenges do you face in the implementation of the policy on improving access to renewable energy in Malawi?
 - b. What mechanisms have been put in place to tackle these challenges?
5. What factors have necessitated the government of Malawi to promote renewable energy in the country?
6. What are the main RETs being promoted by the government in this country?
 - a. Which one of these is the most common?
 - b. What would be the reason?
7.
 - a. What has been the response of the general public towards RETs?
 - b. What reasons do people cite when adopting RETs?
8. What conditions have been put in place to ensure more households access RE?
9. The government has embarked on several projects to promote RETs. What is the importance of such projects?
10. According to the Malawi energy mix, RETs occupy about 2.0% of the mix. What do you think has been responsible for this decimal performance?
11. What has the government done so far to address these issues?
12. What problems is the government facing in improving access to RETs?
13. Has the number of households using renewable energy increased?
 - a. If yes, what is the rate at which people are accessing RETs in Malawi?
 - b. If no, what would be the reason for the failure?
14. If you were to recommend RETs to other people, would you recommend solar energy? And why?
15. What would you say has been the impact of the solar energy to the rural households?

*****Thank you very much for your time*****

Appendix 6: Guide for interviews with board member MHPF

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

KEY INFORMANT INTERVIEW GUIDE: MHPF BOARD MEMBER

1. Would you please provide a background of the MHPF
2. What has been the role of the MHPF in these two villages?
3. In terms of solar electrification, what made CCODE & MHPF to choose these two villages for the project?
4. What has been the response of the villagers towards solar electrification project in the villages?
5. What has been your role as an organization in the implementation of this project?
6. What challenges did you face when implementing this project?
7. What problems does the project face now?
8. What do you think should be done to solve these problems?
9. In your personal capacity, do you think this project has been a success or has managed to achieve its objectives? In either case, please explain.
10. Would you recommend other groups to embark on such a project? And why?
11. What would be your advice on successful implementation of such projects?

*****Thank You*****

Appendix 7: Guide for interview with Head Teachers

RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE STUDY Chitala & Chimonjo villages, Salima, MALAWI 2013

KEY INFORMANT INTERVIEW GUIDE: HEAD TEACHER PRIMARY SCHOOL

1. What has been the performance of the pupils at this school for the following periods:
 - i. 2003 – 2008 academic years
 - ii. 2009 – 2013 academic years
2. What do you think has been the reason for such a performance in the period 2003 – 2008?
3. What do you think contributed to such a performance in the period 2009 – 2013?
4. What other changes have you noticed in the school from 2009 to present?
5. Would you say the solar electrification project in the village has been a success or failure?
6. Please give a reason for your answer above.
7. What would be your advice for those villages looking to embark on solar electrification projects?

*****Thank you very much for your time*****

Appendix 8: Interview guide for focus group discussions

INTERVIEW GUIDE FOR THE STUDY ON RENEWABLE ENERGY OPTIONS & EFFICIENT BIOMASS USE

FOCUS GROUP DISCUSSIONS (Chitala and Chimonjo villages, Salima. 2013)

1. Main sources of energy in the village (*please put them in order of importance*)
 - a. What were the sources of energy for cooking:
 - i. Up to 2008?
 - ii. 2009 – 2013?
 - b. What were the sources of energy for lighting:
 - i. Up to 2008?
 - ii. 2009 – 2013?

A. FIREWOOD

2. Can you describe the availability of firewood in the area:
 - i. Up to 2000
 - ii. 2001 – 2013
3. Can you describe the usage of firewood in the village:
 - i. Up to 2000
 - ii. 2001 – 2013
4. Are there any changes in smoke levels you might have noticed in your households from the use of firewood and other sources of energy for cooking
 - i. Up to 2000?
 - ii. 2001 – 2013?
5. If yes, what can you describe these changes
6. Scarcity of firewood:
 - i. What are the reasons for the scarcity of firewood in the area? *In order of importance*
 - ii. Describe the problems that you face as a result of firewood scarcity.
7. Describe the roles of men and women in the following categories:
 - i. Provision of firewood in the home
 - ii. Management of firewood in the home

8. Has there been any change in the acquisition of firewood in the last 20 years? *If yes, please describe the changes*

B. SOLAR ENERGY

9. Means of lighting before using solar energy:
- i. Can you describe the sources of lighting you used before you acquired solar home systems? *Put them in order of importance*
 - ii. What problems did you face when using these sources?
10. Please describe the benefits that you have realized from the use of solar home systems in your households.
11. What changes do you see in your homes ever since you started using solar energy?
12. Can you describe any other solar needs that you might have in your household
13. Who is responsible for managing the usage of solar home systems in your households?
14. Please describe the problems that you face when using solar energy in your households.
15. Would you recommend solar energy to other people?
16. In either case, why?

C. ENERGY SAVING TECHNOLOGIES

17. What do you do to save on firewood?
18. Explain why energy saving technologies are not common in this village despite their advantages?
19. What would you have loved to be done about the energy saving technologies so that they are common in the villages?
20. What are you doing as a community to curb shortage of firewood?
21. Are there differences in the type of energy acquired by men or women? If yes, please describe these differences.

*****Thank You Very Much*****