IMPACTS OF SOLAR PV MINIGRID ELECTRIFICATION ON THE LIVELIHOODS TRANSFORMATION OF RURAL COMMUNITIES IN KOROGWE DISTRICT, TANZANIA

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CERTIFICATION

The undersigned supervisor certifies that he has read and hereby recommends for acceptance by the Open University of Tanzania a dissertation titled: *"**Impacts of Solar Pv Minigrid Electrification on the Livelihoods Transformation of Rural Communities in Korogwe District, Tanzania"*** in partial fulfillment of the requirements for the Degree of Master of Arts in Monitoring and Evaluation (MA M&E) of the Open University of Tanzania.

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Dr. Reguli Mushy

(Supervisor)

……..……

Date

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DECLARATION

I, **Shukuru Bartholomew**, do hereby declare that, the contents of this dissertation are results of my own study and findings and to the best of my knowledge they have never been presented in any other University or Institution. Where other people's works have been used, the references have been provided. It is in this regard that I declare this work as originally mine.

……..…

Signature

……..

Date

DEDICATION

This work is dedicated to my lovely wife Lilian Anathe Nkya, my lovely sons Lawrence and Laurian, and my adorable daughter Laura for their care, patience, encouragement and remarkable tolerance they have shown due to my absence, late show ups at home during the whole period of my studies. May Almighty God bless this special family!

This work is also dedicated to my beloved parents Mwl. Bartholomew Meena and Mrs. Mary Meena for their love, care and struggles in setting the foundation of my education background. My sincere appreciation goes to my sister Glory and my brother Faraja for their support and words of encouragement. May God bless you all!

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ABSTRACT

This study aimed at assessing the impacts of solar PV mini-grid electrification on transformation of the livelihoods of community in Tanzania, with the case of Mpale village in Korogwe district. The main focus was to examine the level of awareness on energy savings and efficient use of electricity, examine level of community involvement in the project and to determine the opportunities solar PV mini-grid electricity can create to facilitate the livelihood transformation of the community. The cross sectional study research design was adopted and both purposive and randomly sampling techniques were used to collect data from 100 respondents using questionnaires, interviews, and focus group discussions. Observation was also used to ascertain the project impact. The descriptive analysis of data was done using SPSS version 16.0. Findings of the study have shown that there is basic awareness among the community members on the efficient use of electricity and energy savings. The study revealed that participatory approaches were used during project implementation; community was involved at different stages and capacities hence bring in sense of ownership. The study revealed that though the project impacts have started to be realized on the social and economy aspects, it is only 31.7% of the community is using electricity for productive purposes, due to low awareness on available opportunities. The study recommends for further awareness creation to users on best practices in using electricity efficiently and stimulation of electricity demand by supporting and providing appliances to enterprises for maximized productive uses. These assure sustainability of the solar PV minigrid system and the improved social wellbeing for transformed livelihoods of the community members.

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
AfDB	Africa Development Bank
CFLs	Compact Fluorescent Lamp
DC	Direct Current
EE	Energy Efficiency
FGD	Focus Group Discussion
FAO	Food and Agriculture Organization
Kwh	Kilowatt hour
LED	Light Emitting Diodes
MWs	Megawatts
NBS	National Bureau of Statistics
PV	Photovoltaic
REA	Rural Energy Agency
SDG	Sustainable Development Goal
SE4ALL	Sustainable Energy for All
SPSS	Statistical Package for Social Science
TV	Television
TaTEDO	Tanzania Traditional Energy Development Organization
UNDP	United Nation Development Program
UNIDO	United Nation Industrial Development Organization
VEO	Village Executive officer
VICOBA	Village Community Banks
WHO	World Health Organization
WRI	World Resources Institute

CHAPTER ONE

INTRODUCTION

1.1 Background to the Research Problem

Energy is an important factor in all the sectors and it plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Energy particularly electricity is required for meeting basic needs such as health, agriculture, education, information and other infrastructural services (Chaurey *et al*. 2004). As energy is essential for human development and an important catalyst to spur people's livelihood transformation, it can as well improve different social economic activities at households and community at large (FAO, 2000). Uninterrupted energy supply is vital and economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly (Oyedepo, 2012).

Energy poverty which is caused by lack of access to electricity, poor cooking solutions and inefficiency energy technologies is a global problem which is recognized in the Sustainable Development Goal 7 (SDG7). Mohn (2013) see that lack of access to sustainable energy services particularly electricity has lead most of the developing countries to continue to be trapped in a vicious circle of poverty, social instability, and underdevelopment.

According to OECD (2007), globally, nearly 1.6 billion out of the total population of 6.5 billion do not have access to any form of electricity, and 2.5 billion are dependent on biomass energy for cooking and heating. Moreover, about 1.3 million people

mostly women and children – die prematurely every year because of exposure to indoor air pollution from cooking and heating with traditional, inefficient biomass stoves (OECD 2007).

Providing electricity services to the rural areas is challenging as grid extension is only feasible and cost effective to densely populated and concentrated rural areas. It is challenging also because of the remoteness, poor infrastructures, existing complex topography, dispersed settlement, limited transmission distances, limited electricity generation and financial problems. (Koirala *et al*., 2013, Eder *et al.*, 2015, Baldwin *et al.*, 2015).

Like many other countries, Tanzania still suffers from the lack of reliable, effective and sufficient electricity in many parts of the country. The national grid, which provides approximately 1,438 MW of installed generation capacity (of a total 1,564 MW), where hydro dominate by 42% (656.88MW) serves only about 18 percent of the population (9 million people) (URT, 2016). Solar power contributes only 2MW. According to AfDB (2015), the efforts of the Tanzania government are to diversify and invest into different reliable energy sources for electricity generation as to ensure that by year 2020 at least 50% of the rural population is cost-effectively served by decentralized options than by centralized grid expansion.

The goal of providing universal energy access to all by 2030 under the UN-led SE4ALL initiative calls for new and innovative solutions to rural electrification and is fuelling the recent interest in mini-grids. Mini-grid solutions are emerging as a third alternative to rural electrification, coming between the Development of renewable

energy mini-grids in un-electrified rural areas is considered as the most cost-effective option in achieving universal access to electricity by 2030, as advocated by the UN-led Sustainable Energy for All Initiative (SE4ALL, 2015). Decentralized solar PV mini-grids are considered as ideal alternative and major solutions existing to electrifying rural areas (Contengen & Verin, 2016). It emerges as a third alternative solution for rural electrification coming between the option of large-scale grid extension and pico-scale stand-alone solutions like solar home systems (SHS) or solar lanterns (Pedersen, 2016). Rural areas according to Amous *et al*., 2002), cannot be transformed into a modern economy and their livelihoods cannot be significantly improved if there is no dramatic increase in their access to modern energy services, particularly electricity. Low access rate has inhibited the social economic development. In Tanzania context, the access and connection rates is still very low, whereby only 16.9% of the rural households and 65.3% of the urban households are connected or accessing any form of electricity (NBS &REA 2016). The GoT has all along engaged itself in restricting its electricity sector as to increase the connection and access rates to electricity. Through the Electricity Act 2008, new actors apart from national utility company are being involved to ensure maximized distribution of electricity for modern energy services (URT, 2015). With this enabling environment, few privately owned energy plants are running and they generate, distribute and connect consumers from different sources including solar PV mini-grids (AfDB 2015).

Despite the facts that there have been a number of efforts by various stakeholders to ensure that the rural areas and other marginalized communities get access to electricity through off grid solutions, there is still lack of knowledge and awareness on the

efficient use of electricity and energy conservation among the users of electricity. The study on minigrid status in Tanzania by WRI & TaTEDO in Gordano *et al.* (2017), confirmed that due to low awareness, most consumers of mini-grids electricity use inefficient and old electrical appliances i.e. incandescent bulbs, old fans and old fridges. Mohan & Sil (2014) also said that use of inefficient technology with high rated power capacities with no energy efficiency labels, the behavior of leaving electrical appliances on the power while no one is using is among the factors that accelerate the high expenditures in energy hence jeopardize the sustainability of these systems. It has led into increased rate of unsatisfactory attainment of the objectives of electrifying the community and the intended impacts. Twumasi *et al.* (2017) see lack of awareness and poor demand side management contributes into significant loss of electricity. It is stressed that if these determinant factors for sustainability of energy systems are not properly publicized, regardless of electricity, there will be no significant impacts at individual or community level.

Lack of participatory approaches during establishment of energy projects in rural communities is one of the reasons for the failure of energy provisions systems (Nelson &Wright cited by Parrot 2011). According to Anderson *et al.*(1999), energy planning is often viewed simply as provision and installation of the energy technologies in terms of percentages the communities is electrified, number of energy technologies distributed but the needs of the consumers is considered as an afterthought. Demand prediction is the major part of planning. It is only few project developers that involve the communities they want to help into project development process. Tembo *et al.*(2013) and Anderson *et al.*(1999) said that ignoring the involvement of

communities during demand assessment has in some cases led into undersized and installation of systems with capacities that cannot meet community energy demand especially for productive uses loads. Draeck & Kottsz (2017) also said that unnecessarily over sizing mini-grid increases the cost of the project that the community have to cover, or under sizing can lead to customer's frustration and dissatisfaction with the services quality, which could easily be a way to lose customers and inability of the remaining consumers to cover the costs through high tarrifs. So matching electricity demand with supply is important for the project economics of mini-grids, particularly solar mini-grids which generate only in daylight hours1. Un-sustainability has also been contributed by lack of local technical and management capacity by local technicians.

Lack of skills led into improper maintenances hence no smooth and reliable provision of energy services (Mwihava, 2002). Low level of participation of community in operation, managing, monitoring and evaluation of the energy projects has also contributed into failure to get the right feedback and progress.

In lesser industrialized countries like Tanzania most of the renewable energy projects solar PV in particular have concentrated on residential applications (Etcheverry, 2003). Knowledge on the capabilities of the solar PV electricity and the possible income earning opportunities that solar electricity can create is still little to consumers hence insignificant changes are being seen in their lives. Contejean &Verin (2017) sees that the use of electricity for income earning activities improves quality of life and increase local resilience and self-reliance. Bang *et al.*(2000) insisted that access to information is key whereby the knowledgeable consumers on renewable energy see

different opportunities within renewable energy and associated technologies than those with less knowledge. Since mini-grids are seen as immediate solution for electricity access to the marginalized communities, it was therefore important to study how these key determinant features of mini-grid sustainability have contributed and influenced the livelihoods of the served community.

1.2 Statement of the Problem

Access to electricity through the rural electrification programmes has been the central and cornerstone of most of rural energy strategies in the developing countries like Tanzania. Rural electrification has impacts to most aspects of human welfare including access to water, agricultural productivity, health care, education, job creation, and environmental sustainability (Ordano *et al.*, 2017). Limited access to reliable electricity hinders social economic development activities in the marginalized areas. With the support from the governments, and other stakeholders various actions to combat the challenges of unreliable electricity supply for energy services have been initiated including programmes and projects that installed off-grids energy solutions such as Solar PV mini-grids. These are to improve the quality of life, increased productivity and rural development at large (Mohn, 2013).

Many studies on rural electrifications projects in relation to development have been conducted (Barnes *et al.* 2003). The focuses of these studies have mostly been on the outputs of the off grid electrification projects done by either private or by the government. Despite of the known benefits of solar PV; there have not been many systematic impact studies for rural electrification project powered by Solar PV in Tanzania.

Little has been done in the context of assessing level of awareness of communities on efficient use of electricity, energy conservation, the community participation in development, operation, management of energy projects and type of social-economic activities and opportunities that solar PV mini-grid electricity can create to contribute into fostering the development of the rural poor for the improved livelihoods.

Therefore, this study aimed to fill the observed gaps on awareness, participatory approaches and opportunities through mini grid projects and the findings of this study which was conducted in Korogwe District at Mpale village will be used as basis for similar initiatives in the future for greater impacts for the transformed and improved social economic welfare of the communities.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study was to assess the impacts of Solar PV mini-grid electricity in transforming the livelihoods of rural communities in Korogwe District, Tanzania.

1.3.2 Specific Objectives

(i) To examine the level of awareness of the community on the energy savings and efficient use of electricity from solar PV mini-grid.

(ii) To examine the level of community involvement in establishment, managing and operation of mini-grid project.

(iii) To determine the opportunities solar PV mini-grid electricity can create to facilitate the livelihood transformation of the community.

1.4 Research Questions

(i) To what extent is the community aware and understand on the energy savings and efficient use of electricity from solar PV mini-grid?

(ii) To what extent do community participate in development, managing and operate the mini-grid?

(iii) What type of opportunities created through solar PV mini-grid electricity to facilitate the livelihood transformation of the community?

1.5 Significance of the Study

In Tanzania the rural electrification is still in its early stages, and expanding the grid to more isolated rural areas has proved to be not economically or geographically feasible. Off-grid solar solutions have increasingly becoming a growing sector to meet the energy demands, thus makes this study on assessing the impacts of solar PV minigrid electrification on transforming the livelihoods vital and significant. The findings have revealed the considerable role that solar mini-grid electricity can play towards changing the people's lives. The livelihood transformation is attributed to awareness on how to efficiently use electricity, participation of community during initiation, establishment and implementation of the projects and also to the opportunities that electricity can accelerate and facilitates its establishment in order to reduce the poverty at our communities.

Due to that, this study is very essential as it has provided lessons on how the users' livelihoods can be maintained and improved through a sustainable energy services provision; thus the study report can be used by different project developers in the

country to learn on the appropriate participatory procedures required when establishing similar energy project initiatives.

The project is also significant as the report can be used by financing institutions and suppliers of equipments to understand and learn on the opportunities that are within the renewable energy sector. They can provide loan for appliances that when used productively can increase income opportunities that make the community livelihoods improve.

The findings of this study will also be shared to the project developer (Ensol), village leaders and the committees whereby these findings may help them to learn on the issues that require their immediate attention in order to improve the ongoing project so that there is a continuous life changing caused by electricity. Finally, the study will serve as literature and roadmap to future studies that aim to link impacts of energy to other issues like economics, gender and development in general.

1.6 Scope and Limitation of the Study

The scope of study was to assess the impacts of solar PV mini-grid electrification on the transformation of the livelihoods of the rural community in Korogwe, Mpale as the area of study and whereas the targeted population was users of electricity. The study faced some limitation including minimal understanding of the respondents on the meaning of some questions due to low literacy level; so researcher had to modify the tool and change the strategy and administer most of the questionnaires face to face to respondents to avoid getting responses which were not reflecting what was required by the study. Availability of women was a challenge as most were in the farms

harvesting horticultural crops so had to undertake the data collection even at late hours as to get their opinions on the study.

1.7 Organization of the Study

The study has been organized into five chapters. Chapter one presents introduction and study context. Review of related literatures to the study is presented in chapter two. Chapter three presents research methodology, Chapters four presents findings and discussions of the study. Chapter five provides summary, conclusions and recommendations. References and appendices are placed at the end of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the review of literatures and theories related to this study. It is comprised of conceptual definitions of key concepts terms that were used in this study, the theoretical framework, the empirical literature reviews, conceptual framework and research gap.

2.2 Conceptual Definitions

2.2.1 Livelihood

Different scholars and groups have defined livelihood in different ways. Conway &Chambers(1992) defines livelihood as a means of gaining a living. A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. They said also that livelihood become sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

The important feature in this livelihood definition is to direct the attention to the links between assets and the options people possess in practice to pursue alternative activities that can generate the income level required for survival (Elis, 2000). The livelihoods assets or capital includes, natural capital(natural resource stocks from which resource flows useful for livelihoods are derived i.e. land water, environment), social capital (networks, membership of groups, relationships of trust, access to wider

institutions of society), human capital (skills, knowledge, ability to labour and good health to pursue different livelihood strategies, and physical capital (these are basic infrastructure i.e transport, shelter, water, energy, and communications and the production equipment and means, which enable people to pursue their livelihoods.

2.2.2 Solar Energy

Solar energy is the sunlight energy collected and used to provide electricity, heating, cooling homes, businesses or industry. It is a sustainable source in the sense that it does not provide greenhouse gas emissions and proved to be environmental friendly sources of energy. It is free and maintainable as the sun is here to stay. It should however be kept in mind that although solar energy as a source is free, its conversion is not free as it requires different devices like solar panels, batteries, inverter and different cables and switches to mention few, which in the end have costs. Makhijani and Alexander (2013) provides that there are two main categories of solar electricity which are Photovoltaic (PV) modules and Concentrating Solar Power systems (CSP) that focus on the sun's heat to drive a steam turbine. The focus of this study will be on the Photovoltaic solar energy.

2.2.3 Photovoltaic Solar Energy

Maycock (1999) defines photovoltaic (PV) as the direct conversion of solar radiation into electricity. This is particularly because photovoltaic energy conversion is based on photovoltaic effect. Photovoltaic solar modules convert the sun light directly into electricity. Solar PV can be used at any scale, from small-scale electronic appliances to decentralized household rooftop systems and from installations that power industrial facilities to utility scale PV farms (Makhijani and Alexander, 2013).

Photo Voltaic (PV) technology uses the electrical properties of materials known as semiconductors to produce electricity. When hit by sunlight, a semiconductor material creates an electrical charge, which can then be transferred through a circuit to anything that uses electricity. In a PV system, these semiconductors are produced in the form of cells, which are then assembled in a structural panel. Panels can then be assembled into larger groups, or arrays, to produce increasing amounts of electricity, depending on the amount of energy needed. Solar arrays can vary in size to provide the electricity needed for a home, office, or larger facility (Obeng and Hans, 2009).

2.2.4 Sustainable Energy

As per Davidson *et al*. (2007) sustainable energy is the energy that provides affordable, accessible and reliable energy services that meet economic, social and environmental needs within the overall developmental context of the society for which the services are intended, but distributed equitably to meet local needs.

2.2.5 Sustainable Development

Based on that concept the World Commission on Environment and Development (WCED, 1987) through the Brundtland report defined sustainable development *as a development that meets the needs of the present without compromising the ability for future generations to meet their own needs.* There is a link between the presence of renewable energy resources, deployment of technology and the potential impacts which in deed leads into sustainable development. Boateng (2016), see the concept of sustainability as inevitable subject in all development programmes, which seeks to improve the socio-economic and environmental conditions of the local people. Based on the definition given, fulfilling basic/essential human needs and extending it to

higher opportunities can lead into satisfying ambitions for a better life. Boateng (2016) affirm this by saying that providing the renewable solar mini-grid electricity in isolated rural community can fulfill the basic needs, which can extend to other opportunities for improved life.

2.2.6 Minigrid

Mini-grids are small electrical distribution systems connecting multiple customers to multiple sources of generation and storage. The mini-grids have three main characteristic features, which include nature of the power supply (AC or DC); the targeted market (domestic or industrial and the size of the system (Pedersen, 2016). Mini-grids are typically characterized by multipurpose electrical power service to communities with populations ranging up to 500 households with overall energy demand ranging up to several thousand kWh per day (Viral &Bansal, 2013). Minigrids have many features but an important feature of a mini-grid is that it can operate autonomously and supply electricity to isolated rural populations in circumstances where connection to the national grid is practically impossible or economically unfeasible. Nevertheless, the technology may also be designed to integrate with the central grid and operate accordingly except when disconnection becomes important in order to maintain power quality at the local level (Espinar & Mayer, 2011).

However, the designs and operation of mini-grids in rural areas can be on temporary basis while a community may be waiting for the arrival of the mainstream grid and the system may eventually be joined to the central grid, demonstrating the flexibility of mini-grid applications (Espinar & Mayer, 2011; Ruud, 2013).

2.2.7 Solar PV Mini-grid System

Solar PV mini-grid comprise of several arrays of PV panels designed to generate electricity from the sun independently for local distribution that serve numerous applications at household, business, and institutional levels (Palit *et al.* 2014). It is sometimes referred to as stand-alone PV system because it does not combine other energy technologies to produce electricity. At village-scale solar mini-grid systems, capacity usually ranges between 10 – 100 kW, which is of much bigger capacity than solar home systems and electricity is converted to AC quality power for local distribution (Ulsrud, 2011), typically for a limited number of hours. Generated electricity can be for domestics, commercial or for community requirements.

It consists of centralized power generation e.g. an array of PV modules, a bank of batteries, an inverter to convert from generated DC to AC power and a distribution system including poles, wires and consumer units. The size of the solar plant and the number of solar panels for a mini-grid is largely dependent on the calculated energy demand data of the particular community in which the plant is to be installed. Mohanty & Muneer (2014) emphasized on the significant feature of solar PV minigrid is that it utilizes a collection of lead-acid storage batteries to store and provide power in hours when the sun is unavailable.

2.3 Theoretical Literature Review

Many studies and researches are guided by theories and this study was guided by two theories, which are Amartya Sen's Capability Approach and Chambers Participatory Theory. These approaches were adopted for this study, as to show how the solar PV mini-grids can enable communities to transform their lives but also how their

participation in the whole process of the establishing renewable mini-grid project and using electricity efficiently and in a conservational manner can contribute into project sustainability that facilitate transformation of their livelihoods.

2.3.1 Amartya Sen's Capability Approach

In this study, the Sen's capability approach, which was developed in 1980s and being used in different studies of human development was adopted and applied. The focus of the study was on assessing the impacts of the solar PV mini-grids into livelihoods transformations of the rural communities, and the immediate changes in human development capital that has been caused by the presence of solar PV minigrid electricity.

Sen's theory of development as an expansion of capabilities is the starting point for the human development approach, whereby the idea that the purpose of development is to improve human lives by expanding the range of things that a person can be and do, such as to be healthy and well nourished, to be knowledgeable, and to participate in community life. Seen from this viewpoint, development is about removing the obstacles to what a person can do in life, obstacles such as illiteracy, ill health, lack of access to resources, or lack of civil and political freedoms (Fukuda, 2003).

According to Sen (1989), the development should be conceptualized in terms of people's capabilities to function; effective opportunities to undertake the action, the activities that they want to engage in and be whom the people want to be. Moreover, the capability approach sees human life as a set of beings and doings which some time are called *"functionings"* which includes working, resting, being literate, being

healthy, being part of a community and it relates the evaluation of the quality of life to the assessment of the capability to function (Robeyns, 2005). These beings and doings, which Sen calls functionings, together constitute what makes a life valuable.

2.3.2 Chambers Theory of Participation

Robert Chambers has been one of the leading proponents of participatory development practices through his arguments of *"putting the last first was necessary for rural development"*. This argument calls for a totally new way of thinking and doing development by calling for a complete shift towards approaches that are more community-driven and process-orientated. Chambers (2008) recognizes that in order for any development to be truly participatory, a new professionalism is required that entails changed approaches and methods. Chambers see participation as one of key concept that ensures the locals and the beneficiaries' genuine demands and priorities are put first.

By making the local community participate in the development, it gives them powers, and sense of ownership. Chambers see that the use of local information can help in to clarify problems and needs, enhance solutions, lessen the chance of misunderstandings, reach more people, and increase the commitment of the local people to the project, thus increasing the chance of sustainability and success of the project. He also argues that there is a need for the development professionals to proactively listen to and learn from the very people who they're trying to help, hence any development' should be done *by* or *with* the people concerned, rather than *for* or *to* them.

Other scholars and practitioners of participatory approaches see participation as an input to development projects. It can improve effectiveness and efficiency through use of local information and contributing labor and resources of the community,which in turn can lead to local ownership and promote self-reliance (Nelson and Wright, 1995: 183 cited in Parrot 2011).

It is argued that participation may be an end in itself which can increase confidence of the local citizens and make them feel empowered and part of the change. Duraiappah (2005) says that this can only be realized through representations of all groups who will be directly or indirect affected by project, equal participation to contribute through skills and abilities among beneficiaries, high level of transparency should be maintained, shared responsibilities in decision making.

Participation theory is seen as it is in dynamic state rather than in static state, in the sense that theories and ideas of community participation have been changing overtime due to the change of the society needs. Duraiappah *et al.*(2005) asserted this by saying that in late 1960's there was exploration of different models of participation and their relationship to community development and in 1970's, participatory methods and techniques became central tools for community development but since 1990's these approaches have become a mainstream and expected component of development.

2.3.3 Relevance of the Theories to the Study

The Sen's capability approach is relevant to this study as was used to show how the availability of solar PV mini-grid electricity in rural areas can gives rural communities

freedoms or valuable opportunities (capabilities) that will lead to the kind of lives they want, what they want to do or be the society that they want to be. Through solar minigrid the communities will be able to perform and accomplish many tasks, which could not be possible without solar power minigrid, hence increases their freedom of choice of services and reduce level of poverty.

The capabilities of solar electricity into transforming the livelihoods will be practical if it is used productively to increase the productivity and profitability of their day to day activities and business, stimulates the establishment of new microenterprises, improve their social services delivery (health, education) and access of information to improve their knowledge and skills.

The use of Sen Capability approach will set the base of argument that the success of the renewable energy solar PV mini-grid project in rural community will be assessed in terms of how it has impacted people's lives in expanding their freedom and capabilities; doings and beings. The participation theory by Chambers is also relevant to this study as it was used to assess how effective the community participation has been in ensuring the project sustainability. Long term impacts of the project can easily be seen in areas where communities are part of the implemented project.

The level of participation determines how sustainably the operation will be. The level of involvement in decision making, knowledge transfer, operation, management and in technical aspects are among the factors that were assessed based on this theory. Through this theory, it has proved that close participation brings sense of ownership to community and ensures security of the infrastructures.

2.4 Empirical Literature Review

2.4.1 Awareness on Energy Efficiency and Energy Conservation

Energy efficiency has become the key driver of sustainable development in many economies in the world. Improving energy efficiency, i.e. obtaining more final energy services from less energy is the surest and most direct way of increasing sustainability of the use of energy resources and decreasing the negative aspects as environmental pollution and financial costs which are associated with using energy and producing goods (Oyedepo, 2012).

In view of the important nature of the energy sectors and the effect it has on national development of any country, there is a growing concern about energy consumption, savings, and waste, particularly about electricity consumer's attitudes, behavior and practices with respect to energy sustainability (Uduoka & Okure, 2017). There have been impacts of using energy technologies which are not efficient, reliable, safe and affordable which then results into insufficient energy services provisions and this shows lack of awareness regarding the usage of such technologies.

According to (Rahman *et al.* 2016),energy awareness is referred to as the knowledge about how much energy is consumed. Showing its importance, Fragidis *et al.* (2015) said that energy consumers' awareness is a first step in adopting energy saving behaviours which is leading to efficient use of energy by consumers. Consumers and end user of electricity and other sources of energy need to reduce their energy consumption but they do not know how to do it without the knowledge. More importantly, consumers need to know in details about their energy consumption, such as how much electricity they use, when they use it, and how much it costs in time to

appropriately impact their monthly electricity bills and have to earn the result of their savings efforts. On the other hand, the more knowledgeable they are, the more interested they are in adopting energy saving practices.

Piccolo *et al*.(2014) say that on the energy efficiency context, efficiency gain has to be achieved at all stages of the energy chain, from generation to final consumption, though however, the main problem in this chain has been at the end users. Sometimes even if there is adequate knowledge of how to save energy and there is desire to do so; many consumers still fail to take noticeable steps towards Energy efficiency (EE) and conservation. Energy awareness towards energy saving requires an appropriate attitude and human behavior of the house inhabitants.

A study in Malawi on efficient energy use for household revealed that if users of electricity are well educated on the potentials of using high efficiency appliances, changing behavior of electricity, it plays role in saving electricity bills and it eventually increasing access to the majority lot who are not connected to power (Kamunda, 2014).

Lack of knowledge of how to monitor the energy use by consumers has led into reckless use of energy. Jain *et al.*(2012) asserted this by saying that energy consumption is very difficult to observe for the consumer, for various reasons. Most consumers have practically very few possibilities to effectively monitor their energy usage level, especially at the time of consumption rather their basics option has been to review their billing account and mostly it takes place after the consumption (Rahman *et al.*,2016). Though now days the availability of technologies for

monitoring energy consumption, especially smart meters are being used in some off-grids solutions including solar PV minigrids; it is still a new technology, not well known and are expensive for most of individuals to afford.

The lack of information on energy consumption for consumers in terms of how much energy they consume in their daily activities, practices that triggers high electric consumption, the presence of efficient electrical appliances, can lead into practices which discourage the energy savings. The consumers can become careless, uninterested to energy efficiency solutions, put less priority on efficiency and insensitive to environmental friendly energy technologies and policies. According to Fragidis *et al.*(2015),a general rule on this is that the more knowledgeable the consumers become, the more interested they are in adopting energy saving practices and in participating in energy saving policies and programmes in their respective areas.

A study by Ouda *et al.*(2017) in Saudi Arabia on the awareness on energy conservation among residential consumers revealed that despite of the existing of energy efficiency labeling system for appliances since 2010, only 43% were aware of the system and when buying appliances in the market only 57% do check for the efficiency label in the accessories. Understanding of consumer on the amount of energy that their products use is limited. This indicated that energy efficiency is not priority to consumers when buying appliances and also understanding and attention to energy labeling was limited. The use of old electrical appliance can also contribute into high consumption of electricity at all levels of consumers. A study to examine the electricity consumption and development of household's energy performance in India

was conducted and found when old appliances are replaced with the energy saving components, consumption was reduced by 46% on an average. The maximum reduction was observed by replacing fans and lights with energy saving equivalents. The high efficient appliances reduce consumption without reducing the hours of usage and efficient use of electricity reduce consumption and protect the environment (Mohan & Sil, 2014).

As saving energy and using it efficiently are key aspects to sustainability of the energy provisions, there are practices, which hinder the attainment of the objectives of most of the developed energy systems in off grid areas. According to Etiosa *et al.*(2009), some habits have been identified as reasons for energy wasting by electricity consumers. These include the dominant use of incandescent light bulbs, putting on lights to advertise goods, switching on outdoor lighting during the day, setting appliances on standby mode, simultaneous use of multiple appliances inpublic buildings, leaving appliance on when not in use, multiple use of inefficient heating equipment, purchase of second-hand appliances in fear of buying a new but substandard product and negligence in checking the wiring systems to avoid electrical leakage. Lack of understanding and awareness of such habits can be overcome by making people aware of their actions and the effect it has on the environment and energy system.

Though Abrahamse *et al.* (2005) said that awareness on energy efficiency is not necessarily a trigger to the behavior change of consumers, and that awareness is not sufficient for energy saving rather the behavioral change depends on how motivated the consumers are and their engagement, it is rational to assume that increasing

consumers' awareness about their energy consumption may influence (i.e. reduce) their consumption behaviours. Jain *et al.(*2012) affirmed that understanding what energy consumers want to know, how they perceive and realize energy efficiency and how they can be motivated to improve their energy saving behaviour is very important for the development of energy efficiency.

2.4.2 Community Participation in Development and Operation of the Project

The majority of renewable energy projects in many parts of the developing countries have been established by commercial developers. Only few of these developers especially those who are socially orientated have actually considered community involvement in any form, and majority of them just make contacts only at implementation stage.

According to Chambers (2008), the participation of the community in the development projects may be for the purpose of satisfying donors who are funding the project so that the project looks good while there has been no actual participation, or for cost minimization as the locals will be used to contribute time, and labor or it can be for empowerment of local community in decision making and owning the project hence contributions to the project sustainability.

The study by Draeck and Kottsz (2017) under UNIDO experience on the relevance of community participation showed that if the community participates in the development of the renewable energy mini-grids, it increases the understanding of local needs and productive uses of the electricity.

Kimera *et al*. (2014), see the community involvement and participation in the projects at early stages as key determinant of the future of the project because the assessment phase of the project must integrate an analysis of the local conditions and the rural community's needs. Azimoh (2016) also said that it is easier for rural electrification programs to survive if their design takes into consideration the existing structure, accommodates business interests, population growth and the corresponding load increases of the community. If participation is maximized in the design considerations it reduces chances of project failure, increases security, reduces chances of project rejection, theft and vandalism of project equipment and infrastructures, hence little chances of negative potrayance.

According to Roodt, (2001), the good indicators that there is a good participation of community, is when there is an interactive participation, people take part in joint analysis, in planning process and members of community are taking charge of their development process He added that involvement of local community in setting up the mini-grids infrastructures is one way of empowering the community as they will have employments which facilitate the rate of improving their lives.

Existing experience indicates that if renewable energy projects are purposefully designed to address local participation and gender issues, the chances that they will deal more effectively with local needs are higher, which in turn also enhances the possibilities of project sustainability (FAO, 2000). Moreover, the experience shows that without community being part of both the designer and implementer of the project concept, sustainability of the project may not be achieved since the community is

unlikely to take responsibility for something they do not own themselves (Wasilwa, 2015).

Smooth operations of the energy systems depend on how best the consumers are paying for their monthly bills or other charges. Draeck & Kottsz (2017) says that it will be easy to understand the willingness and ability of the community to pay for the energy services if at all are being involved. It helps in structuring tarrifs, which are affordable. Verin & Congojean (2017) said that if community is not aware on the tarrifs setting from the beginning, there is a tendency of not paying their bills hence results into inability of the project to cover for operation costs.

The sustainability of the renewable mini-grids solar PV mini-grid in particular depends much on how they are operated and maintained. Capacity building at local context is key for the performance of the systems. Thirumurthy *et al*. (2012) and Mwihava (2002) see that involving locals on the aspects of technicalities and maintenances of the energy becomes a valuable feature for project stability and sustainability hence extend the potential impact of the project on the communities. Lack of local capacity and inadequate maintenance procedure has been linked as source of problems to energy systems in rural areas (Ulsrud *et al*. 2011). Local knowledge and logistics of how to get spare parts is key to the project performances. According to Azimoh (2016), a study was conducted in one of the renewable mini-grid in South Africa and showed that smooth operation of the plant can be affected if there is no local knowledge and capacity to undertake replacement of parts as it has to wait for experts from town.

2.4.3 Types of Opportunities Created to Facilitate Llivelihood Transformation

Different studies on renewable energy, solar energy in particular, sees the energy systems as channel to development and livelihood transformation in the rural areas. The linkages between the improvement of the living conditions of rural communities, sustainable socioeconomic development, and appropriate rural energy services, particularly electricity, have long been debated, but it is now generally accepted that they are critical (Zomers, 2014).

Rural electrification is considered as key to enable households to move up in the energy ladder and shift from low-efficiency and polluting biomass-based fuels to electricity. Photovoltaic solar energy positively impacted the rural lively hoods in different ways and there are notable transformational signs in all sectors which prove the capacity of solar energy in transforming livelihoods through improved education, health, creation of employment, information and communication and environment conservation. Sawe (2008) see access to modern energy services particularly electricity as not only a pre-requisite for agreeable living standards, but it is an indispensable input for productive, economic and improved social services.

Simultaneous access to electricity according to Kirubi *et al.* (2009) enables and improves the delivery of social and business services from a wide range of village-level infrastructure (e.g. schools, markets, and water pumps) while improving the productivity of agricultural activities. Zomers (2014) also said that the awareness and understanding on use of electricity for productive use has started to have positive effects on local employment and income generation for the poor.

2.4.3.1 Promotes Education

The use of solar energy electricity has been notably to have significant impacts in improvement of education in most of the households and communities in rural areas.A study by Gustavvson (2007) in Zambia showed that rural electrification contributes in education improvement. It has reduced drudgery and allows children especially girls to expand their opportunity for school attendance and other educational activities, changed the study routine time and has increased the school marks. The assessment done in Peru also showed that the attendance of children from electrified villages is higher than to un-electrified villages (ESMAP 2003). In her study in India, Buragohain (2012) said that providing solar electricity light for children to study at night may results in major improvement in their education performance.

A study in Philippines shows that electricity creates a child friendly environment whereby children from electrified households have higher education levels than those without electricity. It helps to obtain sufficient luminescence for study in a household at night and are able to utilize TV, radio, and Information and Communication Technologies for educational purposes (Kanagawa & Nakata, 2009).

Similar study was done in Honduras where through electrification, the application of ICT in schools was possible to enable students to learn and use modern and sophiscated appliance as to become more aware of what is happening in the outside world, (ESMAP,2002). There are other direct impacts of electrification in education improvement such as using of computers, televisions, or improving working environment through retention of qualified teachers who are attracted to the electrified villages.

2.4.3.2 Improving Health

Public health is a critical sector in off-grid communities but the health improvement can remain a myth if the issue of reliable energy supply is not addressed in disadvantaged and in marginalized areas not connected to grid.

The study in India by Buragohain (2012) showed that solar lighting has helped different households to overcome health problems, which resulted from use of kerosene and candle burning in the closed rooms. Colombo *et al.* (2013) said that the dominance uses of charcoal, coal and unprocessed biomass for cooking and heating purposes in households cause respiratory problems and high levels of mortality. The indoor air smoke contributes to respiratory infections that account for up to 20 percent of the 11 million deaths of children each year (DFID cited by UNDP, 2004). Access to better lighting facility, efficient and cleaner technologies for cooking, boiling water and space heating decreases the health risks and environmental degradation. It also improves health knowledge through awareness programmes in televisions for improved nutrition (Madhu & Narasimha, 2009).

Access to solar PV electricity in health facilities is one of the indicators of the improved livelihood. Pregnant women and children life in most of the rural areas have been at risks since they are not accessing quality health services (AfDB, 2014; Chaparro, 2016). Women deliver under very uncomfortable conditions due to the lack of essential equipment, medical facilities and poor visibility after sunset. With reliable and consistent supply of electricity to these facilities, they can be able to power water pumps for clean water, power medical and diagnostic equipment, vaccine refrigeration, equipment sterilization and operating theatres (van Leeuwen, 2014).

The challenge of health facilities to lack access to electricity has persisted for long though recently there has been a sharp decline in the cost of solar components, which could be used as alternative sources. The study done by WHO (2014) in Uganda revealed that only 58% of the operating health-care Uganda had access to electricity. Similar case of was also reflected in the whole of sub-Saharan Africa, where only 28% of the health facilities have reliable access to electricity. Tanzania like many other countries faces the same challenge whereby a study for the same revealed that by year 2006, more than 50% of heath facilities in Tanzania had no access to electricity, which implied that there are serious lacks of access to modern energy facilities for a better health services provisions.

2.4.3.3 Promotes Income Generation and Job creation Opportunities

Electricity whether it is provided through decentralized energy systems like solar home systems, minigrids, village energy centres or centralized grid utility, it is the main driver of economic activities for sustainable development (Roche & Blanchard, 2018). Where there is no electricity, businesses are less likely to start or expand; adding value to agricultural goods through processing is costly; and enterprises are usually limited to working during daylight hours (Baldwin *et al.*2015). One of the main forces driving renewable energy policies and development is the potential to create new industries, particularly small and medium enterprises, and generate new jobs.

According to REN 21 (2014), renewable energy jobs are estimated to be 6.5 million globally, with many more indirect jobs linked to it. The economic activities drive development in the community and energy will be required for productive business

activities to succeed. Boateng (2016), see that if the communities lack access to electricity, it also lacks basic infrastructures that can stimulate economic development to deliver a change in the lives of individuals and the community as a whole.

Etcheverry (2003) said that despite the facts that rural renewable energy projects have often concentrated on residential applications, and to a lesser extent on community needs, awareness on potential of mini-grids electricity has led into a growing number of projects that are now using renewable energy for productive uses. Martinot *et al* (2002)see there will be no improved life if access to electricity is only for residential uses rather for income earning activities. Agriculture is the sector, which more than 60% of the world population is engaged with. According to FAO (2005), securing access to water plays a strategic role in ensuring agricultural production. Etcheverry (2003) said that by addressing energy issues related to agriculture and off-farm activities, it can help to increase prospects for income generation in rural households/enterprises by providing energy for irrigation, food processing, food preservation and many types of manual production during evening hours. India alone, it is estimated that 4,200 solar pumps (200 W to 2000 W) have been installed in rural areas for agricultural applications such as horticulture, animal husbandry, poultry farming, high value crops, orchards, and also for providing drinking water (Martinot *et al.*(2002).

Rogers and Allderdice (2000) said that access to electricity can stimulate enterprises establishment which is opportunities for income and employment among the rural communities. Among the enterprises that can be established includes agro-processing,

carpentry, welding workshops, beauty salons, restaurants, food vendoring. Small rural stores can also expand their inventory by adding items that can be preserved using solar-powered refrigerators (Etcheverry, 2003).

2.5 Conceptual Framework

Conceptual framework is the system of concepts, assumptions, expectations, beliefs, and theories that support and inform research. It is a conceptual model of how one theory makes logical sense of the relationship among the several factors that have been identified as important to the problem (Kombo and Tromp, 2006). In addition, conceptual framework is considered as a map that draws together the concepts that students use to guide their research and suggests how they are related.

According to Adam and Kamuzora (2008), research variable is a factor or characteristic of interest that a researcher would like to handle, observe, investigate or manipulate in the research process so as to establish relationships between variables. This study focused on two variables, which are independent variables and dependent variable, though, the extraneous or moderating variables was partially assessed.

The study was guided by the framework Figure 2.1 which shows the correlation of different dimensions in the solar PV Minigrid which contributes into livelihood transformation in rural areas. Through the developed framework and based on the literatures that evaluates the impacts of the renewable energies project towards contributions in transformation of livelihoods various aspects dimensions have been studied.

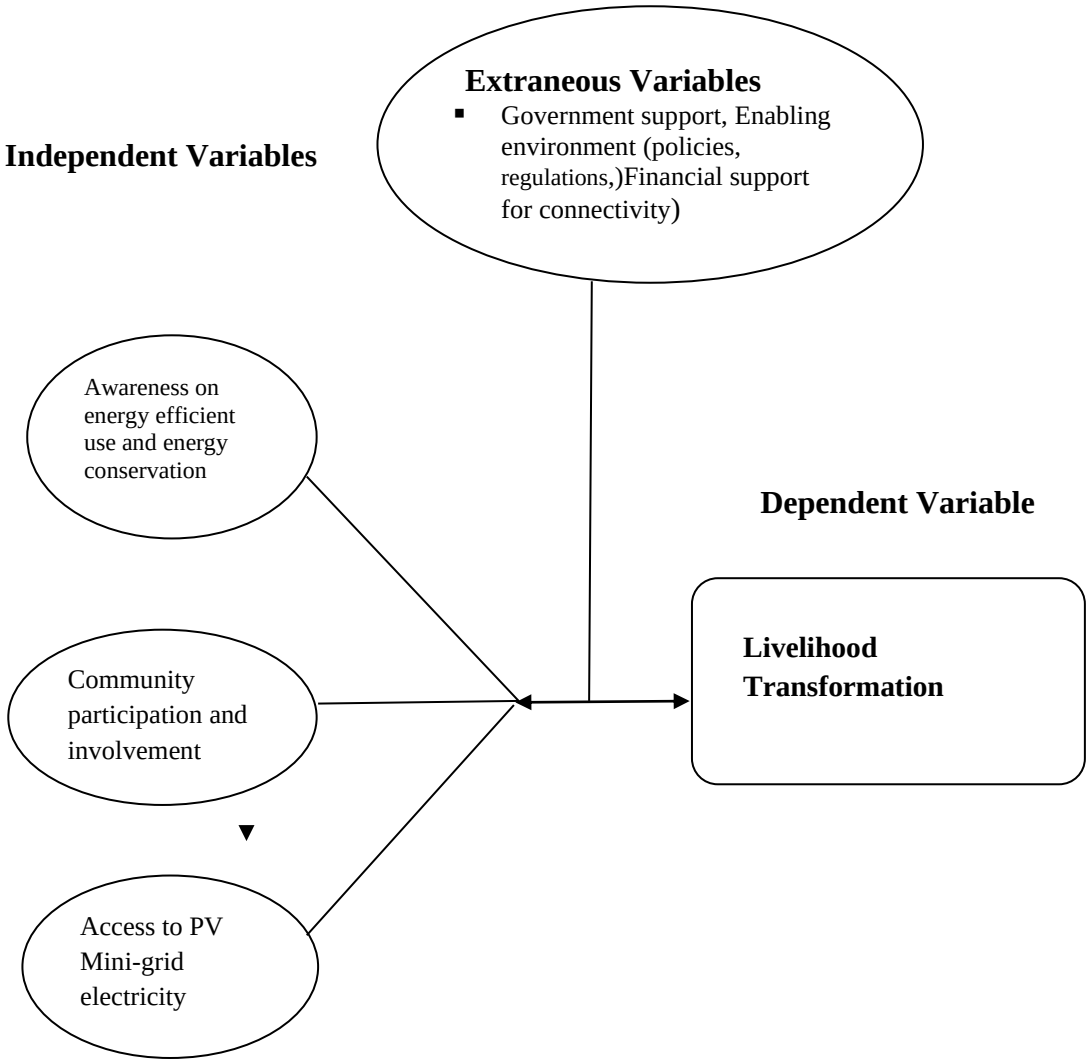

Figure 2.1: Correlation of Different Dimensions that Contributes on Livelihoods Transformation

Source: (Field 2019)

It has been shown that awareness creation on the efficient uses of electricity plays bigger role in saving electricity, costs, time of doing things, reduces risks of accidents, but also improves standards of social services delivery. The close relationship between level of awareness on energy efficiency uses, energy conservation and livelihoods transformation can be attained if there are supportive policies, strategies on efficiency or financing mechanisms to support for efficient appliances or knowledge transfers.

According to Oyedepo (2012), when energy is efficiently used, users can obtain more final energy services from less energy and this increase the sustainability of the use of energy and reduce the negative aspects like financial costs. The diversion of the saved resources to other social economic aspects contributes significantly into the improving living status and livelihoods in general.

Sustainability of the developed project requires participatory approaches where the community is involved in every stage of its establishment. In this framework it is shown that there is a close relationship between the community participation in the projects and their livelihoods improvement. Involvement in knowledge transfer, decision making or demand assessment makes the project speaks the needs of the community (Mwihava, 2002; Thirumurthy et al., 2012). The sense of ownership, trust and the bond that is built between project and community assures a transparent management and operation of the project thus a sustainable services provision that leads to livelihood transformations.

Access to electricity is the driver to the social economic development that leads to poverty reduction. The existing relationship between access and the livelihoods transformation of the community is determined by various factors including favorable policies, regulations, better financing mechanism and support from the government. The establishment of the Mpale mini-grid became possible due to the Electricity Act 2008 that allowed independent power producers to sell electricity in off-grid areas. The result based scheme of financing from REA enabled the financing of wiring to consumers that accelerated access rate of electricity for a total transformation of the community livelihood. The livelihood transformation can be measured by assessing

the electricity access rate and Kirubi *et al.*(2009) confirmed the significance of electricity access by saying that it creates opportunities which assures increases to income, improved social service delivery, improved access to communication and increased productivity, value addition and quality of produced goods.

2.6 Research Gap

Renewable energy projects have been the ideal alternatives to the national grid in ensuring sustainable electricity supply for the marginalized and rural areas communities as it is cheap and reliable. The uses of traditional and inefficient sources for lighting and powering other electrical appliances have been costly to the users in terms of costs, time, health and environmental impacts (Buragohain, 2012). The developed off grids solutions in various rural have not been sustainable rather inconsistent in providing energy services. As the sustainability of the energy projects is determined by several factors, Kembo (2013) said that without long term sustainability, the benefits of the rural electrifications cannot be fully realized.

In the empirical review, most of the studies on Impact of solar PV energy focused on the financing mechanisms, affordability and willingness of consumers to pay for the electricity generated, revenues collected and barriers for connectivity. It is unfortunately there was no significant and detailed information in these studies on the in-direct impacts of solar PV mini-grids electricity and the correlated factors that contributes into livelihood transformation of the rural communities. Due to that the study was conducted in Korogwe District at Mpale village as to fill the noticed gap.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Research methodology is a way to systematically solve the research problem. This chapter is focusing on the research methodology that was used to obtaining necessary data to support the subject under study, and it provide the details of the methods that was used in the field and even after field for collection and analysis of data. It covers Research Philosophy, Research Design and strategies, Research Approaches, Study Area, Sampling Procedures and Techniques, Data collection Methods, Data Processing and Analysis.

3.2 Research Philosophy

In this study the research philosophy used was Positivism, whereby as per Saunders *etal*. (2009), this prefers working with observable social reality and the end product of the research can be law like generalizations similar to those in physical and natural sciences. The Positivism philosophy was used because the study involved observations of various aspects of the studied project including the infrastructures, the users of electricity with their activities and the changes that have already happened at the village that have resulted from the existence of mini grid.

3.3 Research Design/Strategies

According to Saunder *et al.* (2009), research design is the general plan of how the researcher will go about answering his/her questions basing on the clear objectives of the particular research. It also describes the sources from which the researcher intend

to collect data and much consideration on constrains which are often inevitably like access to data, time, location and money.

The exploratory cross-sectional research design was used for this study. According to De Vaus (2002), a cross-sectional research design involves collection of information from representative population sample in one-time duration at a single point.The cross-section study was used to examine and determine the level of knowledge and awareness, level of involvement of community and opportunities created and associated practices by the community. Based on the objectives; cross-sectional study was applied as to give a clear description of the impacts of solar mini-grids electrification in transforming rural community livelihood at Korogwe Mpale. This implied collection of both qualitative and quantitative data through various methods such as indepth discussions and interviews.

3.4 Research Approach

The inductive research approach was applied during the study due to the facts that the identified concepts contribute into development of theories related to the study.

3.5 Survey Population

Target population is a group of respondents from which a researcher intends to make a study for generalization (Kumar, 1999). The target population of this study was users of electricity who are connected to the Solar PV minigrid at Mpale Village. Users included connected households, business centres (retail shops, butcher, restaurants, repairs centres, and TV shows centers), the social centres that is school, dispensary, and the faith based entities like mosque and church.

Since the population of connected customer was big, a sample of connected customers was made for the study for time and cost effectiveness reasons; and the information collected from the sample have represented the views of the rest of connected users. The users who were sampled out were identified through consultation and support of Mpale village leaders, and the Ensol project officer in charge who is based at the village.

3.6 Study Area

The study was conducted in Korogwe District, at Mpale Village, Tanga Region. Korogwe is one of eight Districts within Tanga Region and is centrally located, well connected to the other region, northern and the central-coastal areas of Tanzania. Other districts include Lushoto, Handeni, Muheza, Kilindi, Mkinga, Pangani and Tanga.

Korogwe District has an area of 3,756 square kilometers, which about 13% of the total land area of the Region. The district lies in the latitude 4º15″ and 5º15″ south, and in the longitudes 38º0 and 38º45″ east, as shown in Figure 2. As per 2012 census, the district population is 310,346, while the village of study has about 3,700 people.

Mpale village was purposely selected as area of study because it is a typical rural marginalized village, with all criteria that fits for the focus of the study, which is presence of an operating solar PV mini-grid plant. Solar PV plant of 48kW with distribution network of almost 8km was installed in 2017 by Ensol (T) Ltd, a company dealing with solar energy technologies.

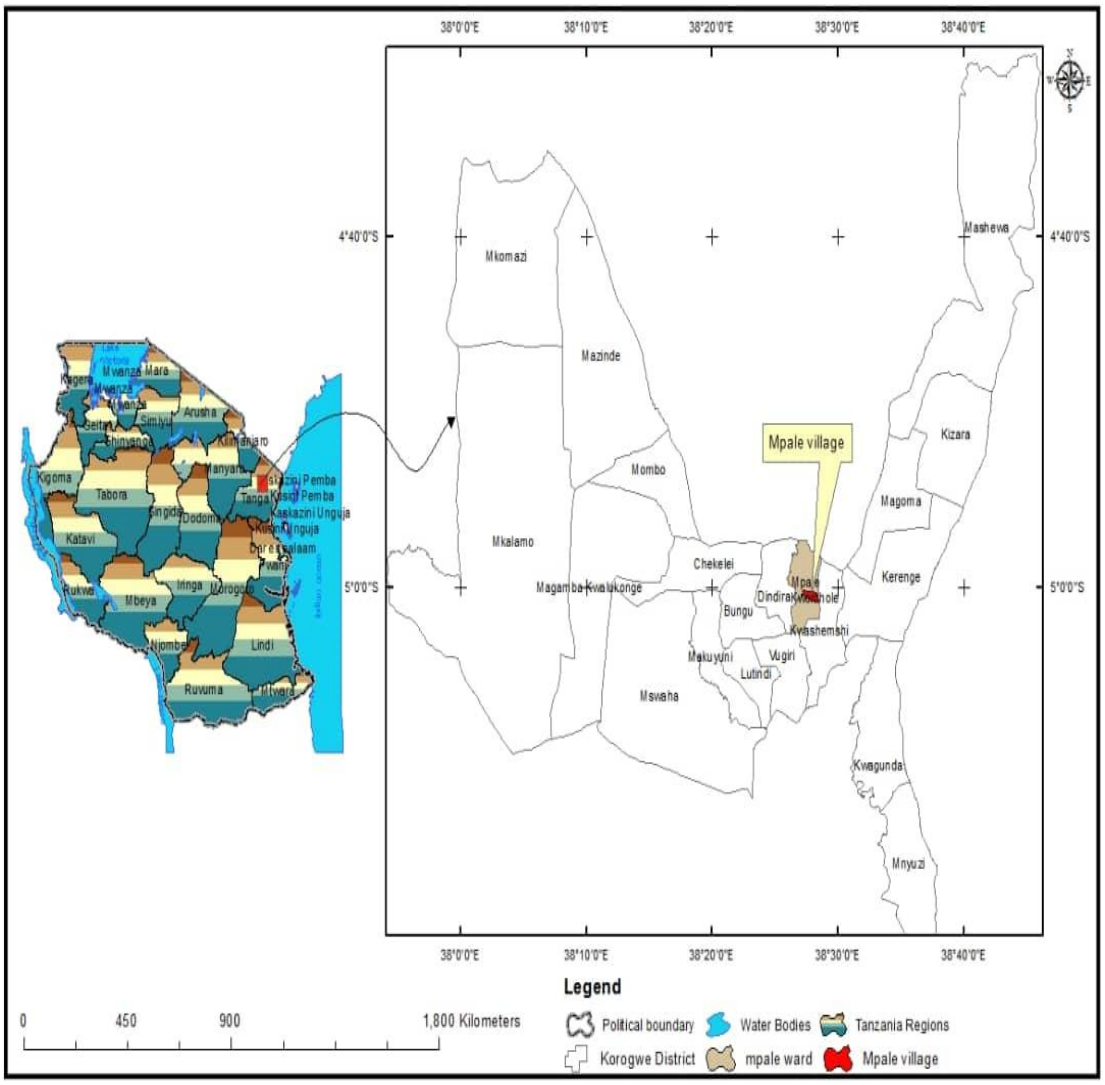

Figure 3.1: Map of Korogwe District showing Area of Study, Mpale Village

3.7 Sampling Design and Procedures

Before deciding on the better method that will be used for data collection there is a need to determine relevant sampling techniques (Kothari, 2004). In this study, both purposive and random sampling techniques were used.

3.7.1 Sample Size

Sample size is a finite part of a statistical population whose properties are studied to gain information about the whole. It is recommended that the size of sample should

neither be excessively large, nor too small but optimum. An optimum sample is one, which fulfills the requirements of efficiency, representativeness, reliability and flexibility. While deciding the size of sample, researcher must determine the desired precision as also an acceptable confidence level for the estimate (Kothari 2004. Sample size of the studied population was determined using Yamane's (1967) formula, which is;

$$\mathbf{n= \quad N/\ 1+N(e)^2}$$

where by e = level of precision error, N =size of the total village population, n= sample size(users of electricity thus households, business, institutions)

Initially N = 3700, e = 10%, **n** =?

From the formula:

n = 3700 / (1+ 3700 *0.1^2) = **97.37**(since we cannot sample a fraction of person)

Then, n = **100**

3.7.2 Purposive Sampling Technique

In this study the purposive or judgmental sampling technique was adopted in selecting the participants for the focus group discussions and interviews. The technique was used to fulfill the purpose of getting participants who had detailed information, experience and knowledge regarding the project impact, its implementation approaches, as well as strategies that ensures sustainability of the project. The participants were identified with the support from the village leaders. On that basis a total of 40 participants were purposively selected for group discussions and interviews.

3.7.3 Random Sampling Technique

The random sampling technique was also used to select the sample size out of electricity users at the village. A sample size of 60 respondents was randomly selected from the list of names of connected customers and users of electricity (*herein refers to households, businesses and institutions*) from each sub village. Since number of connected end users was different from each sub village, a calculation was made to determine the percentage of connected customers who were to be part of the study in each sub village. Their names were written in the papers, put in the bag, mixed and randomly picked up to reach the total desired sample size of 60.Sampled customers were visited and administered with questionnaires, and the gathered information was analyzed and presented in different form.

3.8 Methods of Data Collection

Data collection refers to the process of gathering specific information aimed at proving or refuting some facts (Kombo and Tromp, 2006). Data Collection is an important aspect of any type of research study.

3.8.1 Primary Data

According to Kothari (2004), the primary data are those, which are collected afresh and for the first time, and thus happen to be original in character. This implies that these are data, which are collected directly from the respondents. The following data collection methods were used.

3.8.1.1 Questionnaires

The semi-structured questionnaires with both open and closed ended questions were used to gather the required data among the electricity users. The questionnaires

designed to four sections where section A was for personal profile of respondent and section B, C and D contained open and closed questions relatively focusing and addressing the specific objectives of the study. Through this method the behaviors of respondents, attitudes, preferences, and opinions of the sampled out users of electricity towards the Solar PV mini-grids electricity at Mpale village were gathered. Both self and interviewer administering techniques were used during collection of data. The questionnaire used for the study is as indicated in Appendix I.

3.8.1.2 Semi Structured Interviews

During this study, the face-to-face interviews with some of respondents were conducted. Researcher conducted semi structures interviews guided with open ended question with Ensol project developer officers at the village, the school teachers and medical officer to obtain information regarding the social, economic impact of the installed solar PV mini-grid and implementation approaches of the project. The respondents were introduced to the objectives of the study so to enable them to participate by listening, responding on the posed questions or issues that required clear responses.

The open ended questions were used to introduce new ideas and the questions were probing more information or checking the meaning of whatever explained by the respondents. Through these interviews researcher got to know and understand the project better and the immediate impact in social services and economy of the villagers. During interviews both notebooks and tape recorders were used to records the responses and various descriptions given by respondents for easy data analysis.

The interview guide question checklist is as in Appendices II and IV of the research dissertation.

3.8.1.3 Observation

Observation is the most commonly used method especially in studies relating to behavioral sciences and it is keysince it gives the actual and real situation on the ground. In this study the observation was used to gather some important information related to the behaviours of the users on the efficiency use of solar mini-grid electricity. Other issues which were directly observed during the study includes; established enterprises at the village such as barber shops, compressor center, the events that are happening at the village such as utilization of electricity through socialization activities i.e watching news bulletin and soccer matches at show centers, businesses being open till late night hours, the developed infrastructures and the immediate changes that have been accelerated by the mini-grid. These observations prompted many questions to respondents especially during FGDs and interviews so that to understand from them their feelings and perception towards the mini-grid project and its services at their village. It was then observed that through skills, knowledge and awareness that was created prior project, majority are practicing the efficient uses of electricity especially on lighting practices and efficiency; only few were not abiding by living appliances in operation while no users around.

3.8.1.4 Focus Group Discussion

In order to collect more information of this study, focus group discussions (FGD) were carried out and the participants of these discussions were purposively identified and randomly selected based on their experience on the project, benefits and their

tasks within the project. Three focus group discussions were organized. The identification of the participants was done with the assistance of the village leaders and the project officers.

The first group discussion was purposely set for 12 women who are users of electricity at both business sites and households. Women discussions were held separately to ensure that speak freely on how the project of solar grid electricity has impacted their lives, how women and girls are empowered, their contribution and participation in the project, whether they feel marginalized, challenges faced, what productive activities and business have been created by women through electricity and their views on areas the project could improve for better energy supply.

The second focus group participants were village government council members. This comprised of two (2) top leaders who were village chairperson and village executive officer (VEO) and other twelve (12) members of village government council. These were gathered together to give out key information regarding their participation, influence and support towards the success of the project.

The third focus group discussion comprised of mixed participants who included 5 members of project management committee, 1 faith based institution leader, 1 micro financing group leader of VICOBA group, 1 former village chairperson –who received the project from the beginning and 1 leader of business owners at the village. In the discussions various issues were informed including how the project have helped and boosted different sectors at the village and even the feeling towards the project.

The FGDs were necessary for the purpose of testing and confirming thevalidity of information, which came up from the administered questionnaires and observations made during the study. The guide questions for both FGDs are as indicated in Appendices II and III of the dissertation.

3.8.2 Secondary Data

The secondary data are data which have already been collected by someone else and which have already been passed through the statistical process (Kothari, 2004). The secondary sources of data and information for this study included the progress reports of the project by officers, published articles regarding the project, internet materials regarding the project and workshop proceedings and presentations made to different stakeholders by the project developer that relates to the project. These information and data from these sources were useful by enriched and complementing the primary data.

3.9 Data Processing and Analysis

In this study both qualitative and quantitative data were collected using various methods. In order to visualize how the collected data were organized and summarized to assess the association between different variables in each objective, the collected data were entered into a standard Statistical Package for Social Science (SPSS) version 16 for analysis. The descriptive statistics was used whereby data were summarized into a table of frequencies and percentages. This has simplified interpretation of the data from ideas and opinions of the respondents for better presentation and description of the information. In this cross sectional study, the descriptive statistics assessed the respondents' characteristics, their level of awareness

towards energy efficiency and energy conservation, the participatory approaches and also the uses of electricity for opportunities that could lead into transformed livelihoods.

Furthermore, in this study, some of questions required responses, which specifies whether they strongly agree, agree, disagree, strongly disagree or they don't know. The responses were scaled and assigned numbers; 5 for strongly agree; 4 for agreeing; 3 for don't know; 2 for disagreeing and 1 for strongly disagree. During administering the questionnaires, the positivism or negativism of the respondent was indicated by one's agreement or disagreement with the statements.

In order to make an easier analysis and interpretation of the results, the researcher has combined responses of "strongly agree" and "agree" to show the agreement towards the particular question in each objective, "disagree" and "strongly disagree" to mean disagreement towards the question. On the other hand, where the respondents indicated "*don't know*" responses, through analysis it means that the respondents had no ability to weigh what was requested or lack knowledge on the particular topic or question.

3.10 Validity and Reliability

Validity refers to the extent to which the data collection method accurately measures what they were intended to measure (Saunders *et al*. 2009). The quality that a procedures or an instrument (tool) used in the research has to be tested. In this study the validity was made through pre-testing the questionnaires by a small number of respondents, and through this exercise is where the researcher discovered that

understanding of the respondents was low and could be a challenge in getting consistence results and answers every time, hence modified the tool and strategy of collecting data so as to capture the required information.

Reliability refers to the extent to which the data collection techniques or analysis procedures yield consistent findings. This was done by giving questionnaires to different respondents at different occasions whereby as per the expectation of researcher, the same and similar results were obtained. Reliability was also assured since all data were obtained from reliable sources being users of electricity and the officers from the company installed the plant.

3.11 Ethical Considerations

During the study the ethical issues were considered at high level, all the respondents did all on their own will during administering questionnaires, interviews and attending the FGDs. There were some of the sampled responds who werealso not ready to be part of the study due to various reasons and the researcher did not force them rather they were replaced by the household closer. The respondents were also assured the secrecy of the information they provided and were informed the information was only for academic purposes.

The study was also conducted in line with respecting the traditions and customs of the selected sample population. The questions, which were asked were non-offensives to respondents or to any actor involved in the project. The researcher was allowed officially by the University authorities to collect data through the clearance letter that was submitted to Ensol (T) Ltd to request for their assistances during the study as seen in Appendix V.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the findings of the study on the impact of solar PV minigrid electrification on transforming the livelihoods of the rural communities in Korogwe District, a case of Mpale village. The analysis of the level of awareness of community on efficient uses of electricity and energy conservation, community participation in Solar PV mini-grids development and operation and opportunities created by min-grids electricity to facilitate the transformation of the livelihoods of community members are discussed in detail.

4.2 Demographic Characteristics of the Respondents

The respondent characteristics were categorized in different groups,which included the age, sex, marital status, educational level and occupations. The characteristics shown are for the respondents whom their information were gathered through questionnaires.

4.2.1 Gender of Respondents

Figure 4.1 shows the gender of the respondents of this study. The research shows that 62% of the respondents were men (male) and38 % of the respondents were women (female).

The male group appears to be higher due to the fact that most of them are head of the families (households) and owners of the businesses, and also because they work little on the farms for horticultural crops. During the study, the harvest season for

horticultural crops, beans and the sugarcanes had started; so most men were either at home or at their business sites while majority of women were in the farm harvesting.

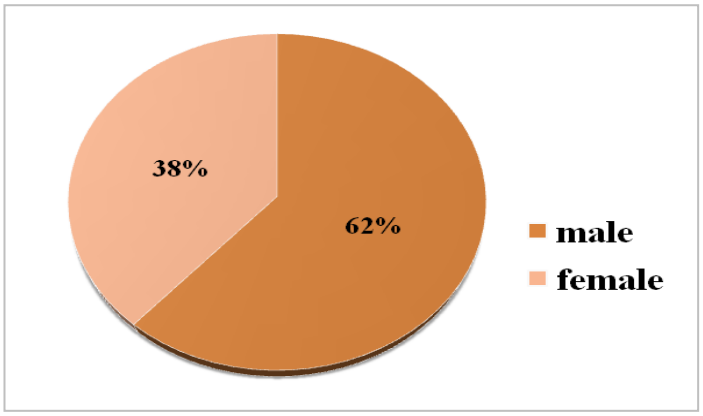

Figure 4.1: Gender Distribution of Respondents
Source: Field Study Data (2019)

4.2.2 Age of Respondents

The majority of respondents in this study had the age-range of 26 – 45 years, which is 53.3%, followed by those aged between 46 and 60 years, which is 21.7%. The age above 60 years is representing 13.3% while the group aged 18-25 years constitutes of 11.7% of the respondents as it is shown in Figure 4.2.

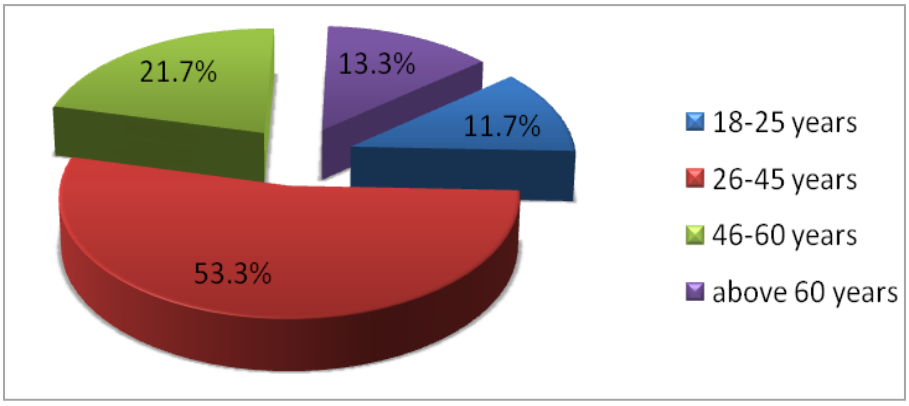

Figure 4.2: Age of Respondents

Source: Field Study Data, (2019)

Based on the findings, the age that ranged from 26-45years are energetic, active and it is the productive age, which is part of the working age population of years 15-64 according to NBS (2014). Majority are the owners of various assets in the village including business, houses and activities that utilize electricity productively. The age that ranged from 46-60 years represent middle age adults whom most of their activities are just close to their homestead like keeping livestock and small business. However, the group aged above 60 years which is 13.3% of respondents represents elderly people whom most of them are retired civil employees, not actively involved in the productive uses of electricity rather using electricity for basic s consumptive uses like watching TV, listening radio or in their small businesses.

4.2.3 Marital Status of the Respondents

In this study the marital status of the respondents was assessed, just to find out if there is any difference in utilization of energy based on the marital status. The findings as have shown in Figure 4.3 indicate that about 73.3% of the respondents were married, while 16.7 % were single, 3.3% were divorced and 6.7 % were widow. It implies that couples are financially stable, can afford costs associated with connection, wiring or appliances, compared to other groups.

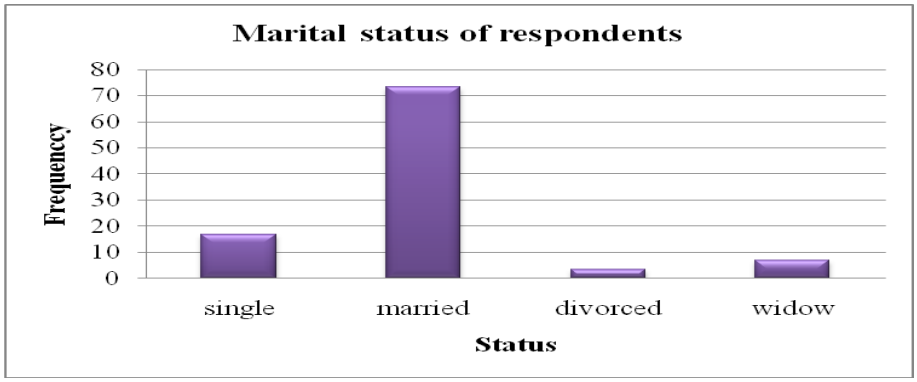

Figure 4.3: Marital Statuses of Respondents

Source: Field Study Data (2019)

4.2.4 Education level of Respondents

In this study the level of education of the respondents was also considered. Results in Figure 4.4 show that the majority of respondents (56.7%) had primary level education, followed by those with secondary education (25%). About 6.7 % of the respondents have never attended any formal classes in school. Only 1.7% had attained the degree level of education.

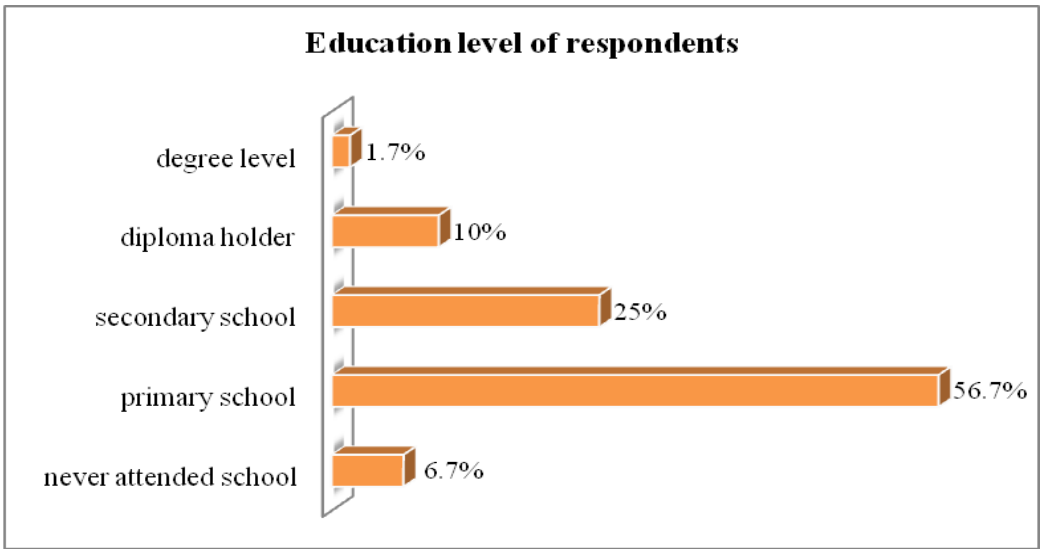

Figure 4.4 Educational Levels of the Respondents

Source: Field Study Data (2019)

As per the study, those attained diploma level were government employees including agricultural extension officer, teachers, nurses, clinical officer (who save at the school and dispensary in the village). The respondent with degree level was a priest of Roman Catholic Church. The number of villagers attained higher level of education is not impressive, this shows that; there could be various factors that could have hindered villagers to attain high levels of education; it is presumed may be lack of access to better and modern energy services including electricity could be one of the factors. The long term impact of the project would be able to establish this in the near future.

4.2.5 The Occupation of the Respondents

The information regarding the occupation of the respondents was also gathered as indicated in Figure 4.5, whereby group of farmers forms 45% of the respondents, while those dealing with businesses forms 31.73%, the employees forms 15%, livestock keepers forms 5% and the other 3.3% was formed by the group of other occupations which included the cleric.

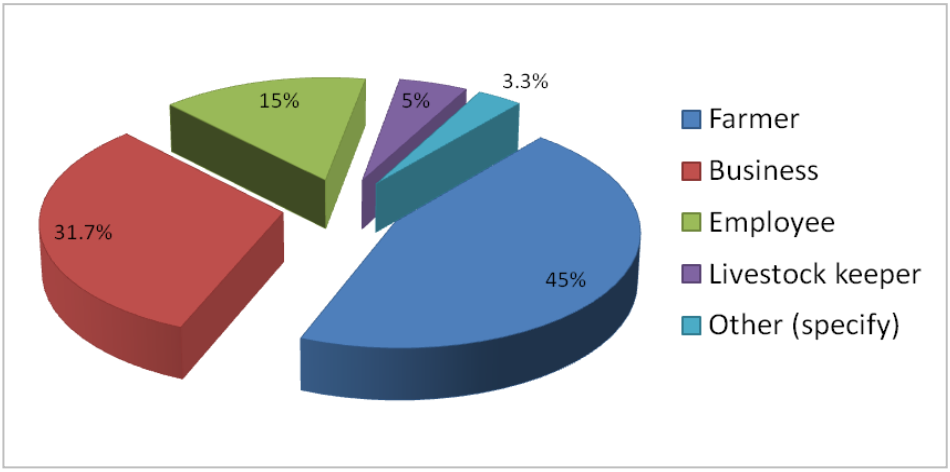

Figure 4.5: Occupation of Respondents
Source: Field Study Data (2019)

With these findings it implies that the backbone of the village is still relying on small and subsistence farming and petty businesses. Despite the fact that the minigrid has been working for more than 18 months by the time of study, not much has been invested that uses electricity productively that could reflect into presence of different or more occupations. Productive uses activities such milling, water pumping for irrigation, welding, metal fabrications and fittings are still the untapped opportunities. If will be well utilized could create new services and business lines that will provide a wide range of occupations for greater changes in terms of businesses, self-employment and income generations at the village.

4.3 The Main Sources of Energy Currently used in the Village

Energy demand in poor households normally arises from two major end-uses, which are both lighting and cooking. Cooking energy demand often accounts for about 90% of the energy demand in Tanzania (REA&NBS 2016). During the study, the findings have shown that biomass is the dominant source of energy in the village as indicated in Table 4.1 whereby 66.7 % of the respondents use firewood and 25% of the respondents use charcoal for cooking and heating.

Table 4.1: Type of Energy Sources used in the Village

Source of energy	Frequencies	Percent
Firewood	40	66.7
Charcoal	15	25.0
Kerosene	16	26.7
Electricity	60	100
Petrol &Diesel	1	1.7
Solar	11	18.3
Biogas	0	0
LPG gas	10	16.7

Source: Field Study Data (2019)

In the discussions it was informed that firewood is easily obtained in the farms and in the village forest, but charcoal is bought from the nearby villages. Charcoal is used mostly in restaurants and by some of government employees who can afford it. It was observed that the biomass energy sources are mostly used in traditional three stone firewood stoves, which are inefficient as they have high heat loss and cause indoor air pollution. Being dominant source of energy has caused a lot of pressure to the village forests catchments and poses risks to deforestation. This implies that there is a need of

creating awareness that apart from using efficient cookstoves; the minigrid electricity can also be used for cooking and heating when using efficient appliances such as pressure cookers, rice cookers and water thermo pots. Thus assures extended and proper utilization of electricity while conserving the environment.

As per Table 4.1, kerosene is also used by 26.7% of the respondents even though all the interviewed respondents are connected to minigrid electricity. It was informed that the monthly expenditures on lighting has been reduced substantially after get connected to the mini-grid. Kerosene is only used in smaller quantities mostly as a lighter to facilitate the startup of fire when using charcoal or firewood or sometimes used as source of light when there is an emergence power interruption from the minigrid supply.

These findings are similar to the study in India done by Buragohain (2012) whereby on the evaluation of the Impactof solar energy on rural development; significant reduction of kerosene was reported, thus cost saved, and health improved. Solar PV is another source of energy at the village whereby 18.3% of the respondents have smaller systems that range from 10- 40W, for few lights and phone charging. These are used as back up in-case of emergence.

LPG is another source of energy, which is used by 16% of the respondents who mostly are government employees. The study found that there is no LPG supplier at the village, rather users have to travel or make order from suppliers who are 45 km from the village for refilling services, which imply that it is an expensive source of energy, only few can afford. Petrol and diesel is also used by 1.7% of the respondents and this is for running a generator, which is used as a back-up in-case of emergencies.

4.4 Community Awareness on Electricity Efficient use and Energy Conservation

4.4.1 Knowledge on the Efficient use and Energy Conservation

In determining the level of awareness and knowledge of the villagers regarding the efficient use of electricity and energy conservation, the findings revealed that 51.7 % of the respondents had good level of knowledge, 18.3% had a very good knowledge, 20% with moderate knowledge while 8.3% had poor knowledge and only 1.7% had very poor knowledge level of the efficient use of electricity as shown in Figure 4.6.

Generally, the knowledge level of majority of the respondents on efficient use and energy conservation majority is good, and this has been contributed by the prior series of awareness raising campaigns and knowledge sharing by the project developer to the community.

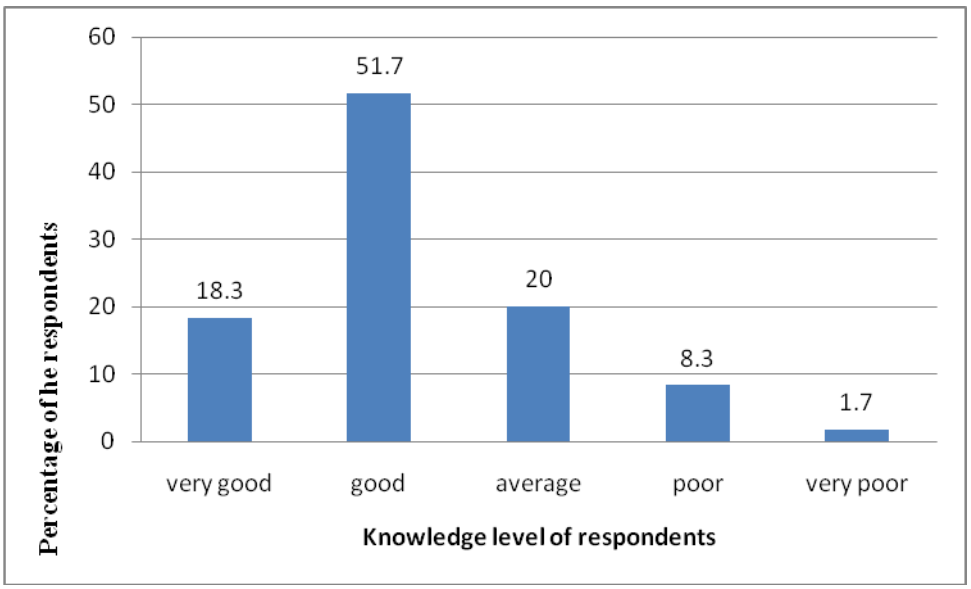

Figure 4.6: Level of Knowledge on the Efficient use and Energy Conservation
Source: Field Study Data (2019)

The importance of the prior awareness raising done at village was signified by conclusion made by Fragidis *et al.*(2015) in their study that energy consumers'

awareness is a first step in adopting energy saving behaviours, thus without knowledge that leads to efficient use of energy by consumers, there is no reduction in energy consumption. Efforts are required to ensure the minority (10%), whom their level is poor, are also imparted with appropriate knowledge on the energy efficiency as a strategy of not leaving anyone behind for the sustainable use of electricity.

4.4.2 Awareness on the Practices Lead to Efficient use of Electricity and Energy Conservation

The respondents level of awareness of the practices that lead into the efficient use of electricity and conservation of energy such as the use of high efficient appliances such as LED bulbs, switching off lights when not in use, switching off the appliances in the sockets, uses of fridges and where to position fridges for increased efficiency was tested. The findings as shown in Figure 4.7 have indicated that 52.5% of the respondents had moderate awareness of the practices, 25.4% had just little awareness while 11.9% had a lot of awareness and 6.8% were extremely aware and only 3.4 % of the respondents had no idea or awareness at all.

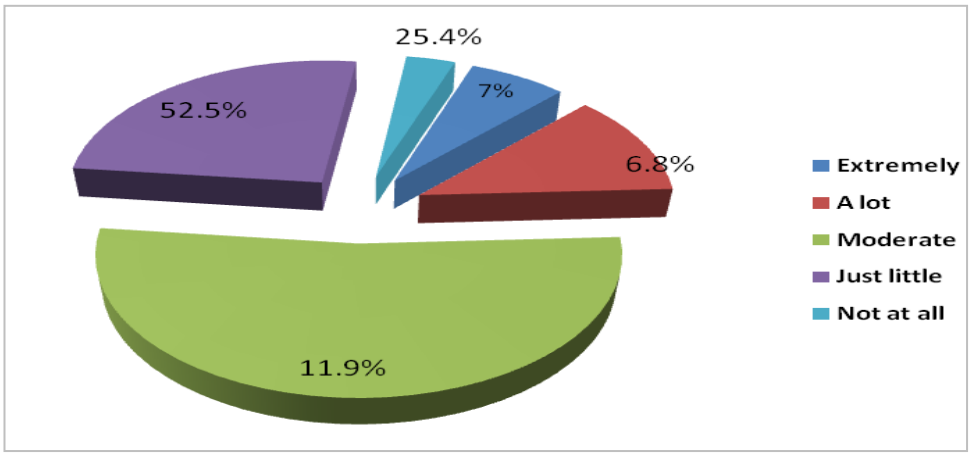

Figure 4.7: Awareness on the Practices Lead to Efficient use of Electricity

Source: Field Data Study (2019)

These findings imply that the majority has awareness on the efficient practices especially on light and lighting and it has been so due to awareness and demonstration meetings that has been frequently conducted by the project developer and her associates to the villagers. High efficient lights i.e. LED bulbs have become common at the village and now electricity consumers can easily replace them once those provided by project are burnt off. The market for CFLs and incandescent is diminishing; during the study only few houses were found to use CFLs lights and no one observed to use the incandescent bulbs. In some houses, owners have changed the old versions televisions which most have high rated power capacities of more than 150W and switched to efficient flat screen televisions which have less rated power.

Most of TV and radio users seem to understand better why switching off the equipment should be on the socket rather than leaving the equipment at the *"standby mode*" as it helps to avoid excessive use of electricity. Despite of awareness created, five houses were found to use electricity inefficiently by leaving lights ON in the afternoon, radio and TV operating while no one was in the house.

The assessment of the data has also shown that some users respondents on awareness depended much on the appliances and equipment they possess, thus no respondent indicated to be aware of the best practices related to ironing clothes or scheduling services for milling machines as no electric users own iron or heavy machines. Since energy conservation and energy efficient are new terms and practices, the connected houses were provided with a guide manual that have Dos and Don'ts on using electricity; it is placed near the smart meters where it is easily seen and has contributed in reminding them how appropriately they should act so that they can save

energy, save costs and ensure their appliances last longer hence contributes into livelihood improvement. During FGDs one respondent pointed out that in order to ensure that there is a continuous energy efficient practice; there should be a mechanism that will allow pupils and students as a young generation to become aware of the practices because they are also part of the users; to ensure sustainable utilization of electricity. This was supported by the quote below by one of the civil servant at the village;

> *"there is a need for energy efficiency issues to be included in subjects in primary and secondary schools, for our kids to be aware and should go along with professional training, that could raise consciousness and basic knowledge about the efficient use of energy and the most recent technologies that can contributes much into families savings when use electricity"*

4.4.3 Relationship between Consumer's Behavior and Electricity Monthly Tarrifs

During the study, it was informed that the tariff payment system is a pre-paid mode and there are different types of tariff groups/ category; but the monthly tariff for each category is flat rate. The tarrifs categories are determined by the type and number of appliances that the customer posses; and depending on the demand and ability to pay the customer decides the tariff group. Tariffs range from TZS 11,000 per month to TZS 53,000 per month. There is a fixed wattage allocated per day and incase the customer has defaulted by adding appliances not allowed for that tariff group, the electricity cut off even if there is a balance in the pre-paid bill.

For those feels to have higher energy demand they can request from the project developer to shift to upper tariff category. Based on that arrangement, the respondents were asked whether they were aware that their monthly bills are determined by their own behaviors in using electricity. The results in Figure 4.8 shows that 45% of the

respondents said that they were aware that their behavior in using electricity can be the determinants of their monthly bills, 48.3% said that they knew a little bit that their bills depends on their behaviors and only 6.7% of the respondents said that they had no idea.

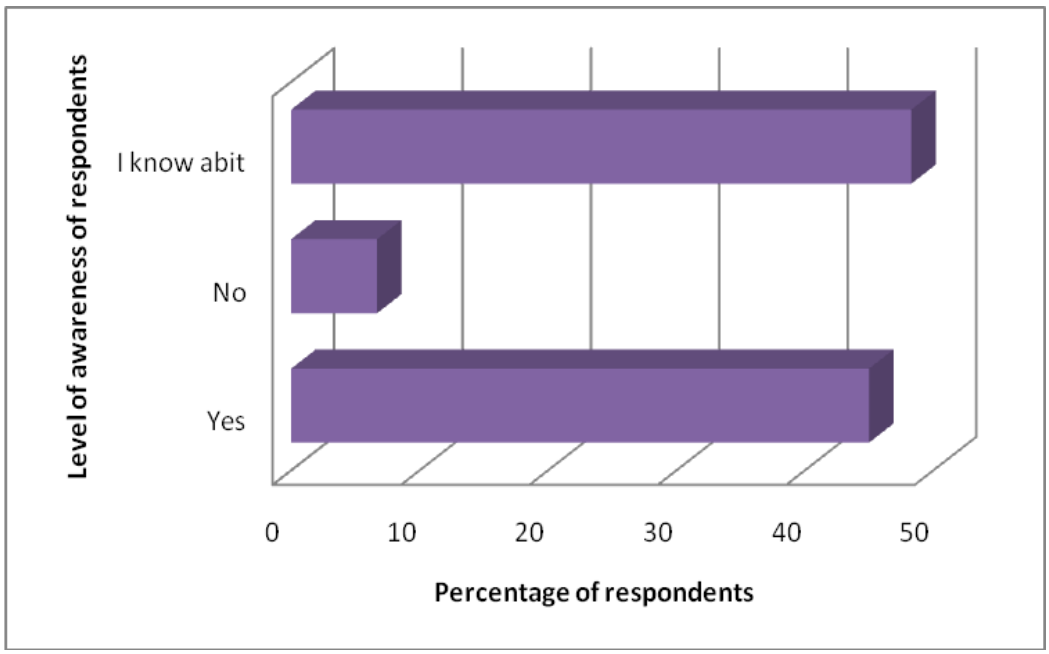

Figure 4.8: Awareness on Consumers behaviours in Relation to Monthly/Bills
Source: Field Study Data (2019)

These responses imply that knowledge on the behavior change in relation to the costs incurred monthly by consumers need to be strengthened so that consumers can adapt the behaviours that can make them see the positive changes on their electricity use and their monthly bills. Respondents were also asked whether they have seen changes ever since they started using electricity in efficient way. Though the tariffs are fixed but majority of the respondents as shown in Figure 4.9, which accounts for 58.3% said they have seen little changes and 26.7% said there are great changes in their monthly expenditure and only 15% said that there were no changes in the expenditures.

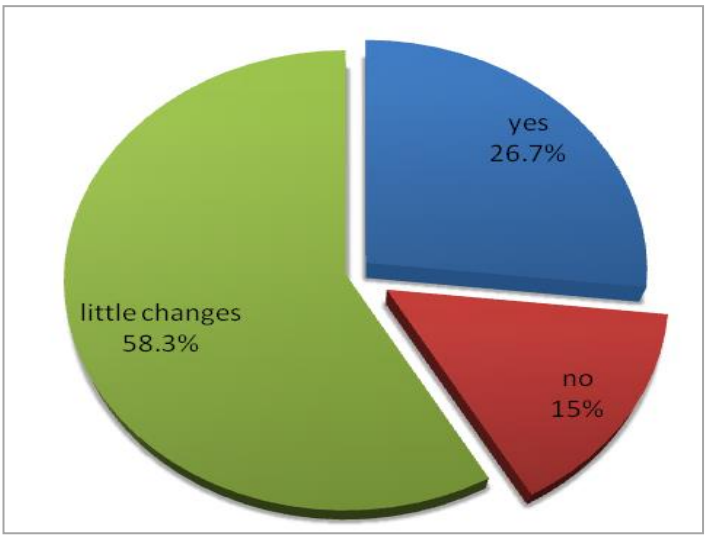

Figure 4.9: Observed Changes on Monthly Expenditures by Consumers

Source: Field Study Data (2019)

Based on these findings the changes that were seen included their ability to use the allocated wattage of energy per day (275W) without experiencing power blackout, few cases of appliances burn off, lasting longer of accessories and appliances like bulbs and plugs. It implies that level of awareness and knowledge on how efficiently electricity can be used for significant savings by electricity consumers is good. Saved costs can be used to supports other households' requirements that can lead into improved livelihoods.

4.4.4 Requirements for Additional Information on Efficient uses of Electricity and Energy Conservation

Despite that the respondents have shown that they have a certain level of knowledge and awareness on the efficient use of electricity and conservation of energy, they were also asked whether they think they would need more information related to the same. Figure 4.10showsthat 81.7 % of the respondents indicated to need more information,

16.7% indicated to need a little bit of information and 1.7% said that they would not require additional information, probably s/he knew it all.

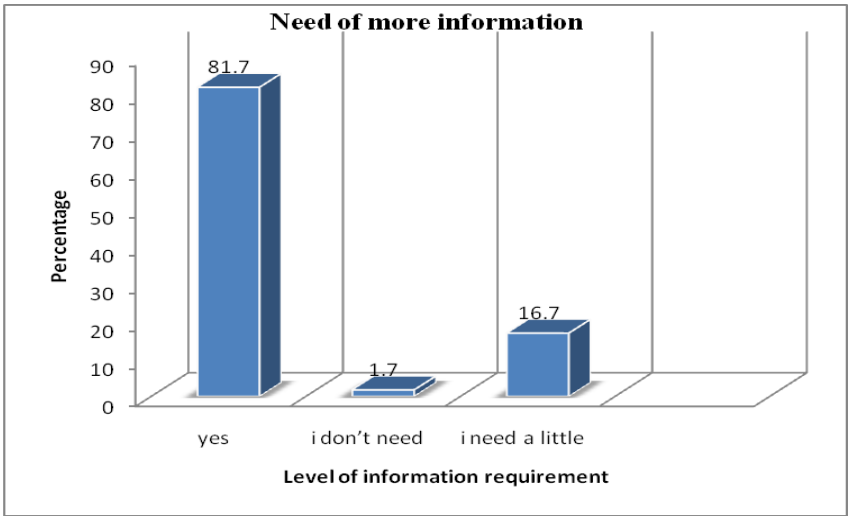

Figure 4.10: Need of Extra Information on Efficient uses of Electricity

Source: Field Data Study (2019)

It was informed that the reasons for some of respondents to require additional information as to reduce the energy efficiency gap included; some needed to know more on how to cut down daily operational costs and expenditures on energy, to plan better for additional appliances, better understanding on features to consider when investing for electrical appliances and families to be more aware of the efficient practices. One of respondents who is a retail shop owner said that, they need regular awareness sessions so that they become updated on the new appliances in the outer market.

> "*although awareness was created by Ensol and her partners regarding the efficient uses of electricity through leaflets and meetings but we need it on regular basis because the technology and type of appliances are changing now and then, this will help us to make informed decisions, this can be done by bring up the educative videos and we are ready to learn"*

Respondents were also asked what was the motivation for them to undertake the energy efficiency and energy conservations practices. It was informed that these

practices were done because consumers felt like the monthly/ weekly bills are higher so they need to be careful in order to reduce electricity monthly expenditures, they want to save costs reducing the rates of buying new appliances after every short period of time, protects equipment and appliances from burning off when not switched off at the socket. Other reasons include being sure they use the agreeable and recommended wattage per day to avoid power cut-off and to save time and increase efficiency by covering the utensils when boiling and cooking. Other respondents described the effects of not using electricity efficiently by linking efficiency and climate change, whereby through the use of LEDs bulbs and other efficient appliances; it reduces the green houses emissions, whereby collectively the impact in climate is reduced.

4.4.5 Factors Considered by Consumers when Buying Electrical Appliances

In this study, assessment was also done to understand whether respondents consider efficiency as a priority when buying appliances. It was noted that respondents have different factors or features which they consider as priority and important when they shop. Their responses on priorities when shopping areas indicated in Table 4.2 and Figure 4.11.

Table 4.2: Factors Considered when Buying Electrical Appliances

Factor/ feature	Frequencies	Percent
Cost of the appliance	37	61.7
Brand of the appliance	31	51.67
Energy/rated power of appliance	25	41.66
Status of the appliance	32	53.33
To meet the purpose/objective of possessing it	1	1.67
Shape, color, and appearance of appliance	18	30
Others, specify-quality of appliance	2	3.4

Source: Field Study Data (2019)

Findings have shown that 61.7% of the respondents considers costs of appliances, 51.8% considers brand of appliances (*i.e. Hitachi, Sony etc.),* 41.6% considers efficiency *(energy / rated power)* of appliances, 53.3% considers status of appliance whether is new, second hand, old), 30% considers shape and color while 3.4% of respondents said they consider quality of the appliances. Based on the findings; energy efficiency of the appliances seemed to be a factor of less priority compared to other factors.

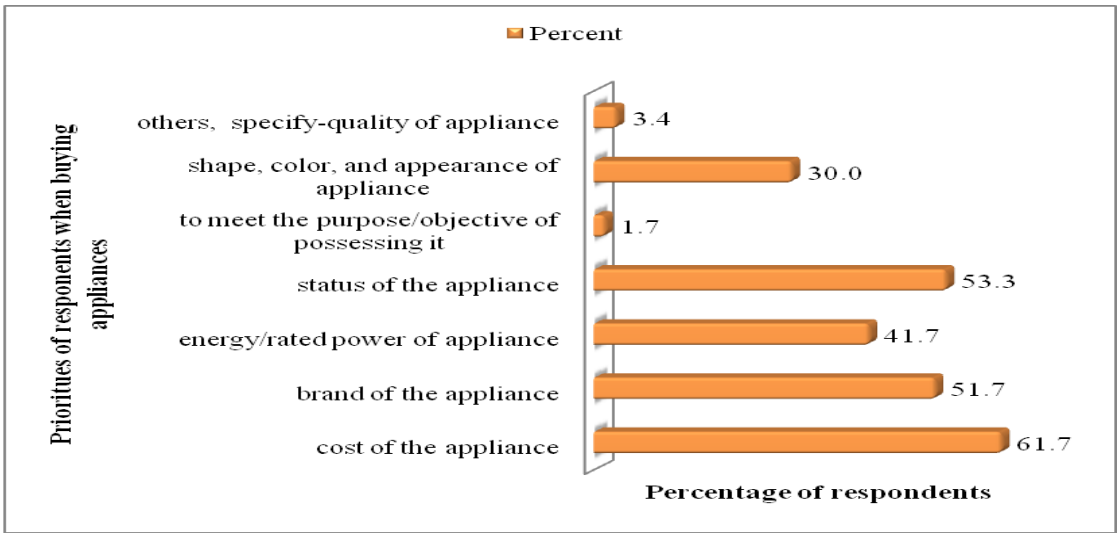

Figure 4.11: Factors Considered when Buying Electrical Appliances

Source: Field Study Data (2019)

This implies that users still don't understand the implications of acquiring inefficient appliances, which even if they use it efficiently there are no significant changes that can be seen in terms of savings in their daily routine uses of energy. This study is similar to the one which was done by Ouda *et al. (*2017) in Saudi Arabia where it was found that despite of existence of energy efficiency systems that include labeling; the understanding of consumers on amount of energy that their products use was limited, they were procuring appliances without considering their efficiencies. Based on the findings it implies that more awareness and capacity building knowledge is needed for

consumers to be able to identify visually the low rated power capacity appliances *(believed to be high efficient*) since not all appliances can be taken to labs to tests its quality and efficiency.

4.4.6 Factors that may Influence and have Effects toward Efficient use of Electricity and Energy Conservation

During the study, factors influencing efficient use of electricity and conservation of energy in the community were also assessed. In understanding the importance of information and awareness on efficient use of electricity, the results indicated in Figure 4.12 have shown that 81.7% of the respondents agreed that lack of awareness and information on the inefficient uses of electricity can lead into high uses and loss that may have positive or negative effects and can influence the efficiency use of electricity while 13.3% disagreed and 5% of the respondents said they didn't know.

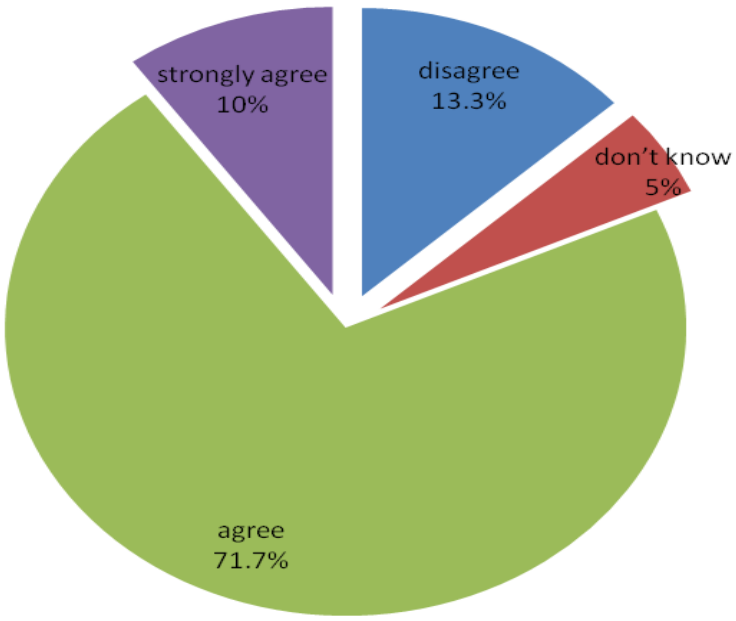

Figure 4.12: Lack of Awareness can Cause High uses and Loss of Electricity

Source: Field Study Data (2019)

In these findings the information, which seems to lack the most among the respondents includes standards of electrical appliances, sizes of cables and accessories that can be used to prevent the loss of electricity.

On the other hand, the respondents were also asked how they see buying high efficient electrical appliances and replace with inefficient one can be useful to save electricity and costs to users. On this Figure 4.13 shows that 55% of the respondents agreed on the idea while 30% disagreed. On the other hand, 15% of all the respondents said that they did not know whether that idea can be useful for the significant costs saving.

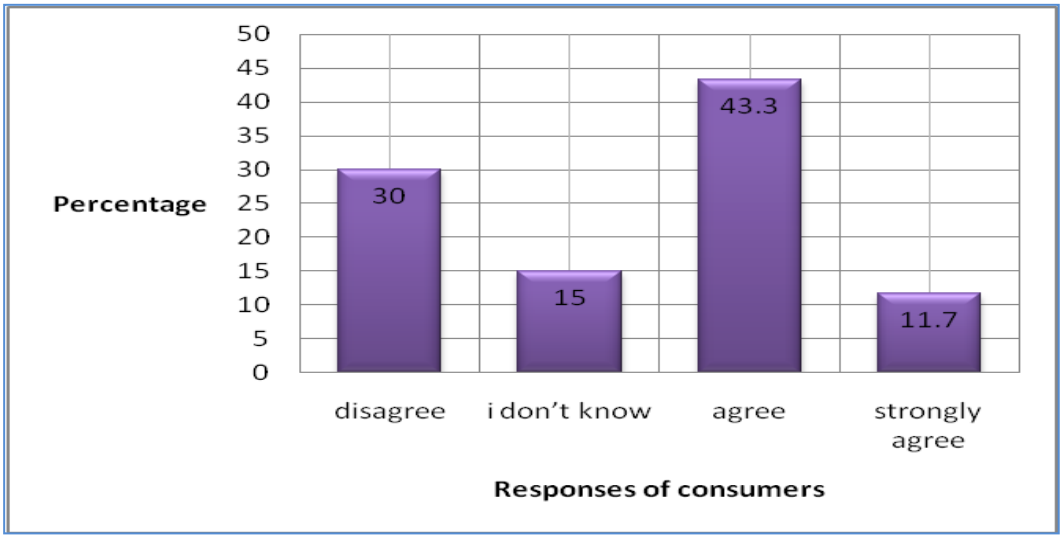

Figure 4.13: High Efficient Appliances Save Electricity Costs than Old Appliances

Source: Field Study Data **(2019)**

It was observed that the group that disagreed and claimed to be unaware or knowledgeable whether there could have been some costs savings and changes is the one which still uses efficient lights/ bulbs that were provided by the project, their bulbs have not burnt off yet, so they have never tested different types hence they could not be able to tell the difference. However, for the group, which agreed it implies that

it uses electricity not only for lighting and charging phones alone but powering other appliances like TV, radio and decks. One of the respondents who own a television said that;

> *"previously I was using an old TV famous "kichogo" and was consuming a lot of electricity, but after buying the flat screen, I have seen changes, electricity units are not going fast as before, this made me asked the project officer to change me from the higher tarrifs group to the lower one so that I pay for electricity that I can fully utilize.*"

Issues of costs of appliances and purchasing power were also assessed. When respondents were asked whether the high costs of efficient appliances and low ability to buy (purchasing power) can be the reasons why most of the villagers are not using efficient appliances, their responses are as shown in Figure 4.14 whereby 78.3% of the respondents agreed while 18.3% disagreed and only 3.3% of the respondents said they did not know (in their reply they hesitated to point directly) whether those could be the reasons.

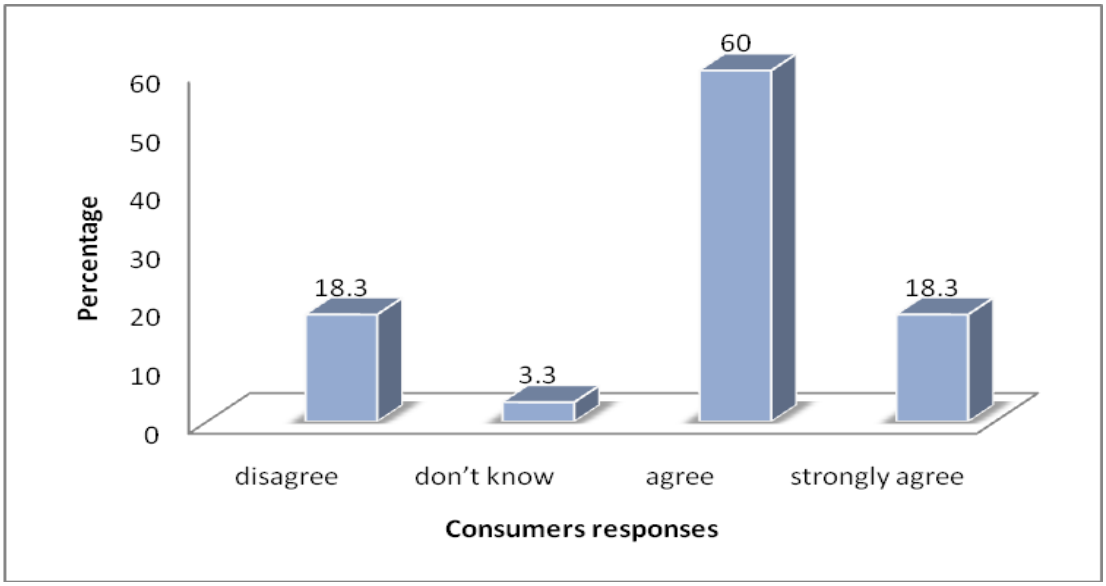

Figure 4.14: High Costs and Low Ability to Pay Limits Access to Efficient Appliances

Source: Field Study Data (2019)

The findings have shown that majority have indicated high costs (affordability) has been the hindrance towards the uptake and adoption of high efficient appliances, because their income is seasonal and not consistence hence they cannot afford for upfront payments for the appliances. Linking electricity consumers with financing institutions to access loan or loan for appliances from developers was seen as alternatives for increased usage of efficient appliances and equipment.

During FGDs and interviews it was also informed that not all electricity users managed to do internal wiring by their own, however there is no strong micro-financing institution that can support villagers with loan for such energy services. Only small groups of village community banks (VICOBA) do exist and their capital comes from members monthly contributions; which collectively cannot meet the financial demands for accessories and appliances in their houses. To ensure enough registered consumers to support the operations of the plant, the project developer had to take a step ahead and provide loan to customers for internal wiring. The loan came under the scheme of support from Tanzania Rural Energy Agency (REA) through its results-based financing mechanism. Customers had to inter into agreement with developer on the repayments terms. Despite of the agreements between the parties there has been a challenge on meeting the repayment schedules by customers but loan has greatly facilitated the rate of connectivity.

The findings are similar to what Sarker & Sigh (2010) observed in their study on financing energy efficiency and equipment in developing countries that since the low purchasing power of consumers is among the barriers to energy efficiency investments, access to loan under agreeable terms could be the alternative solution to

the majority. This is also similar to what Amous *et al.* (2002) found in their study in Ghana where the enterprises were supported by the project through arrangements with NGOS, and micro-financing institutions to accelerate connectivity and technology uptake to increase uses of minigrid electricity.

In assessing the mode of controlling the utilization of electricity, the respondents were asked if regular monitoring of bills helps to control the energy consumption. Results of study as shown in Figure 4.15 indicates that, 76.7%agreed, 16.7 % disagreedand 6.7% said they had no knowledge whether regular monitoring of bills could help.

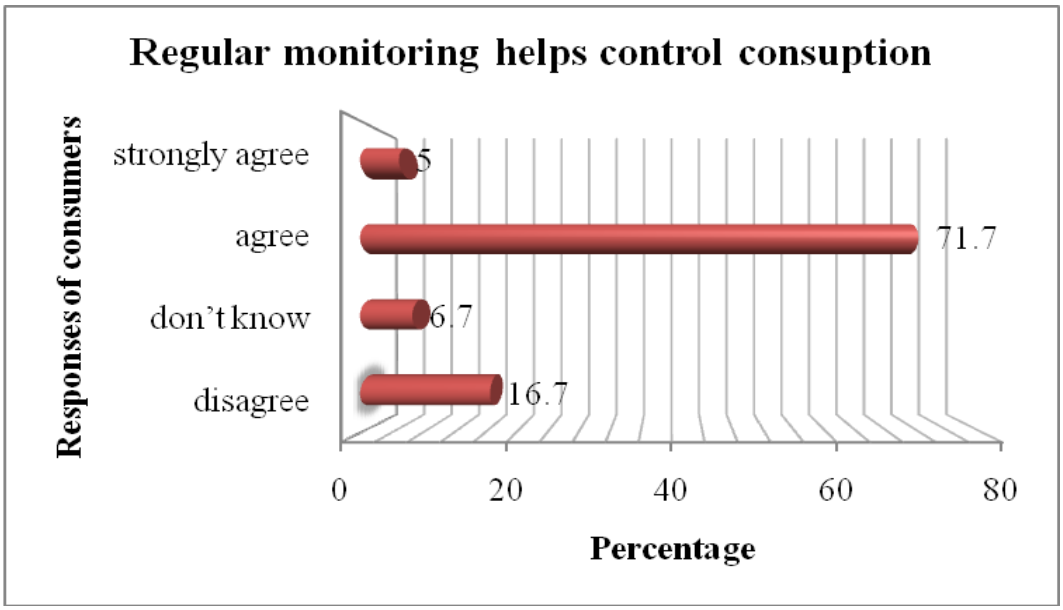

Figure 4.15: Regular Monitoring of the Bills Control Power Consumption

Source: Field Study Data (2019)

The monitoring of bills was seen to be useful as it alerts the consumer on their trends in using electricity. Though monitoring of bills helps but was reported to be a difficult practice as it requires close observations when using electricity through the signals displayed at the in-house smart meters.

The multi use of electrical appliances at the same time and lack of knowledge on how to monitor the energy use have led into reckless use of energy that causes power cut off to some of the users. In their study Jain *et al.(*2012)said that itis difficult for consumers to observe the energy consumption due to various reasons including lack of knowledge and sometimes the complexity of the measurements tools used to monitor the consumptions. This shows that there is a need to educate and give more knowledge to the consumers on various techniques that can simply help them to monitor their uses.

4.5 Community Participation in Mini-grid Project Development and Operation

Community participation is regarded as key factor to the sustainability of the project. Participation and involvement of communities can be done with different purposes and at different levels of project intervention. In view of that, different information was gathered; firstly, to understand how the village got the project and the procedures that they had to fulfill prior the implementation of the project. Based on the information from key informants, the focus group discussions with the village government council members and the project management committee, it was informed that the project developer (Ensol Ltd) came and approached the village leaders in 2014 and express their willing to develop a project at the village.

This came after a pre-feasibility study, which was done by Ensol in other nearby villages as well. Though the geographical location of the villages is in mountains, the solar insolation for Mpale village was found to be good and signified why it was chosen for the project.

4.5.1 Approaches used to Notify and Engage Villagers on the Project

The approaches and methods that were used by the project developer to deliver the messages to the villagers on the processes, actions in establishing the solar project at the village were assessed. This was purposely done as to understand the level of villagers' participation and stages they were involved in that led into accepting the project. Findings of the study as in Figure 4.16 have shown that 94.9% of respondents said that they knew about the project from village leaders through various villages assemble meetings, and 5.1% said they didn't know how villagers got information in the first place because they are new comers to the village.

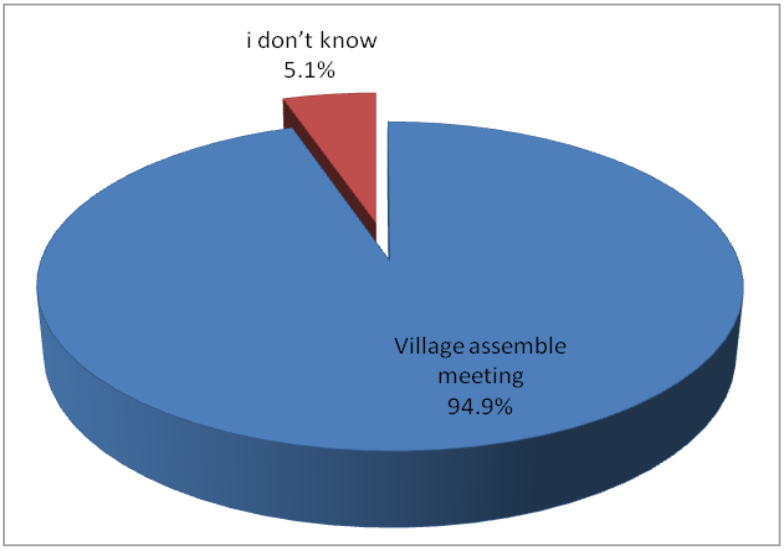

Figure 4.16: How Respondents knew about the Establishment of Project
Source: Field Study Data (2019)

One of the things which were mentioned by many of the respondents through questionnaires and in FGDs is that all the prior information and preparations for the project were communicated by their leaders through meetings. The meetings agendas were focused on informing the villager's different stages of the project, the requirements of the project, roles of the villagers and consumers in the project, terms

and conditions to join and get connected to the mini-grid. It was in these meetings where they inquired for clarifications when there was information, which was not clear regarding the project.

It was the forum where their needs and expectations on the solar energy system minigrid plant were expressed. According to Kimera *et al.* (2014), when involving community from early stages it enables the project to integrate the analysis of the local condition and community needs hence assures smooth uptakes and future of the project.

4.5.2 Level of Participation in Establishment, Implementation of the Project

In assessing whether the community participated fully or partially in the whole project establishment process, the results in Figure 4.17 shows that 79.7% of respondents indicated that the community participated fully from designing, planning, implementing stages of the project while 15.3% said they did not know whether the participation was fully and 5.1% said that the community did not participate.

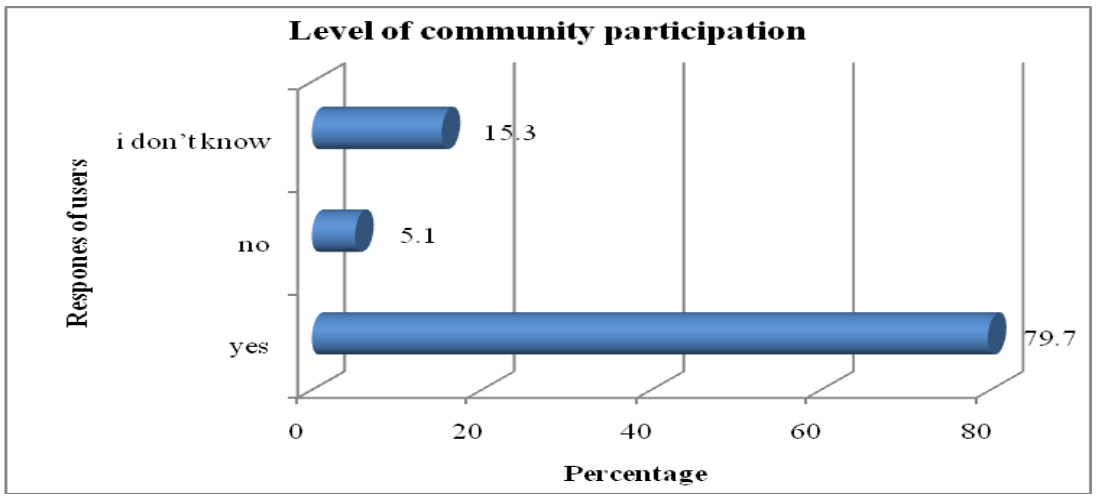

Figure 4.17: Participation of Community in Establishment of Electricity Project

Source: Field Study Data (2019)

Despite of the different responses on the level of participation, it was informed that high level of efforts was made by the village leaders and developer at the initial stages of project to create awareness on the importance of the community to participate in this project. That helped the community to understand the importance of attending the meetings at different stages and made them become aware and be part of important decisions being made. Among the decisions included the identification and agreement on the appropriate location for the energy system plant, land acquisition mode of compensations for areas where the distribution lines networks could pass and selection of various committees to oversee the project activities.

At initial stages of project such as during energy demand assessment, the community was involved where their views, their anticipation and opinions on the kind of energy plant required were key inputs in designing the energy plant that accommodates needs of community. In construction, the community was involved in various activities and contributed their labor, which in one way reduced project costs, increased security of the project and strengthened the bond between the project and the community.

The findings of this study are similar to the conclusion drawn from the study by Azimoh (2016)on *"Sustainability and development impacts of off-grid electrification in developing countries"* that involvement of community from early stages helps to reduce risks of project failures as it accommodates all needs and requirements. It is important for mini-grid developers to take time to understand the needs and priorities of the communities in which their mini-grids will be installed as to make sure that the projects have broad local support and the earlier the community is involved the better for the project (Draeck, Kottasz, 2017).

Partial or lack of community participation implies that it could lead into project rejection or conflicts in its implementation. Community participation level on the implementation of the project was also assessed. Figure 4.18 shows that 55.9% of the respondents said the participation of community in project implementation was high while 23.7% said the participation was higher, 10.2% rated participation was average and another group of respondents said participation was low.

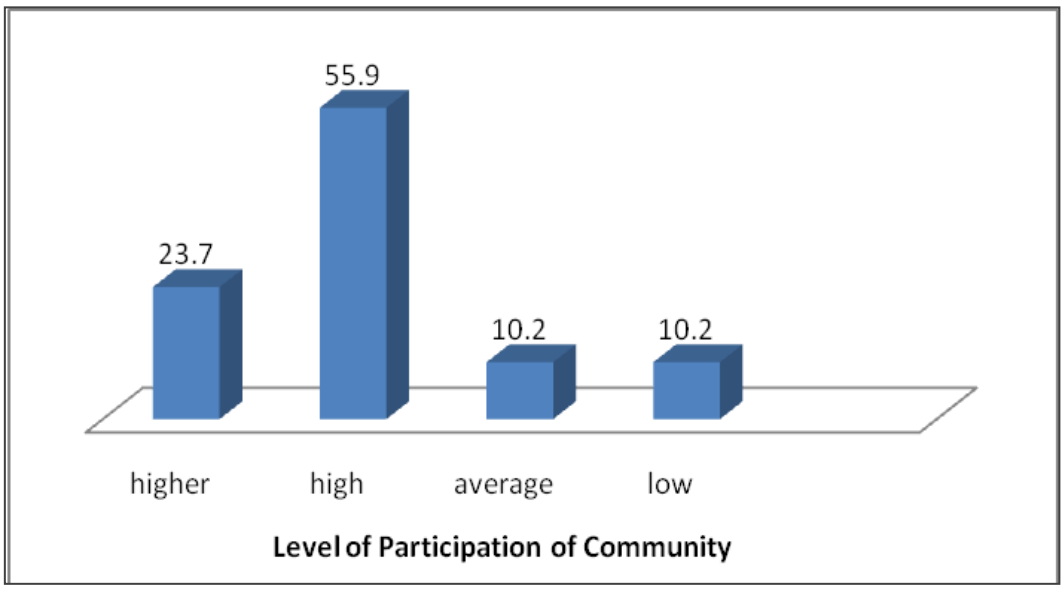

Figure 4.18: Level of Community Participation in the Project Implementation
Source: Field Study Data (2019)

The participation of the community considered to be high because of the rates they have been involved in all project activities. Some of activities which community participated were construction of the solar PV plant through local artisans, construction of distribution network infrastructures, and setting committees that play part in ensuring project activities are smoothly implemented. Though every respondent had different understanding and opinion on the level of participation but these findings generally implies that when there is higher participation of community

in the project implementation, the community acknowledges, become satisfied because they are well informed on whatever stage.

It also brings sense of ownership to the community, and a close relationship between the community and the project can easily be established. Chambers (2008) said that if the community sees the project is theirs, it ensures the safety and sustainability of the project in general.

The inner feelings of the respondents towards the project were also tested by asking them whether they feel that they are part of the project. The result as shown in Figure 4.19 indicates that 82.7 % of respondents said that they feel being part of the project while 16.9% said that they don't feel that they are part of project.

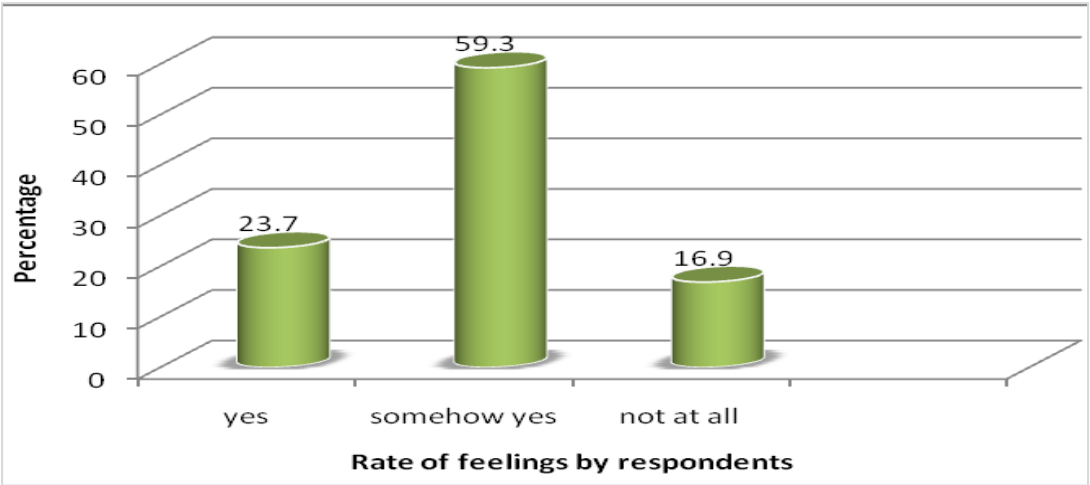

Figure 4.19: Rate of the Feelings on being Part or not Part of the Project
Source: Field Study Data (2019)

The majority of the respondents said that they felt being part of project because of the level of their involvement in the project from the beginning, while others said it is because of the quick responses and attention they get from technicians when they get technical defaults in their houses or in the mini-grid, and other group felt part of the

project because they have been imparted with the knowledge on electricity use, and they get required services as per the bills they pay and being involved in meetings and discussions regarding the tariff structures.

These findings are similar to those by Frame *et al.* (2011) on their study on "*a community based approach for sustainable off-grid PV systems in developing countries"* where it was found that in Malawi and Gambia community feels being part of energy projects because they were capacitated in operation, maintenance of the energy systems and were part of the committees to supervise the project. On the other hand, the minority felt to be not part of project because they were not part of the project management committee or some decisions related to the project were made on their absence.

4.5.3 Women Participation in the Project Management Committee

For the project to be successful it should consider involvement of both men and women so as to understand their needs, priorities and mode preferred for energy service delivery. The research findings on women's level of participation to project are as indicated in Figure 4.20. The results showed that 11.9% of respondents said the participation of women in the committee is highly considered; while 37.3 % said participation is moderate and majority which forms 50.8% of respondents said women involvement is low.

During focus group discussions, the main concern of women was that the project management committee is not gender sensitive and considerate. Only one fifth (1/5) of

the committee member was a woman. This composition made women feel marginalized, that gender specific energy needs are not well presented in the committee and they feel that their importance in the project is not recognized regardless of them being the principal household electricity consumers.

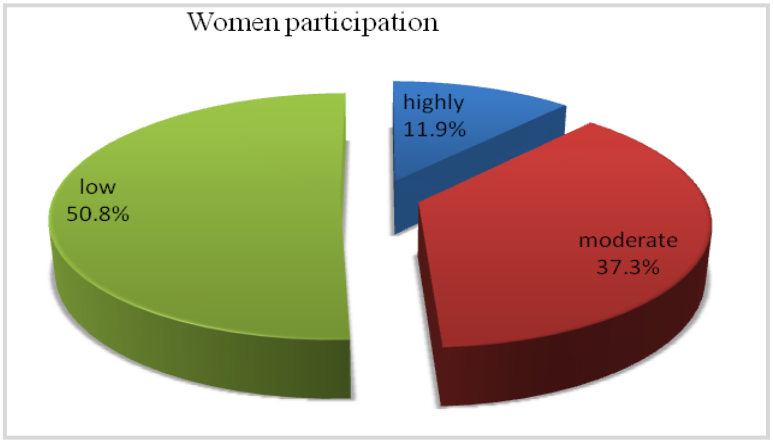

Figure 4.20: Consideration of Women Participation in Management/Committee
Source: Field Data Study (2019)

They feel that if the team members' composition could be 50% by 50% it could give them power to advice to the project developer and introduce things that might be the concerns of the women such as installation of street lights for more security in centres they do petty businesses.

In the study, assessment of the general participation of women in some of specific key functional areas of the project was done. The findings of the assessment are shown in Figure 4.21. It was reported by 94.9% of respondents that women were actively involved at initiation and planning which are early stages of the project. This was through attending various meetings and mobilizations. At these stage women were key source of information during energy demand assessment, which contributed into the design of the installed mini-grid energy system.

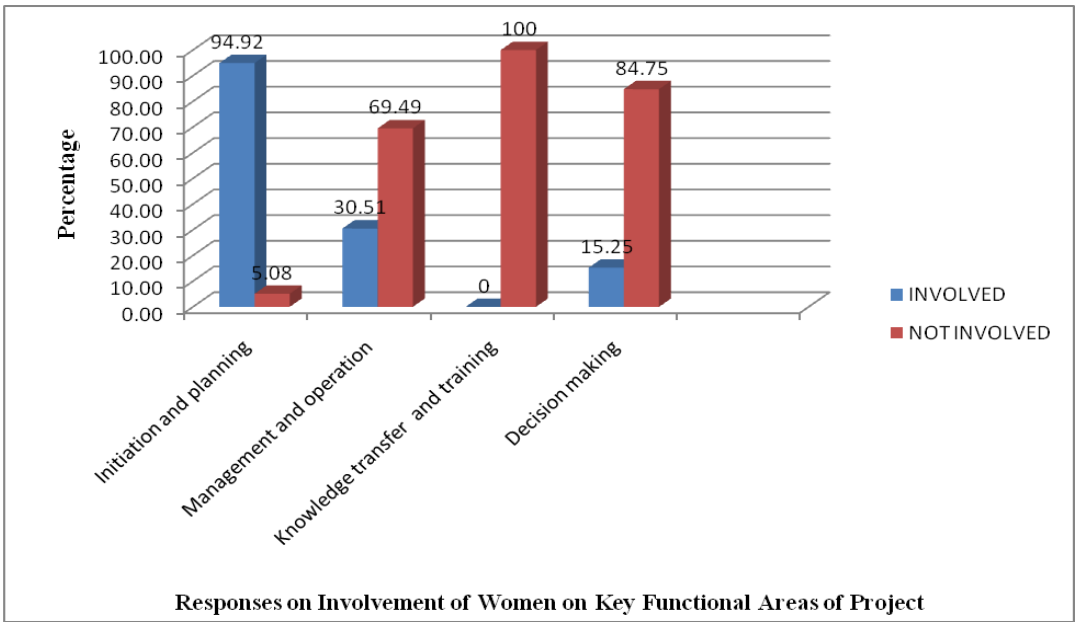

Figure 4.21: Key Functional Areas where Women and Girls Participated in Project

Source: Field Study Data (2019)

On the other hand, 30.51% of the respondents said that women are involved in management and operation of the project, and 15.3% said women were involved in decision making on various issues of project. On the issues of capacity building, it was reported that no women were involved in the knowledge transfer and technical trainings on the operations of the plant.

Based on these findings women participation on day-to-day management, operation and decision making of the project is still low, due to underrepresentation of women in the management committee and also not being part of the technical team that is managing the project. Though their involvement at early stages was remarkable there should be a continuous way of engaging them in the project. This implies that there is a need of engendering project activities implementation and actions so that there is a well representation of women who can provide views, contributions and constructive

critics that can help the project to grow and sustain. This is in-line with experience from Peru where Ceceleski (2000) reported that for women to benefits from the mini-grid and other energy projects is not necessarily that they build, or operate the systems rather they can participate in management and decision making which gives them control to determine the use and benefits of the projects.

Similar findings as per study done by Haag (2007) in Bangladesh have showed the significant roles of women in energy projects. The report said that women participation in the committees and other advisory bodies for minigrids plays roles in advocating the uptakes of mini-grid and associated technologies and appliances hence improves and strengthening gender practical, productive and strategic needs which indirectly contributes into sustainability of the energy systems.

However, despite of the lower representation in some of key functional areas electricity has enabled women and girls of Mpale to participate in some of the events/ activities that are organized in late hours at the village such as VICOBA meetings, selling of horticultural products (vegs), and trivial business at village square till late hours. They can also attend late or evening prayers in church and in the mosque.

4.5.4 Community Participation and Sustainability of Energy Systems

The sustainability of the energy projects is determined by different factors including the active participation of the community that promotes transparency and accountability. Respondents were asked to indicate how the community participation can have effects in the project sustainability through its development, management and operation. The results as indicated in Figure 4.22 have shown that 93.2% of the

respondents have agreed that involving community at all stages of the project has helped them to understand the purpose of the project, the outcomes and their roles which assures sustainability and only 6.78% disagreed with the idea.

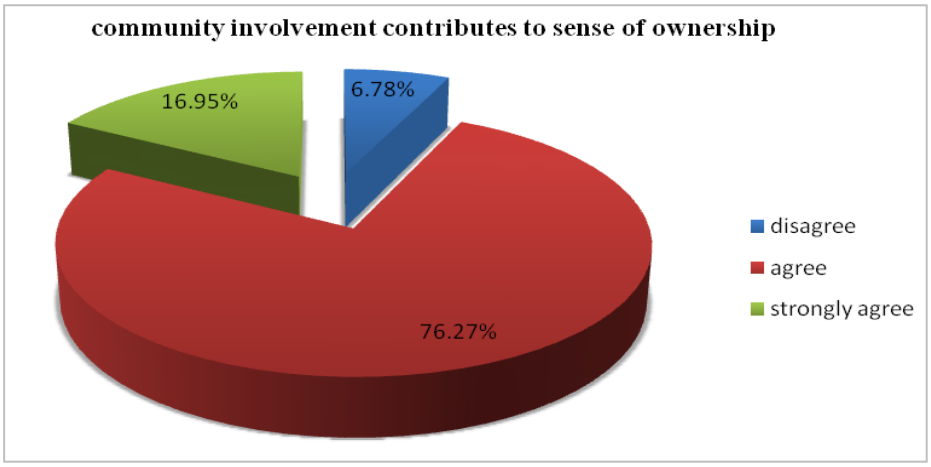

Figure 4.22: Community Involvement Strengthen Project Sense of Ownership

Source: Field Study Data (2019)

These findings suggest that the involvement of the community in all stages of the project have triggered transparency, has ensured proper flow of information among the main actors of the project (developers, leaders and community through the management committees), it has built trust since there is no information gap. There could be information gap if their involvement was only in some stages and if there was no clear information on the intentions of the project. The created gaps could have led into challenges in operation and management of the project.

On the other hand, when respondents were asked on how the community participation could have contributed into reducing other project costs; their responses are indicated in Figure 4.23 whereby 30.5% of the respondents agreed that the participation of community can contribute in reducing project costs while 54.2% disagreed and 15.3% didn't know if the project costs can be reduced through their involvement.

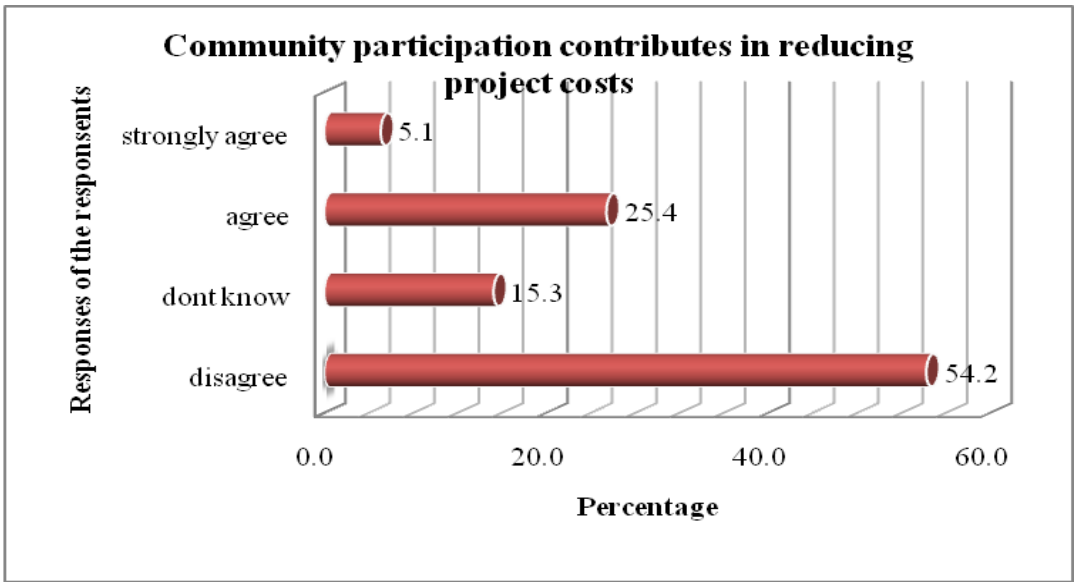

Figure 4.23: Contribution of Community Participation in Reducing Project Costs
Source: Field Study Data (2019)

Based on these findings, the majority of respondents disagreed with the idea because they said that when the project started all relevant costs were settled by the project developer, here they referred to heavy equipment, materials, transportation of equipment and technical expertise in installation. They didn't consider their participation as a key contribution to reduced project costs.

This implies there is lack of knowledge in interpretation of how greatly they have supported the project undertaking that led into costs savings. In reference to discussion with project officer, the project saved costs through laborers whom most were from within the village and few from nearby areas, the project got some of the building materials such as stones, sands locally at a cheaper price community participation in the project as one of key actor led into simplified procedures to acquire land for the plant where there was no compensation as it was treated as the village project. If it was to charge all the items that were obtained from village or

contributed by the community at the market, the cost could have been higher hence a burden to the project.

On the technical issues, results as shown in Figure 4.24 indicates that 89.9% of the respondents agreed that lack of technical capacity to local technician can lead into challenges in operations and maintenances of project machines, 6.8% disagreed and 3.4% of the respondents said that they didn't know whether there may be challenges.

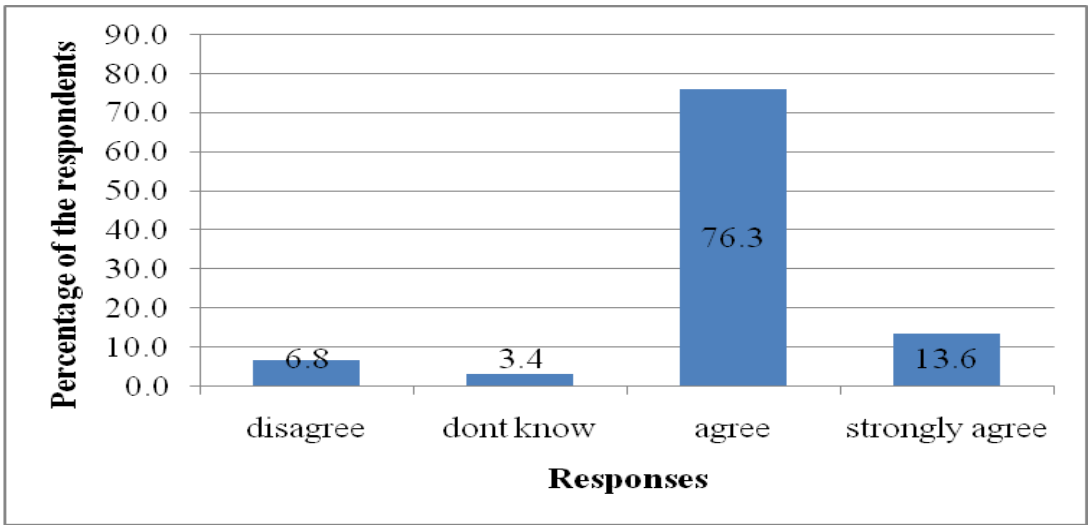

Figure 4.24: Lack of Technical Capacity and Challenges in Projet Operations

Source: Field Study Data (2019**)**

In order to ensure there is operational sustainability of the energy systems; it is important to have adequate technical capacity on operating, troubleshooting and perform the machines and equipment maintenances. Majority of the respondents agreed with the idea of technical issues due experience they have gained when there are technical defaults in the plant system. The plant is being operated and maintained by two young men who originate at the village. They are well trained and have been doing good job because they had skills and knowledge on electricity. They have Grade I Test Certificate of electricity from Vocational Education and Training Authority

(VETA). Their main roles have been to run and operate the installed energy system, troubleshooting at control center and in power supply distribution network, connect new customers and sometimes undertake wiring. The local capacity has been useful as operators are capable to attend any reported defaults on time as affirmed by one of respondent;

> "*training two of our young men has been of good benefit, whenever I need a technical assistance at my house I get it on time, and they also advise us on things to avoid so that we use our electricity efficiently. If they had to come from Korogwe, running and operating this system could have been worse, so we thank Ensol for training and offer them employment"*

Though the energy plant is owned and run by the developer, the local capacity has its importance since it assures continuity of services provision Findings of this study were complimented by Mwihava (2002) who said that lack of technical skills can lead into improper maintenance that may cause un-sustainability of provision of services. On the issues of empowerment; the respondents were also asked how they see involvement of community as a way of empowering villagers throughoffering employment, the management and ownership of the project.

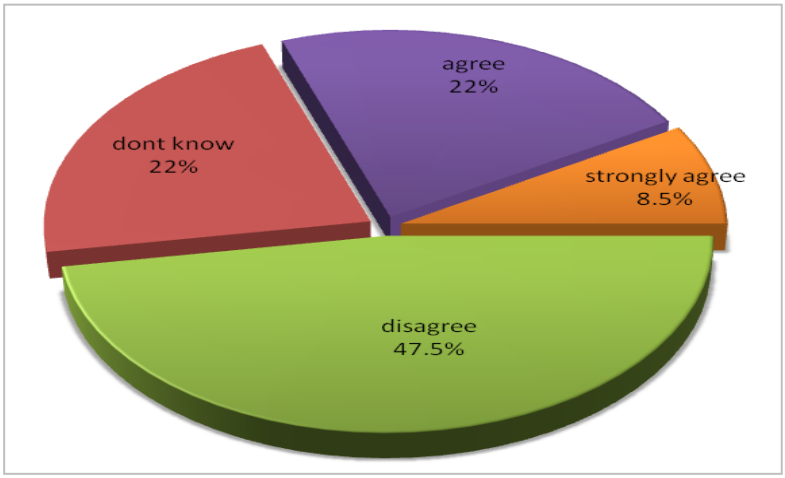

Figure 4.25: Community Involvement is One way of Empowerment

Source: Field Data Study (2019)

The results as indicated in Figure 4.25 shows that 47.5% of the respondents disagreed, 30.5% agreed while 22% of respondents said that they didn't know if that could be a way of empowering the community.

According to Czuba and Page (1999) they see empowerment as a multi-dimensional social process that helps people to gain control and act on things that they define to be important in their lives, to their communities and in their societies. When looking on the concept of empowerment at the village context, this was found to be not clear to majority because they consider that main part of project operations and management is under developer. Based on that perception it was informed that since its inception the project has empowered the Mpale community in different dimensions.

Among the areas the community has been empowered is on operation and management of the project whereby a project management committee was formulated and capacitated on with different management skills, and this has been done on regular basis. Another area the community is empowered is on employment. Both temporary and permanent employments have been offered by the project to the community members; villagers were temporary employed during construction of the plant system and distribution network and permanent employments has been offered to three villagers whereby two have been employed as operators and one as a watchman. Technical capacity has been given to operators' as to be conversant in their day-to-day operations of the entire energy system.

The project has also supported women groups in the village with business and entrepreneurial skills trainings. Despite of the facts that the village mini-grid plant is

operated under the financing model of build, own and operate (BOO), some concerns regarding community empowerment for future management of the energy plant were discussed. Some of FGD participants pointed out that they would like to see a different model in the future where the ownership is transferred to the villagers.

The assumption being that after the developer has recovered all costs incurred in building, owning, and operating the plant can then transfer the ownership of the energy plant to the community (BOOT). One thing they were not sure of is whether the village leaders would be capable enough to run the energy supply business. This observation implies that there is a need of regular meetings with the villagers to remind them on the ownership models that the project developer and the community representatives who are village leaders and committee agreed upon.

Tarrifs setting, type and mode of payments are important and key feature when pricing electricity services. It is often the most challenging part of developing the business model for the renewable energy minigrids. The willingness to pay largely reflects the community's knowledge about the benefits of electricity and their ability to be involved in setting tariffs.

The researcher wanted to know their opinions whether sustainability of project can also be assured if the community is involved from the beginning in setting and determining the tarrifs. As it is shown in Figure 4.26, only 10.2% of the respondents disagreed, 3.4% said that they didn't know and majority which forms 86.5% of respondents agreed that involving community from the beginning for tarrifs setting ensures sustainability.

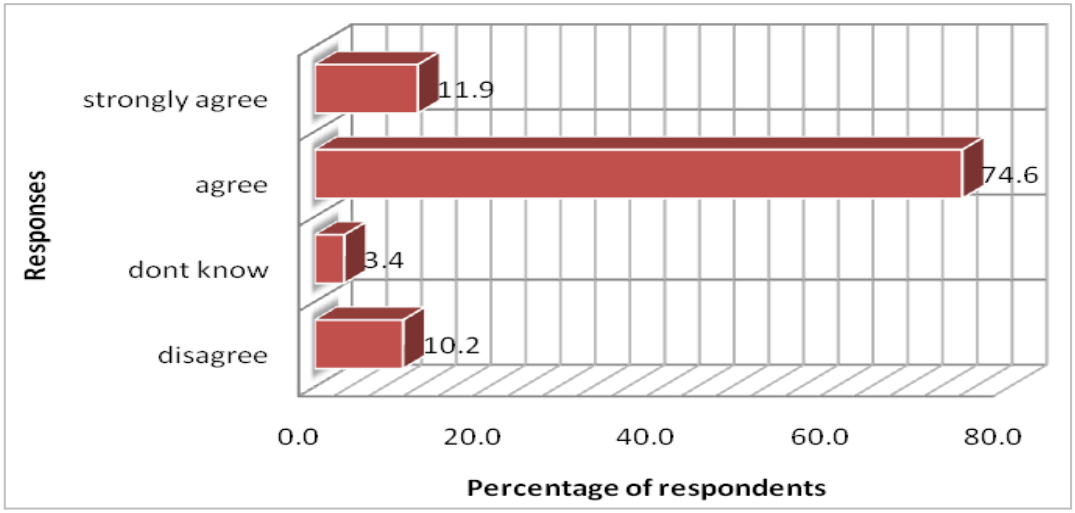

Figure 4.26: Community Involvement in Tariff Settings Ensures Sustainability

Source: Field Study Data (2019)

In order to have a sustainable system, consumers must be willing and able to pay the consumed energy, that the tariff should be structured so as to balance both sustainability and affordability. The findings of this study show that community had agreement with developer on the type of tariff and mode of payment and the setting was on the basis of ability to pay and appliances used. Failure to better agreement could have jeopardized the operations of the system hence poses the risk of system un-sustainability. Similar experience was observed by Draeck and Kottasz (2017) on the studies done in Chad and Guinea Bissau under UNIDO experience of renewable energy mini-grids. Communities in both countries were involved in setting tariffs in a manner which ensured that the costs of the developer or operator are covered and at the same time the community's energy needs are reflected.

4.6 Types of Opportunities Created to Facilitate Livelihood Transformation

This was also another objective of this study that aimed at finding types of opportunities and activities that have been created and are powered by the installed

solar PV mini-grid in the village. It is obvious that most of the project developers invest in minigrids project so that apart from meeting basic energy needs for households, it can also be productively used for income generating and improve the living standards of a particular community. The use of electricity productively assures the sustainability of the project and services provision through revenues generated from selling electricity.

4.6.1 Kind of Energy Sources used before Electrification of the Village

Access to energy solutions determines growth rate of social economic development of the particular community. At Mpale, villagers have been accessing different energy solutions to meet their various energy demands. The study attempted to find type of energy sources that were used by community before the construction and installation of the solar PV minigrid project. Different types of energy sources which were used at the village before minigrid project are shown in Figure 4.27.

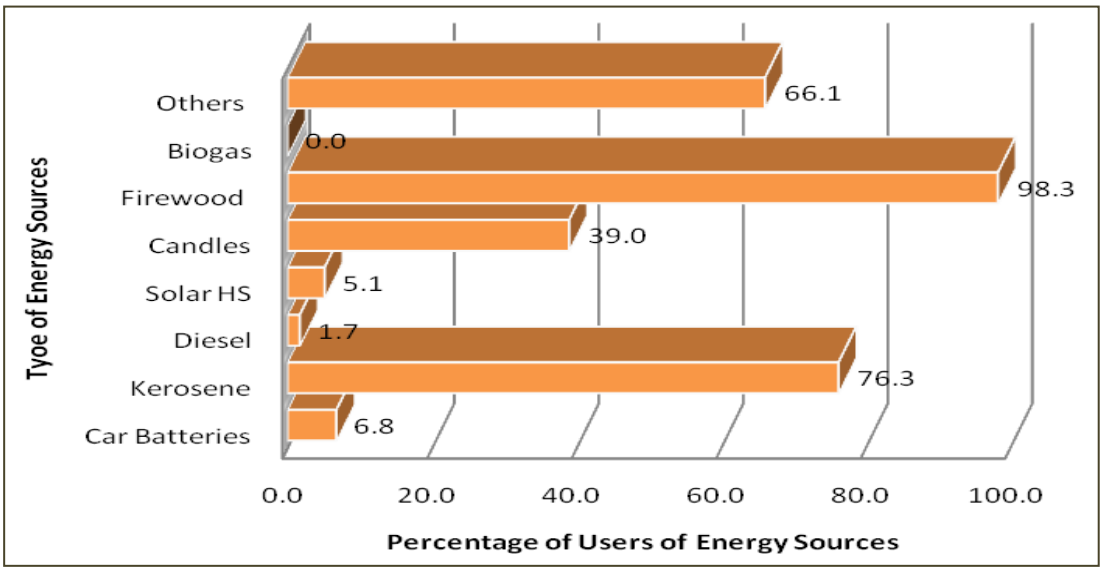

Figure 4.27: Type of Energy Sources used at the Village before Minigrid

Source: Field Data Study (2019)

The findings have shown that 98.3% of the respondents were using firewood for cooking and heating and the firewood was used in open-inefficient cook stoves. The effects of such stoves causes' indoor air pollution which lead into detrimental health impacts such as upper respiratory track disease, flue, and red eyes; sometime it poised risks of fire accidents to the users. The findings are similar to the report by NBS&REA (2016) whereby firewood is dominantly energy source for cooking which is used by 92.2 % of the rural households in Tanzania mainland.

As per Figure 4.27, the use of kerosene lamps was also reported where by 76.3% of respondents said they were using kerosene lamps primarily for lighting and fire start-up when using charcoal or firewood. On the other hand, 5.1% of respondents were using small solar PV systems with capacities ranging from 10-40W for lighting and charging phones, while 39. % were using candles for lighting, 6.8% were using car battery for powering radio and lighting and 1.7% of the respondents was using diesel to power generator. It was informed that for lighting through solar, generator and car battery only incandescent bulbs were used.

It was also observed that there were other sources of energy that were used at the village before the mini-grid electrification. These included charcoal, LPGs, the rechargeable lights and this reported to be used by 66.1% of the respondents; however, they were sourced outside the village or nearby town. Despite the facts that there are some villagers practising zero grazing and were sure of getting feedstock for biogas, no one was using biogas for cooking due to the high costs per volume which are associated with the construction of the biogas systems. Based on these findings, the villagers were suffering using un-environmental friend sources of energy for

cooking and lighting (kerosene, charcoal and firewood) and according to OECD (2007), the harmful gases from these sources have led into into pre-mature death of more than 1.3 billion people worldwide. In general, through these findings it implies that more sensitization is needed for the community to switch off from the inefficient sources of energy to efficient one and the mini-grid electricity is the enabling stimulus for such trade off.

4.6.2 Effectiveness and Capabilities of the Solar PV Mini-grids Electricity

Respondents were asked to give views and compare the effectiveness and capabilities of solar PV minigrids with different energy sources and solutions which were used before to electrification project.

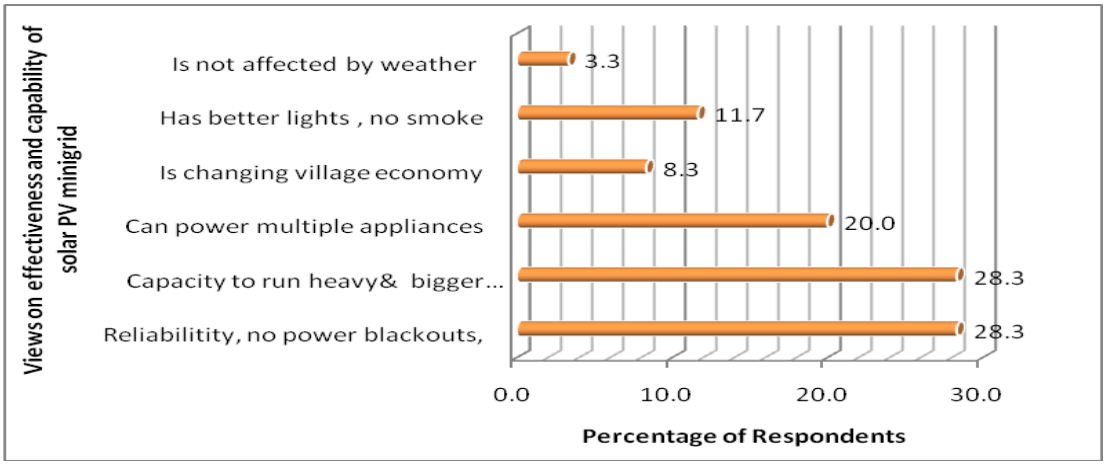

Figure 4.28: Effectiveness and Capabilities of Mini-grid Electricity

Source: Field Data study (2019)

Different views were given and the findings are as presented in Figure 4.28. Majority which account for 91.7% of the respondents indicated that there are major differences between the solar mini-grid electricity compared to other energy sources which were previously used. On the other hand, 8.3% of respondents had different opinion on the economic perspective.

Among the respondents who gave out their opinions and make comparisons were users and owners of the solar home systems. About 20% of the respondents said that their small solar systems, which ranged between 10-40W could not power multiple appliances rather only 3 lights and charging 3-4 phones for few hours. After being connected and use mini-grid electricity, there has been no limitation in appliances usage so long as it is within the tarrifs category of the customer.

Other heavy appliances such as radios, TV, fridges are used through solar mini-grid and the big difference with the smaller solar systems is that all these appliances can be used all together simultaneously. Other respondents, about 28.3% said that the solar mini-grid electricity is different in capabilities whereby it can power even high rated power appliances for productive uses such as electric wood planners, compressors for tyres, and electric soldering machines.

Other difference for solar users is on the reliability of energy supply. It was informed by 28.3% of the respondents that due to the sizes of the systems, the systems charge storage capacities were small and limited. During rain seasons or when the sunrays intensity was not strong enough they could not get electricity throughout, rather for some hours. This had forced them to look for other inefficient alternatives such as kerosene lamps or candles. About 11.7% of the respondents said that challenges of using inefficient energy solutions included indoor air pollutions and dim lights, which cause respiratory diseases and eye problems. Now they get bright lights and no smokes from lighting sources.

Since the solar mini-grid is coupled with high technology and efficient equipment such as batteries, panels and controllers, the connected users have not experienced

shortage of power supply. The system was designed based on the findings and results of the energy demand assessment. The energy storage system can help balance the short term changes in energy supply and demand that can either be due to systems disruption because of weather (rains, cloudy), or changes in the load. So the installed plantcan generate enough power that can meet the village needs throughout.

On the other hand, based on Figure 4.28, 8.3% of the respondents said that the solar minigrid electricity is an opportunity to improve their income and the village economy has started changing. At the moment there are no serious uses of heavy machineries for productive purposes but the capability of the solar mini-grid electricity has stimulated the demand where people are planning to invest and install some of the appliances and machines. Expected investments are milling machines that will be used to add value in agricultural products, water pumps for increased agricultural productivity, timber processing, carpentry and welding machines for furniture and other ornamental products.

4.6.3 Improvement of Women and Girls Energy Needs

In African communities, women are the vulnerable group when it comes to meeting their basic energy needs. They fails to access better energy services due to various factors including social cultural barriers, low ability to pay for the services, lack of information on existence of better energy solutions and use of inefficient energy appliances and technologies. The adequate energy supplies is needed by women as to run and meet their households basic uses, their small-medium scale enterprises and home industries.

In this study, information was gathered through women focus group discussions and the questionnaires and it has revealed that the solar PV mini-grid at the village has helped women and girls to meet some of their daily energy needs which in turn have contributed into improved their living and financial status.

Despite of different opinions given out, the key areas, which the respondents felt that the solar minigrid electricity has directly or indirectly touch girls and women lives are presented in Figure 4.29.

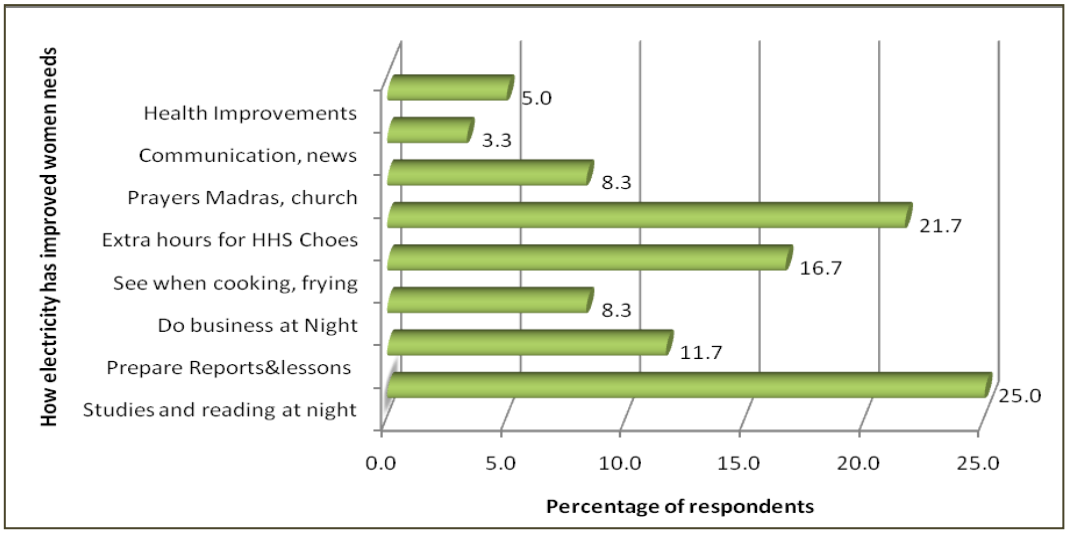

Figure 4.29: Areas Women have Improved Due to Mini-grid Electricity

Source: Field Data study (2019)

Some of the respondents said that before the electrification project it was difficult to undertake household chores after the sun set. They had to use different energy sources so that they could manage. After being connected 38.4% of the respondent said that electricity has simplified their tasks, they can do the evening household chores much better than before. Some said that electricity has helped them to manage their time and now they have extra hours for various tasks. Currently they can wash dishes in the evening comfortably, they can clean children clothes, clean their houses, and with

better lightings they are also cooking fast while doing other multiple activities which were not easy before due to limitation of light and associated risks.

On the other hand, 3.3% of the respondents said that electricity has enabled them to get access to various information through media like radio, and television. The means of communication has also improved because they can charge their phone at a lesser cost. In order to ensure that they contribute into family income, some women have started becoming productive.

In reference to discussions made as per Figure 4.29, the 8.3% of the respondents said that electricity has enabled them to be innovative and start entrepreneurial activities such as preparing bites, pancakes, groundnuts and can work for many hours in the evening compared to when they were using kerosene and candles. Lack of electricity made them prepare bites products using inefficient sources and several times they ended up making poor quality products which were smelling kerosene hence were rejected. There were times they could not go out to sell the products due to security reasons. One woman, a food and pancake vendor at village square said that;

> *"first I must admit the project has impacted my life directly, I have been making and selling pancakes before this project, but I was only selling in the morning, little package and the profit was too little. After electrification people started hanging out at the village square till later hours, and realized that those could be my potential customers, so I started working and selling even at night. Now the number of pancakes am making has increased because I have enough customers and am getting good profit that enables me to contributes and support my husband to meet the family needs"*

Even though the electricity has facilitated access to their basic energy needs, women feels that there are still more opportunities that can be utilised through minigrid

electricity. Some were thinking on investing into more sophiscated and efficient electrical appliances for their micro-enterprises when they have financial breakthrough. The interest expressed was for appliances such as beauty salon machines like hair dryer, home juicer machines, the hand sewing machines; these when used productively can contribute into improving their livelihoods. They proposed and requested the project developer to assist them with loans for appliances under the agreeable terms of repaying in instalments for a certain period of time based on the accrued profit from the created businesses.

This implies that immediate intervention is needed to support the innovated business ideas. The project developer should aim to establish a link between the already operating and potential enterprises with sources of credits (this could be from Korogwe town), suppliers of various machines; appliances and business development support. Such investments will create and increase the demand for electricity. This assures long term sustainability of the project and sustained livelihoods of the electricity users.

On the education sector, it was revealed by 25% of the respondents that electricity from the mini-grids has enabled girls' education performance to improve. Electricity has created enabling environment for reading because after helping evening household chores, they have got enough time for school assignments and reading, compared to the era of using candles and kerosene lamps.

Mpale is a religious village and the electricity has also contributing into strengthening women faith whereby 8.3% said that they can attend evening sessions for Madras in

the mosque or choir in church with no fear because there are lights which have contributed into improved village security.

For the women employees who work for the government institutions based at the village such as school and dispensary, electricity has contributed much into the success of their works. As presented in Figure 4.29, about 11.7% of respondents confirmed that due to better lighting facilities and the reliability of the electricity supplied, they are not worried even when they have some pending works. They are now preparing their reports; lesson notes or marking the internal exams from their homes during late hours. Electricity has also contributed into retaining women staff because all the necessary energy services to meet their basics needs are available at the village.

Despite of various benefits and opportunities that electricity has made women realise, it has also assured them better health services. In reference to figure 4.29; about 5% of the respondents pointed out that women and girls are now confident on improved services because the dispensary is electrified and most of the services such as vaccinations and diagnosis of diseases which were previously not available, they are now done at the village. The delivery of babies is now taking place more safely due to better lighting facilities and risks of losing infants and delivery mothers because of poor and inefficient lighting sources like kerosene lamps and torch are no longer there. It was informed by women themselves that since they stopped using kerosene lamps and candles, they have never experience irritating eyes problem, headache, flue or regular coughs that were caused by the emitted fumes. This information was confirmed by one of the Medical Clinical officer at Mpale dispensary. The medical

staff associated the mentioned changes and health reliefs with the current application of electricity in different households.

> *"cases for regular coughs and eye has dropped significantly and for the past 13 months, I have seen some changes, no regular reporting of coughing or eye irritations for patients from Mpale compared to Mali Juu the neighbouring village which is not electrified"*

These findings have generally shown that access to electricity can combat the time poverty, which is the critical driver of gender inequality in most of households. When women and girls have access to the benefits that the reliable and affordable electricity provide, the unpaid work becomes less laborious and time intensive, allowing for the pursuit of education, income-generation, civic involvement, or leisure opportunities.

These findings are backed up by Ceceleski (2000) that reducing women drudgery is the most objective of rural electrification. Report insisted that women involvements in renewable projects and efficiency programs as beneficiaries and implementersis important as they influence their households direct and indirect energy consumption and can educate and shape their children on future energy conservation and consumption habits.

4.6.4 Impact of Solar PV Mini-grid in Social and Economic Activities

When looking of the capabilities of the solar PV mini-grid to impact lives of the community, we are looking on how the presence of this technology has directly or indirectly improved the social life aspects in terms of supporting and promoting education, health, agriculture, small scale industries, enabling income generation and job creation opportunities for poverty reduction. The process of developing these

sectors creates sustained demand for mini-grid electricity that ensures the financial viability of the energy system over time.

4.6.4.1 1mproved Education Performances

Education is one of the most important aspects to the human capital asset and its importance to development is well known. During the study, the respondents whom their information were gathered through questionnaires were asked to indicate how solar electricity has played roles in the education standards of their families especially children. The responses presented in Figure 4.30 have shown that 88.3% of the respondents said that the solar mini-grid electricity has helped and contributed into improving their children education, while 10% disagreed and 1.7% did not if it can contribute.

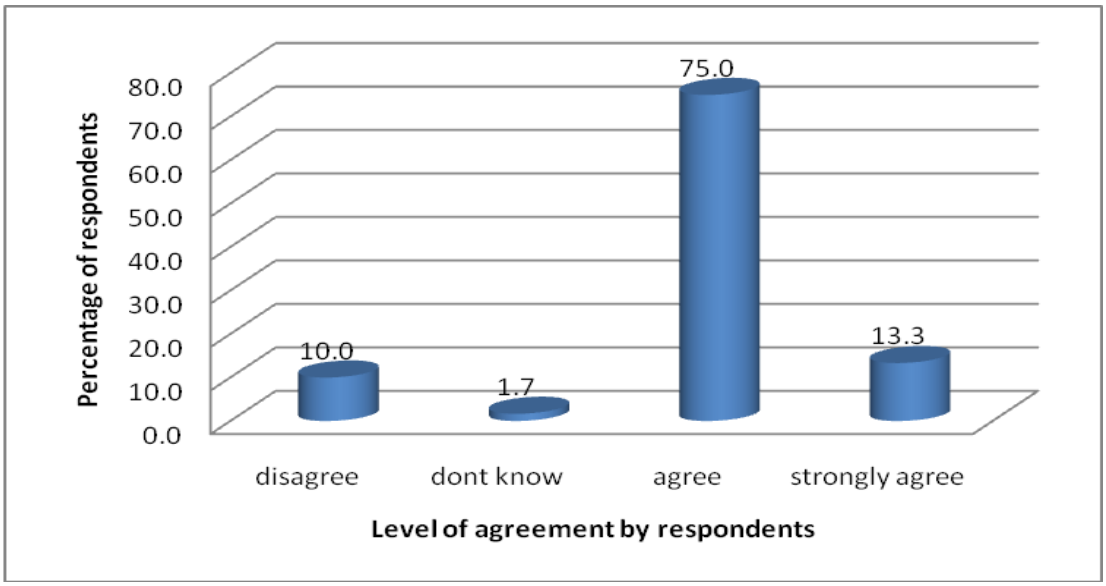

Figure 4.30: Availability of Electricity Contributes in Education Performances

Source: Field Study Data (2019)

The majority agreed on that because they have seen lighting facilities such LED lights have better and bright illumination; hence creates a comfortable and conducive

environment for children self reading. The group that disagreed was families that had kids which have not yet started schools, it was unfortunately that they were not able to link crosscutting roles of electricity in improving mult-sectors including performance in education.

At different occasions during discussions and interviews, it was reportedby majority that before electrification project, their children were doing most of the studies and homework during the day time only, and had no reading habit during the night; rather they would do it occasionally, that confirmed by one parent;

> "*electricity has changed the habit and attitudes of my children towards evening self study. Before get connected to electricity, it was difficult for my children to read in the evening after school, they had no that habit, they were doing it very occasionally after reminded, but I could feel they were not comfortable because of the lights they were using. Now I even I don't remind them, they do it themselves and can read even up to 5:30pm"*

These findings are similar to those of the study done by Gustavvson (2007) in Zambia on the educational benefits from solar technology on the access to solar electric services and changes in children's study routines. The role of solar PV mini-grid electricity for the improved performances of pupils was also affirmed by Mpale Primary school teachers. They said that though the school is not yet electrified, the performance has kept on improving because children have better reading environment at their home.The statistics provided by the Acting head teacher for two classes which do national exams yearly as indicated in Table 4.3 confirmed on the changes.

The rate of performance for standard IV pupils advancing to standard V has shown to increase tremendously at the rate of 92.8% in year 2016, 97.9% in 2017 and 98.5% in 2018. The performance for pupils finishing standard VII and advance to secondary

level education indicated to improved from 55% in 2016, 80% in 2017 and 89.6% in year 2018.

Table 4.3: Performance Trends at Mpale Primary after Electrification Project

Academic Year	Class	Examined	Advanced to next	Percentages
2016	IV	42	39/42	92.8%
	VII	47	26/47	55%
2017	IV	95	93/95	97.9%
	VII	65	52/65	80%
2018	IV	68	67/68	98.5%
	VIII	77	69/77	89.6%

Source: Mpale Primary School Office (January 2019)

Once the school gets connected to mini-grid, teachers foresee better and highest performances. The school has plans to initiate class programs that can be taught early in the morning or late evening so that pupils will have extra classes' hours with their teachers. Kirubi *et al.* (2009) reported on the success of similar experience in Kenya whereby it helped teachers to make up for material not adequately covered during normal hours, due to various reasons. At school the electricity will also be used to teach the ICT by introducing modern teaching aids and appliances such as TV, videos, projected slides for better understanding and for undertaking practical for science subjects such as energy and electricity.

On the other hand, the school has plans to introduce other important modern equipment such as printers, photocopy machines and computers to facilitate teacher's works. The study by Kanagawa & Nakata (2009) on assessment of access to electricity and the socio-economic impacts in rural areas of developing countries confirmed the significant role of electricity in increasing education performance. In

their study at Assam village in India, it shows that the performance and literacy rate increased by 11.9% from 63.3% to 74.4% in a period of a year after the village was electrified.

In other cases, electricity does not attract only students and enhance their learning, it also enhances and contributes into teachers better living and conducive working environment. Electricity has enabled teachers to have more time for lesson preparations thus contributes into the students' performance. They use electricity to power other basic facilities and appliances such as computers, fans, and radios that make teachers more comfortable and increase their knowledge base in terms of information. Availability of electricity in the village has contributed into retaining teachers at Mpale, which is among the deprived villages in the country. Similar findings were reported by Sovacool and Vera (2014) in UNDESA study report that in Argentina the electricity generated from renewable electricity and connected to schools and teacher's compounds contributed into retaining almost two third (63%) of the school staff due to better working conditions and teaching aids that electricity offered.

Despite of the benefits and the positive impacts solar PV minigrid electricity has in education, it was also found that there are negative impacts. Some pupils have not been effectively using the electricity to increase their knowledge through self readings; rather they go to watch movies and cinemas in the TV shows centers until later hours. Some movies, which these kids watch are not filtered and are of western culture. This has resulted into poor performances and low scores at school and bad behaviour in the community.

4.6.4.2 Improved Health and Health Services Provision

During the study, the assessment of the contribution of solar PV mini-grid towards accessing better and improved health services delivery was done and responses are shown in Figure 4.31 whereby 73.3% agreed, 25% strongly agreed and only 1.7% said didn't know whether there are any health benefits.

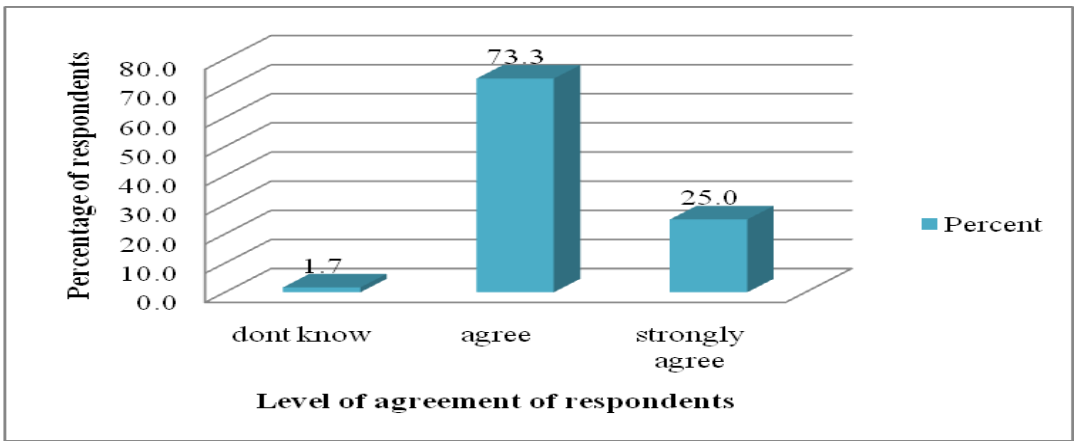

Figure 4.31:Availability of Electricity has ImprovedHealth Service Delivery
Source: Field Study Data (2019)

Based on these findings, majority of the respondents which accounts for 98.3% have agreed that there is a great gain and changes in health conditions. At the family level, there is relief in the problems of eye irritation, chest pains, flue, headache and coughs; these were associated with the smoke from kerosene lamps and candles that were used before electrification. One of the key observations made was the ability of the respondents to compare the situation before and after the electricity.

One of the respondents was quoted saying that;

> "*before the project I used to complain every day about headache, I came to realize it was caused by smoke from the kerosene because we were using it during the night while doors closed and the smoke remains in the house, since I started using electricity I have never experience such problem anymore."*

Another observation was that the total health benefits are yet to be realized because the majority of the community members are still using inefficient charcoal and firewood cookstoves; which is the main cause of indoor air pollutions.; This implies that the realized health benefits at household level should be sustained and scaled-up by creating awareness on efficient cookstoves, and introducing the best cooking practices through electricity (eCook) that will ensure maximized health benefits to the community.

At the village level; the benefits of electricity have also been on the improved social services delivery at the village dispensary. The medical staff reported that the entire dispensary is electrified including the women labor room. Better lighting facilities have assured them accuracy of their tasks during delivery operation. They reported that before electricity women had to come with their own kerosene lamps for labor and this was explained as the most difficult part because some women could not afford to come with kerosene lamps hence their life and the infants were at risk. The availability of electricity has changed everything; previously the night emergences cases such as injuries, animal bites were not attended but now medical staff has confidence and are comfortable when such case happen.

Other noticeable benefits and changes have been on the operation costs of the dispensary. It was informed that before being electrified the dispensary was using a fridge, which was run by gas, but now the fridge is powered by electricity. Refilling the gas was reported to be costly for the dispensary to afford and when it delayed; it interfered some health services such as vaccinations, hence poised risky to people's lives.

One retired civil servant affirmed this by saying that;

> *''we have suffered enough, previously there were several occasions that the gas finished and there were no funds for refilling, that situation forced us travel to Magunga, the Korogwe district hospital which is 45km for compulsory vaccination like rabies. This was costly and time consuming and many of our people could not afford such costs, so it endangered their life''*

Medical equipment is now sterilized by electrical sterilizer, which issafer and convenient to use. The dispensary was spending more than TZS 50,000 for gas to run the sterilizer and fridge, but now it spend less than that amount for electricity which powers the whole centre. These findings on the use of solar PV electricity to power medical appliances for improved health are similar to the study by van Leeuwen (2014), which concluded that the consistency supply of electricity through solar PV can enable health facilities to use modern medical appliances that simplify health services delivery. When undertaken this study it was informed that the dispensary had already ordered a TV and video set and according to nurse in charge the dispensary will soon start to use those appliances to create awareness on maternal health and child care for the patients and community. Madhu & Narasimha (2009) in their study showed that TV program shave significant role for an increased knowledge on health and nutrition for both men and women.

4.6.4.3 Development of new Income Generation and Job Creation Opportunities

Electricity is the main driver of economic activities for sustainable development. The reliability, affordability and sustainable use of electricity assure development at both local and national level. The assessment was done on how the community uses the solar PV minigrid electricity (basic uses or productively), and whether the solar PV

mini-grid electricity has facilitated development of income and job creation opportunity and type of activities or business that has been established. Findings as shown in Figure 4.32 indicated that 31.7% of the respondents use electricity for productive, businesses and income generating activities and 68.3% still use electricity for basic needs such as phone charging, powering small radios, light and lighting.

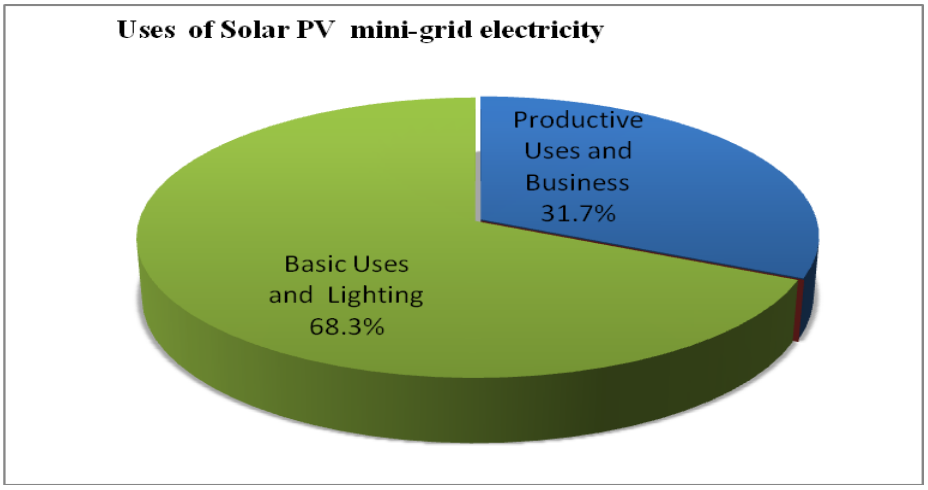

Figure 4.32: The uses of Solar PV Mini-grid Electricity

Source: Field Data study (2019)

These findings show that the level of utilisation of electricity for productive uses which believed to be the backbone of the energy plant system sustainability is still low. That rate should have been higher by considering that the mini-grid has been operational for almost 18 months. This implies that extra efforts are needed to create more awareness on the capability of the established solar –minigrid, available opportunities that will stimulate demand for the increased turnout of productive users.

On the other hand, when assessing what has already been done as the outcome of the mini-grid, it was found that some groups of entrepreneurs have started benefiting by earning income through the use of electricity. These groups include those who have

established new enterprises after village is electrified, long time existing enterprises that are now connected to mini-grid and group of those who have no formal enterprises but electricity helps and facilitate their income earning activities within or outside their houses. Most women have no formal enterprises; their main activities have been making burns, chapatti, packing groundnuts and other edible bites and sells around the village premises such as school, prayer houses or at village market square. The better lighting from electricity enables them to undertake those activities after the sun set.

However, in the interviews and FGDs it was informed that there are new opportunities that have been established or created in the village after electrification. These new opportunities include; 3 new established barber shops, 1 compressor for motorcycles tyres servicing, 1 wood electric planners for carpentry works, 2 shops introduced fridges for cooling soft drinks, 1 electronic repair soldering machine, 3 TV shows centres established, and 4 new established restaurants. Others include 1 incubator with capacity of hatching 252 eggs at a time and a new poultry yard. Electricity has in one way or another facilitated and accelerates their business, hence impact their lives positively. One retail shop owner who has a fridge was quoted saying that;

> *" lack of access to electricity is a door to poverty, before I bought my fridge I was selling hardly 1 crate of soft drinks for 2 weeks, but after introducing fridge I am now selling 2-3 crate every week, customers are attracted to cold drinks, so volume of sales has increased and it has contributed to the increase of my income"*

The contribution of electricity into increased income was also attributed by another business man who has a compressor. He narrated how electricity has opened opportunities to him and his family;

> *" am happy that my life has started to change, I thank Ensol for the loan of this machine, before I was using a small hand pump which was taking me a lot of time to fill one tyre, so customers had to queue for the services. Now in Bungu ward, which has 4 villages I am the only one with this type of machine, all bodaboda comes from neighbouring villages to repair and fill their tyres here. With the income aim earning will be able to finish up the loan by April 2019, and open another centre in the nearby village for a similar service and welding services to increase my earnings and my young brother will be managing that"*

There are future plans by some of the consumers to buy appliances such as fridges, juice maker machines, electrical sewing machines, welding machines, deep freezers and milling machines for productive uses.

On employment, respondents were asked whether they see availability of electricity can contribute into creation of permanent or temporary employment opportunities. The findings as per Figure 4.33 indicates that 60% agreed and 1.7% strongly agreed that electricity can contributes, while 21.7% had no idea and 16.7% disagreed.

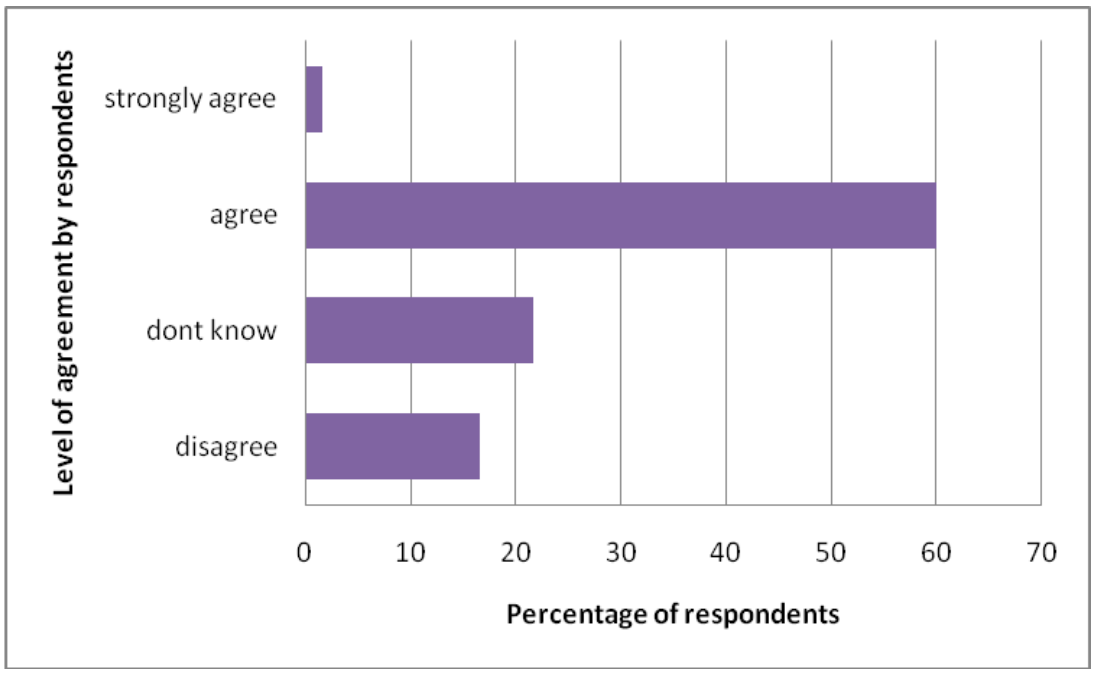

Figure 4.33: Availability of Electricity Contributes to Creation of Employment

Source: Field Study Data (2019)

Emerging of new enterprises indicates that the solar PV electricity has stimulated the economy of the village through new created and planned opportunities for livelihoods improvements. Despite of these facts still some users cannot link availability of electricity and development at individual or community level context. More awareness is needed to ensure the electricity consumers understand the link between livelihoods improvement and energy. This will bring out innovations that will boost social economic development activities, change their income status hence poverty reduction.

4.6.4.4 Business Activities and Business Operating Hours

Accessibility of electricity particularly in rural areas has a great impact on business operations in terms of performance and also in operating hours. Respondents were also interviewed on the contribution of electricity energy into changing the working habits and operations. Their responses as indicated in Table 4.4 that 83.3% of the respondents agreed that electricity has contributed and 11.7% disagreed and 5% had no knowledge of whether it can contribute.

Table 4.4: Electricity Contributes into Changing Working Habit and Operations

	Frequency	**Percent**
Disagree	7	11.7
Don’t know	3	5.0
Agree	45	75.0
Strongly agree	5	8.3
Total	**60**	**100.0**

Source: Field Study Data (2019)

It was observed that most of the enterprises such as retail shops, tailors/ sewing, butcher, restaurants and the electronic repair confirmed that after being connected to

mini-grid, they have changed the closing time of their business, because they have more time to works so in average the opening hours for these enterprises increased by an average of three hours. The retail shops now close at 10:30pm instead of 7:30pm, the butcher which was closing at 6:30pm now close at 8:00pm.

This is due to better lightings and security, and they said that by working more hours it has contributed into increasing their income.

> " *I started this shop 3 years ago and I was only selling mobile phone spares and accessories, I was using kerosene lamp and a small solar 15W, for light, so my shop was always been closed few minutes after sun set, but electricity has made me buy the soldering machine means I have expanded my business by repairing phones and other electronics, so with better lighting which have even improved the security I now have two extra hours of work until 10:30pm*

4.6.4.5 Improved Access to Media and Means of Communications

The recent changes that are seen in the world are because of the fast information spread. The significant amount of modern information is circulated through electronic medium that uses electricity power to operate. Boateng (2016) said that the electricity can either boost or limit the amount or the level of information, which a community can access, especially those living in rural areas without electricity. During assessment, results as in Figure 4.34shows that 95% of the respondents generally agreed that electricity is key factor towards better communications while 3.3% said to had no idea and 1.7% disagreed.

Based on the findings, it was informed that the villagers were extensively marginalised in terms of accessing to information from both local and global level due to failure to access electricity in their areas that led them into a primitive lifestyle.

They had challenges in charging phone, only few people had solar, and were charging at TZS 500, which was un-affordable to majority.

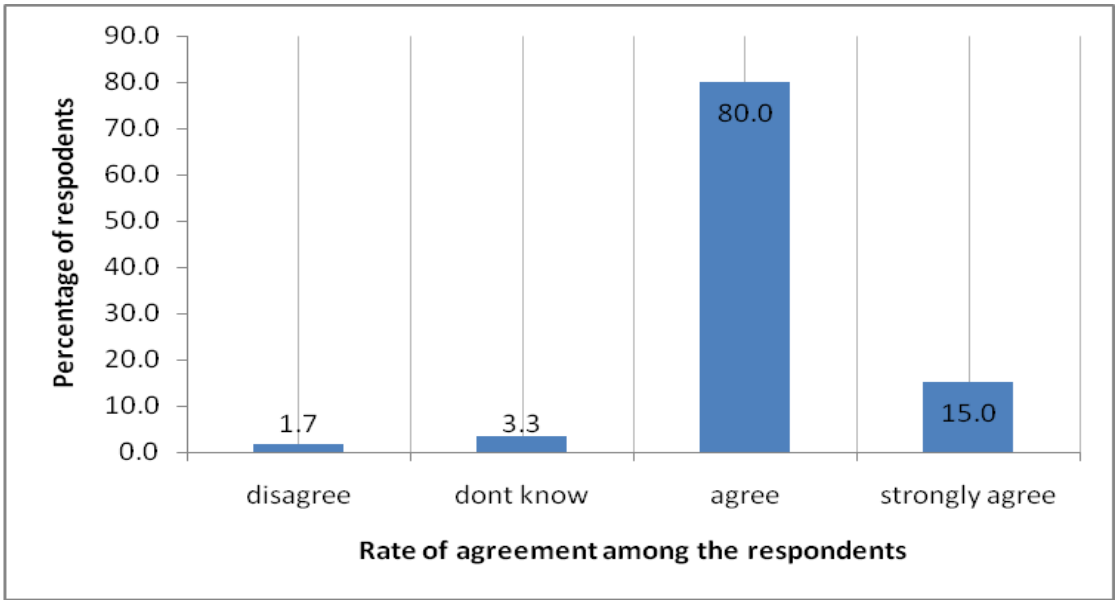

Figure 4.34: Availability of Electricity Improves Communications

Source: Field Study Data (2019)

The outcomes of FGD with village leaders and electricity committee showed that electricity has influenced people to buy mobile phone because it is easy to charge at affordable rates. The mobile phone value has increased because it can be used any time of the day. Some of government employees said they can now access their bank account information through Simbanking because phones are well charged with full signals due to the telecommunication tower which is erected at the village.

Means of communication and access to information through media such as Television and radio has also improved. Previously there was only once center showing TV/ Video and was using generator and the shows were live only in case there were special events like news bulletin at 2:00pm or an important football match. After the village being electrified, more centers were established while the number of

individuals who have bought their personal TVs is increasing People can watch movies, cinemas or football matches or watching news bulletin in TV and video centres.

The situation has improved; this is in reference to a respondent who is a football fan.

> " *our village has become modern, what we see in TV is what we have been hearing from those who are in town, now I know international players like Ronaldo, Lukaku and Messi, we see roads, and other development the government is doing through TV, this is because of electricity"*

The electricity has also played role in facilitating financial services at the village whereby the money transfers has become easy between villagers and people outside the village. One centre for TIGO PESA has started to offers services due to strong mobile signals for quicker transactions. As the demand increases, the services will grow and boost the money circulation hence improve the economy of the village.

4.6.4.6 Increased Productivity, Efficiency and Quality of Works

Lack of electricity is one of the bottlenecks for the improved and increased productivity in SMEs; it limits peoples thinking and creativity capacity. When respondents were asked how they see electricity in terms of efficiency and increased production; results as shown in Figure 4.35 indicated that 60% of the respondents agreed that with electricity there is an increased efficiency in doing works, increased volumes in production and the final products are of high quality. On the other hand, 16.7% of respondents disagreed and 23.3% had no knowledge on whether electricity improves the productivity.

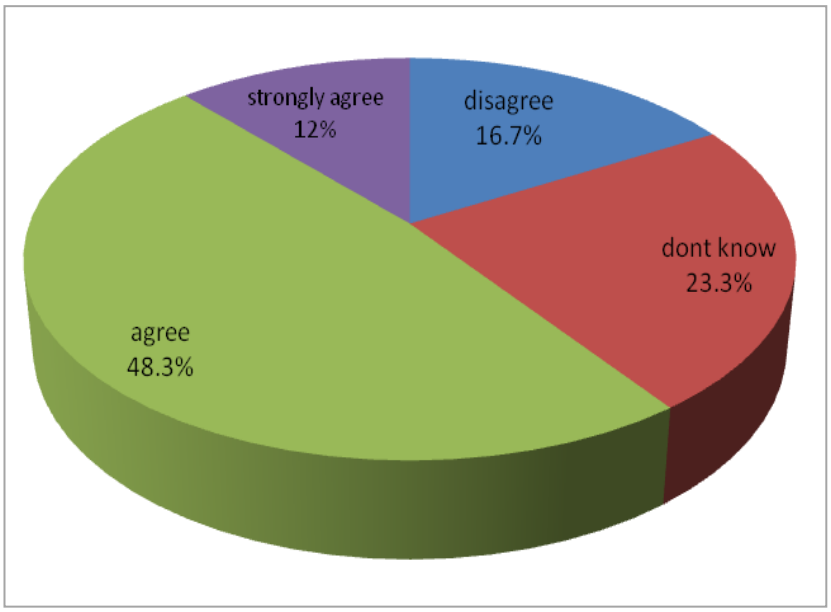

Figure 4.35: Availability of Electricity Increases Efficiency and Productivity
Source: Field Study Data (2019)

Majority of respondents who agreed on the contribution of electricity into productivity are the ones who already have started using it for productive uses. Other group was those who have seen and are aspired to have equipment for productive uses like welding machines, bench drilling machines for metal workshops and electric sewing machines.

During the study, the efficiency, increased volumes and improved quality of final products was vividly observed in one carpentry workshop where the electric wood planner was used. The planner was result of electricity demand stimulation done by Ensol through scheme of loan for equipment. According to the owner of the carpentry workshop, after starting using the electric planer, the work become more convenient, easier, less hard and therefore healthier. He said in the past the work was labour intensive, hard physical work but the machine has replaced all that. He works on the same hours as before but serves more customers in the same amount of time.

The planner has also become source of income in a different way;

> "*When I am not using the planner especially on Friday's I used to rent this planner to my fellow carpenters, they pay me some token that also boost my income". I am happy that my income has increased and I can support my family well than before"*

Moreover, the electricity has made SMEs based at the village such as tailors, butchers, retail shops to operate in longer hours which enable them to produce, or sell more hence more income than before.

Mpale is a mountainous village but it doesn't get rains throughout a year, this has made difficulties in practicing horticulture and subsistence farming practises. During dry season, farmers have to irrigate their small horticultural crop yards using hand water canes that make it tedious, time consuming and less productive. Presence of electricity can stimulate opening of big farms that allow water pumping for irrigation which will results into increased productivity throughout a year hence a significant contribution into income.

All these findings are similar to what reported by Zwebe (2005) in the study done in Vietnam on microenterprises where it showed that microenterprises started to grow after being connected to mini-grid electricity, efficiency for carpentry workshops using electrical machines increased by 60%, time to deliver products for tailors was reduced by almost 50%.It also showed that customer base for the motorbike repair entrepreneurs increased in short period of time due to the quick repairs and the value addition for agricultural products have become easier and faster because of the electric powered milling machines.

4.6.4.7 Improved Security and Safety in the Village

Study results on the contribution of electricity on improving the security of the village as indicated in Table 4.5,have shown that 93.3% of respondents agreed electricity contributed into improving security within the village, while 3.3% disagreed and 3.3% indicated they had no idea.

Table 4.5: Availability of Electricity Contributes into the Improved Security

	Frequency	**Percent**
Disagree	2	3.3
I don't know	2	3.3
Agree	53	88.3
Strongly agree	3	5.0
Total	**60**	**100.0**

Source: Field Data Study (2019)

It was informed that before electrification the movements within the village were limited after sunset; the shops and other services were closed at 7-8:30pm. Cases such as theft in shops and in houses, injures from animal bites during the night were regularly reported to the village leaders. Several times the respondents saidthat previously it was common for witchcrafts to walk in people's houses during the night as the village was totally dark. It is now obvious that though there are no streetlights erected at the village, most parts of the village are shining because of houses, which have already been connected to minigrid. This has made villagers to move with little fear, extend working till late hours time especially women selling food and bites at village square. These findings are similar to the study done in Uganda by Hirmer & Guthrie (2017) on benefits of energy appliances in the off-grid energy sector have

shown that among the potential benefits of electricity, which are known, the security benefits were rated 42% by the community, which was under the study. This implies that when there is a reliable electricity connection and services provision it assures people security; which enables and facilitates them to work in extra hours for more income earnings, and with fearless movements. Once the security lights are erected in some crucial points and the number of connected houses is increased, the security status of Mpale village will improve.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The chapter is segmented into three sections, a summary of the study findings in relation to the objectives of the study, the conclusion of the study findings and recommendations on what can be done on the project or to similar in the future.

5.2 Summary of the Study

5.2.1 General Summary

The research study was exploring the relationship between the different variables that determine the sustainability of the energy projects, which ultimately end up in improving the livelihoods of the community. These variables include the awareness of efficient uses of electricity, community participations and access to electricity for opportunities that ensures the transformation of the livelihoods of the community. The analytical analysis on the background to the problem indicated that low level of awareness on efficient use of electricity, non-participatory approaches in development of projects and non productive uses of electricity can lead to failures in projects, pose sustainability risks hence no expected transformations at individual or community level.

5.2.2 Summary of Key Findings of the Study

Data collected under this study aimed at understanding various issues related to the impact of the mini-grid solar electrification in the livelihoods transformation and also to understand the relationship between various dimensions that contributes into

attaining changes on key variables that reflects transformations at individual or community at large.

5.2.2.1 Awareness on Efficient uses of Electricity and Energy Conservation

In this study it was found that the majority of the electricity users at Mpale village have basic awareness knowledge and information on the efficient use of electricity, the practices that lead to efficient uses and inefficient use of electricity. The findings showed that most of the users were practicing the efficient uses of energy for some reasons including saving costs, protecting appliances and sometimes avoid risks of fire accidents. The data of this study also shows that whenever electricity is efficiently used; some significant changes are noticeable especially in costs savings. The study also showed that high costs of high efficiency appliance are one of the key challenges that have hindered numerous users of such appliances. Moreover, despite of these appliances being expensive, its few of community members who had ideas that energy/ rated power consumption of the appliance is key factor to consider when buying electrical or electronic appliances for efficiency use of electricity. It is was also noted that monitoring monthly bills using the smart meters installed in the users houses was a common way of controlling reckless uses, and it enables users to meet the expenditures of minimum energy power allocated per day.

5.2.2.2 Community Participation in the Energy Project Development

The research study found that the participatory approaches were used by the project developer during the implementation of the project. Through these approaches various decisions and agreements were made in the meetings. The community participated at different project stages including initiation, designing, planning and implementation.

Both men and women participated in the project but at different levels whereby participation of women recorded to be low compared to men due to various home care responsibilities. There was a disproportional consideration of women during selection and trainings of local technician, only one fifth is represented in the project management committee. It was found that based on the inputs from the villagers during participatory demand assessment, it enabled the design of the energy plant system that can accommodate and meet energy needs of the community for both productive and consumptive uses. Despite of disparity in level of participation, most of the villagers feel to be part of the project because of the transparency that is being portrayed in the whole process of implementation.

5.2.2.3 Opportunities Created by Solar PV Minigrid Electricity

The effectiveness and the success of the project is measured based on the impacts that it has on the community members and how the project has contributed into creating various income and employment opportunities. In this study it was found that the solar PV mini-grid has been able to impact the Mpale community through various opportunities that have been created and established including small enterprises, and delivery of improved social services. Through uses of electricity livelihoods of community members have started to change into better ways. Increased income and better social services such as education and health have started to improve. The health benefits from the mini-grid are still partial since none of the consumers have started using electricity for cooking.

However, the awareness on the income earning and job opportunities through solar mini-grid is still low, few villagers can link electricity and their social economic

development, they lack appropriate information on effectiveness and capability of solar grid electricity to power heavy appliances, they lack information on appropriate appliances and their sources and how to use it productively. The data has also shown that electricity has stimulated the creativity and plans to invest among the users and in near future the number of productive users will increase.

5.3 Conclusions for the Study

The success and failure of energy projects depends majorly on how effective the project has been in attaining the objective of its establishment. This study aimed at understanding the awareness on the efficient uses of electricity, energy conservation, and community participation in projects and also the opportunities that solar mini-grid electricity can create to facilitate the transformation of the livelihoods of the community at Mpale village.

Based on the findings of this study, it was found that access to the right information and awareness on the best practices, can lead to efficient use of electricity and energy conservation; and these are key to sustainability of the energy systems. If the community lack such information it can use electricity and energy recklessly and result into high electricity loss hence families incur higher energy costs unnecessary.

The study has also revealed that if there is no appropriate knowledge to consumers on how to select the right appliances, even if there is a close monitoring of how electricity is used; there is no significant positive impacts in uses due to high consumption of the appliances. This has reduced chances of some of the electricity

consumers at Mpale to operate many appliances at a time, or having more connections in their houses.

The result of this study has however showed that community participation has been displayed and practiced as a key factor that has enabled the project to become stable and provide energy services accordingly. Through the participatory approaches at different project activities the community has developed sense of ownership and commitment to the project. It has made them feel that it's their project. Strong bond has already been built between and no conflicts or sabotages have been reported, hence sustainability of project is assured.

Solar PV mini-grid electricity has also been revealed to be an effective alternative that can be used to light up and creates opportunities that bring up social economic development in areas where the national grid electricity is a challenge. The study found that the villagers have already started realizing the impacts of the project which is ultimately leading them into improved livelihoods. This transformation is through operational new and existing enterprises, increased and improved access to social services such as health and education, increased access to information through media and obtain age of extra working hours due to better lights for increased income.

5.4 Recommendations for Project

The findings of this study has proved beyond any reasonable doubt that Mpale solar PV mini-grid is a useful project and immediate impacts and the emerging ongoing success stories are the results of the best practices and approaches used from its

inception. The following are recommendations, which may help the project to improve and maximize its benefits for the livelihoods of the served community.

5.4.1 Strengthen Efforts in Creating Awareness on Energy Use and Efficiency

The study has revealed that there is a basic awareness son the energy efficiency and conservation among the electricity users; especially on practices related to uses of lights and basic electrical appliances. Despite of the good general awareness but still there is lack of information among the consumers and the community in general on other important energy efficiency issues. Among them include standards and appropriate sizes for electrical accessories to use when undertaking indoor wiring and connections to prevent electricity loss and lack of knowledge on important factors to consider when buying electrical appliances such as rated capacities and energy labels.

Due to that, it is recommended that the developer (Ensol T Ltd) to continue with regular awareness campaigns that will benefit existing and the new connected users. The awareness should be done through demonstration meetings at village square using demo kits on efficient use, and through printed informative leaflets, posters and brochures. These will keep on reminding users of electricity to adhere to best practices that assures high efficiency uses and shifting from non efficient to efficient appliances.

5.4.2 Increase Women Participation in the Key Project Activities

The study revealed that a participatory approach was used during implementation of project which has assures its sustainability. However, participation of women was recorded to be low in some key functional areas in the project; especially on decision

making in the management committee and on technical knowledge transfer due to lower representation. Since this is a long term project, there should be ways to continue engaging women in the project.

It is therefore recommended for the developer and the village leaders to; first consider formulation of the technical committee and increase participation of devoted women in management and technical committees to at least 40%. On that basis developer should consider training and empowering women with knowledge on basic technical issues for trouble shootings, and on how to create awareness on efficiency and productive uses since they tend to be trustworthy.

5.4.3 Demonstrate Capability of Solar Minigrid Electricity for Productive uses

It was observed under this study that despite of the minigrid being operational for almost 18 months by the time of the study, less than 35% of the connected customers uses it for productive uses. Low awareness on the capability of solar PV minigrids electricity to perform and power appliances and lack of information on availability of the appropriate, standard and efficient appliances and machineries for productive uses were among the reasons. Since the supply of electricity for basic uses was not the only objective of the project, it is recommended that there should be continuous efforts to create awareness on the potential opportunities and capability of the installed solar PV Plant for productive uses, give the right information on appropriate machines and appliances, their sources and availability of spares. This could be through demonstrations meetings, study tours of inspired entrepreneurs to learn from other villages where minigrid electricity is highly used productively. Inviting experienced and experts on mobilization and awareness creations such as Energy for Impact (E4I)

and TaTEDO for inspirational demonstrations to stimulate creativity and demand for extensive uses of electricity can also be considered.

Lack of capital to buy the appliances and machines has also been seen as a challenge and hindrance to most of the entrepreneurs. This is because of the seasonal and unreliable income. It is recommended that such entrepreneurs should be supported by project developer by giving them loan for machines and appliances. They can also be linked with financing institutions which can support them with lower interest rates loan.

Lack of technical know-how on using the appliances and machines can become a challenge after they have acquired them. It is therefore recommended that developer should provide technical assistance and undertake regular monitoring to see how the installed machines operates and maintained; this will maximize electricity utilization for a continuous flow of income to owners.

5.5 Recommendations for Further Research

Despite of the efforts being made by the project developer in collaboration with the community to ensure the project management and operation meet the requirements for its sustainability, this study has created a room for further exploration. In the study it was revealed that affordability was among the factor, which hinders adaption and uses of high efficiency appliances. It is recommended to undertake further studies on how other factors such as availability, awareness, accessibility and acceptance contributes to slow rate of adoption of high efficient lighting and electronic appliances and possible measures.

Though the main focus of the study was not on cooking but something can be studied on as it is an area where energy is much used. It is therefore recommended to undertake study on the likelihood of adapting cooking and heating practices using solar PV mini-grid electricity through efficient cooking appliances as to reduce the risks associated with the use of charcoal and firewood on environmental and health aspects. If community use electricity for cooking, it will be another way of expanding the range of power utilization, hence increase more revenues to the operator of the energy system.

It is also recommended to undertake a thorough study to assess and make comparative analysis on the social-economic impacts for both connected customers of solar PV mini-grid and non-connected customers.

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APPENDICES

Appendix I: Questionnaires for the Solar Pv Mini Grid Electricity Users

Dear Respondent; this questionnaire is for collecting data related to the Solar Minigrids Project at the Village, where applicable, please tick, circle or fill in the space provided with a correct answer. I expect that you will answer the questions as frankly as possible.

Ward ---------- Village ---------- Sub Village/ Street……

A: Personal Profile

1. Gender

   (i) Male ( )
   (ii) Female ( )

2. Age

   (i) 18 – 25years ( ) (ii) 26 – 45years ( ) (iii) 46-60 years ( )

   (iv) >60 years ( )

3. Marital Status

   (i) Single ( ) (iii) Divorced ( )
   (ii) Married ( ) (iv) Widow ( )

4. Education level

   (i) Never attended school ( )
   (ii) Primary level ( )
   (iii) Secondary level ( )
   (iv) Diploma holder ( )
   (v) Degree holder ( )
   (vi) Others, specify……

5. What is your main Occupation?

   (i) Farmer ( )
   (ii) Business ( )
   (iii) Employee ( )
   (iv) Livestock keeper ( )
   (v) Others (specify) ……

6. Type of electricity User:

(i) Households ( )
(ii) Business *retail shop*, ( )
(iii) Dispensary ( )
(iv) School ( )
(v) SMEs ( ) please indicate (workshop, butchery restaurant, saloon, barbershop
(vi) Church ( )
(vii) Mosque ( )

7. For how long have you been living in this village?

1) 0-10 years 2) 11-20 years 3) 21-30 4) more than 30 years

8. What is your main energy resource in your household?

(i) Firewood ( )
(ii) Charcoal ( )
(iii) Kerosene ( )
(iv) Electricity ( )
(v) Petrol ( )
(vi) Diesel ( )
(vii) Solar ( )
(viii) Biogas ( )
(ix) Others, please explain…….....

9. What are the main uses of electricity in your household/ businesses areas/ institution Please mention……

10. Type of electrical appliances you are have in your place

1) ……, ……..,……
2) ……,……,……
……..

B: Awareness on Efficient Use of Electricity and Energy Conservation

Please circle the appropriate answer

1. What is your understanding on the efficient use and energy conservation?

(i) Very Good (ii) Good (iii) Average (iv) Poor (v) Very poor

2. Are you aware of the practices that lead to efficient use of electricity and conservation of energy?

(i) Extremely ( ) (ii) a lot ( ) (iii) moderate ( ) (iv) just little ( )

(v) not at all ( )

3. Tick the efficient use and energy saving practices you apply at your place

(i) Using high efficient appliances i.e. LED bulbs, TV, radio. ( )
(ii) Switch off lights when not in use ( )
(iii) Using natural light during the day instead of putting light on ( )
(iv) Switching off TV, Fans, Computers in the socket after using it ( )
(v) Cover the pot when cooking ( )
(vi) Schedule for the services provision i.e. milling ( )
(vii) Not leaving the fridge open and avoid overloading it ( )
(viii) Using appliances that have energy efficiency label ( )
(ix) Putting the fridges where can get enough air circulation ( )

a) Do not iron the clothes in small batches ( )

4. Why are you practicing the efficient use of electricity and energy conservation? Give reasons

a) ……
b) ……

5. Are you aware that the following are the practices indicating inefficient uses of electricity?

(i) Yes ( ) (ii) No ( ) (iii) I know abit ( )

(a) Using inefficient appliances such as incandescent, CFLs
(b) Living the lights ON while no one is using ( )
(c) Using and living the lights ON in the noon instead of using natural day light ( )
(d) Not switching off the appliances in the socket ( )
(e) Living the fridge door open and overloading it ( )
(f) Using appliances that have no efficient label ( )
(g) Iron the clothes in small batches ( )

6. Are you aware that your monthly/ weekly bills are determined by your behavior in using electricity?

(i) Yes ( ) (ii) No ( ) (iii) I know abit ( )

7. Are there any changes in your monthly expenditures after you started using electricity efficiently?

(i) Yes ( ) (ii) No ( ) (iii) Little changes ( )

What are the changes……..

8. Do you think you need more information regarding the efficient uses and conservation of electricity?

(i) Yes ( ) (ii) I don't need ( ) (iii) I need a little ( )

If YES Give your reasons……..

9. Please use the scale below, tick how you feel that these factors have effects in the efficient use of electricity and energy savings in the community. Scale (5 = strongly agree, 4= Agree, 3= Don't know, 2=Disagree, 1 = Strongly disagree

S/N	STATEMENTS	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1.	Lack of awareness and information on the inefficient use of electricity can lead into high uses and loss of electricity					
2.	Buying high efficient electrical appliances and replace with old inefficient one save electricity and costs to end users					
3.	Creating awareness on the efficient use of electricity and savings can help to reduce consumers costs and saved costs diverted to other households expenditures to improve livelihoods					
4.	High costs of efficient appliances and low ability to buy them is the reason of why most are not using efficient appliances rather buy second-hand appliance					
5.	Saving energy and using it efficiently are key aspects to sustainability of the energy					
6.	Regular monitoring of the bills helps to control the consumption of the electricity					

10. What do you consider when you are buying the electrical appliance such as bulbs, fans, radios, TV, fridge?
    (i) Cost of the appliance ( )
    (ii) Brand of the appliance ( )
    (iii) Energy/ rated power of appliance ( )
    (iv) Status of the appliance (new, second-hand, old) ( )
    (v) To meet the purpose /objective of possessing it ( )
    (vi) Shape, color and appearance of appliance
    (vii) Others, specify…….

C: Community Participation in establishment of Projects

1. How did you know about the establishment of the solar pv project in your village?

   (i) Village leaders in assemble meeting ( ) (ii) the developer ( )

   (iii) It was a surprise ( ) (iv) I didn't know ( )

2. Did Local community fully participate or participated in designing, planning, implementing, and monitoring the electricity project in the village?

   (i) Yes ( ) (ii) No ( ) (iii) I don't know ( )

3. What was the level of participation in the whole process of the solar electricity project implementation?

   (i) Higher ( ) (ii) High ( ) (iii) Average ( ) (iv) Low ( ) (v)Very Low

4. What is your feeling on the project? / Do you see yourself as a part of theProject?

   (i) Yes ( ) (ii) Somehow yes ( ) (iii) Not all ( )

5. Based on the answer above, what are the reasons behind that over the project? Mention them

   (i) …… ……
   (ii) …….
   (iii) …….
   (iv) …….

6. How women participation is considered in the project management/ committee?

   (i) Highly ( ) (ii) Moderate ( ) (iii) Low ( )

7. Which areas in the project have women and young girls participated?

   (i) Initiating and Planning ( )
   (ii) Management and operation of project ( )
   (iii) Knowledge transfer and training ( )
   (iv) Decision making on various issues of project ( )
   (v) Have not been involved ( )

8. Has the availability of electricity increased the girls and women participations in the evening programmes and events in the village such as meetings, education, programs? How? Explain……..

9. Please tick the appropriate answer how you feel that community participation can have effects in development, operation, management for sustainability of the energy systems.

S/N	STATEMENTS	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1.	Involving community in all stages of project helps to understand the purpose of the project hence bring sense of ownership for its sustainability. (transparency)					
2.	Community participation in the development contributes into reducing projects costs (laborers, free land, infrastructures)					
3.	Lack of technical capacity to local technicians and the community can lead into challenges in operations and maintenances of project					
4.	Involving community s one way of empowerment through employment, management and ownership					
5 .	Through community participation, the similar project can easily be replicated/ scaled up to other areas.					
6.	Involving community at the beginning on the type of tariffs, mode of payment helps in ensuring the sustainability of project.					

D: Activities and opportunities created by Solar PV Minigrid Electricity

1. What are the income generating activities do you undertake using the solar PV mini-grid electricity? Mention them…….…….

2. For how long have been using electricity, please indicate……..

3. What kind of energy sources did you use in your place for lighting, TV, charging, cooking before the village electrified by Solar PV minigrid? Tick the appropriate one
   (i) Car Battery ( )

(ii) Kerosene ( )
(iii) Petrol ( )
(iv) Diesel ( )
(v) Solar ( )
(vi) Candles ( )
(vii) Biogas ( )
(viii) Fire wood ( )
(ix) Other (s) specify ……

4. How do you see the effectiveness and capability of solar minigrid electricity from other sources that have been used by this village before?
Please explain……..……

5. How has the solar PV electricity helped women and girls of this village meeting their energy needs? How? Please indicate
(i) .....
(ii) ……
(iii) ……
(iv) ……

6. How has the solar PV mini grid electricity helped your children in their education Improvement?
Explain..…….

7. Can you mention the health benefits that you have gained through the use of electricity from solar PV mini-grid?.....
……
……
……

8. In the range of scale provided (1-5) please indicate the extent to which you agree with below statements on the significant changes caused by availability of solar PV minigrid electricity (where by 5= strongly agree, 4= Agree, 3= Don't know, 2= Disagree, 1=Strongly disagree)

S/N	STATEMENTS	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1	Availability of electricity can improve delivery of health services in dispensaries (safe delivery, access to vaccines, laboratory)					
2	Availability of electricity can contributes into changed working habits (operate/ work for more hours after the sun set)					
3	Availability of electricity can led into increased access to clean water					

S/N	STATEMENTS	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
	from pumps powered by electricity					
4	Availability of electricity can contribute into increased children performance at school due to more hours of study, can use labs for science subjects, teaching tools)					
5	Availability of electricity can contribute into creating permanent and temporary employment opportunities.					
6	Electricity in the village can improve the means of communication (phone charging, media access, improved transactions among the villagers					
7	The availability of electricity can contribute into the improved security within the village					
8	Use of electricity can lead into reduced cost of energy use per month/ year					
9	Availability of electricity has resulted into increased efficiency and production of quality products (carpentry, welding etc.)					
10	Availability of solar PV electricity has increased reliability of obtaining the services compared to other alternatives					

Thank you for your participation

Appendix II: Interview / FGD Guide Question/ Checklist

For village leaders, village assembly members, and project committee members (if any) and developer (Ensol Ltd) for better understanding of the project, process of establishment and its contribution on livelihood transformation.

1. What is the population of the village? Give figures for Male, female, Children
2. What are social economic activities of the village? Mention them.
3. What have been the sources of energy in this village before this project?
4. What are the steps you had to go through before the establishment of the project?
5. To what extent were the people in the village involved? Do you see any benefits of involving them? Have there been challenges for people to
6. participate in the project?
7. What are the conditions and criteria used for those who want to get connected to the electricity? I.e filling forms, payments, self wiring or?
8. What is the total number of connectivity? What facilities connected to electricity?
9. What are the payment systems for the connected customers? PayGO, cost of unit?
10. Are there any complaints for bills?
11. What economic activities emerged in the village after electrification? What percentage is owned by women?
12. What changes been observed in the village in terms of other social services, i.e costs for other services, transport to services, and establishment of MPESA etc?
13. What are the challenges you are facing with this project at the moment? i.e payments of bills, illegal connections, meet the demand etc?
14. What kind of awareness on efficient use of electricity did community get?
15. How do the projects involve other partners to ensure the project progress well i.e consumers education on efficiency use and conservation of energy, knowledge?
16. Are there rules guiding the consumption of electricity, and how are the people (consumers) observing them? i.e limit of appliance to use, time to use,
17. What are the mechanisms in place which used to monitor the consumption behaviour if it according the agreed principle? i.e smart meters, time limits etc?
18. What are strategies to ensure there are suppliers of efficient electrical appliance at the village especially for productive uses? i.e hardware, or supplier from town etc?
19. What mechanisms to ensures increased connections? Are there any MFI?
20. What are the strategies for managing the project in future?
21. Is there any trained technician at the local level who operates the system?

Thank you for your cooperation

Appendix III: Guide Question for Women Focus Group Discussion

1. How do you see yourself as part of this project?
2. What are challenges facing female headed households in connecting to the mini-grid
3. What would you like the project to do to satisfy your energy needs?
4. Are you aware of the practices lead into efficient use of electricity? Mention them?
5. How did you learn about efficient use of electricity and energy savings?) husband, wife father, meetings, newspaper, books?
6. Which appliances do you have you think are not energy efficient? Mention?
7. Which on would like to add in your stock for future use?
8. Now that you are aware of the energy efficiency and savings, what are plans to replace the equipment?
9. How have you participated in ensuring that your home is using high efficient appliances?
10. Do you have time to enjoy electricity i.e radio, how often do you use electricity? –ful time, evening, afternoon? Why?
11. What are the income earning activities that you do with electricity that you have decisions over it?
12. Who pay for the monthly bills?
13. How did you participate in the project development process? Initiate, planning, development, training etc?
14. What are you doing with the costs saved after using electricity? School fees, new cloths, SACCOS etc
15. If is to ask for improvement of the electricity services, what area do you think will need improvement?
16. What are the main uses of electricity that are of beneficial to women in particular?
17. What changes have you realized healthy-wise after u have started using electricity?
18. What do you think has not gone right to your expectations?

Thank you for your participation!!

Appendix IV: Guide Questions for Interviews with Education &Health officers

1. What are the immediate impacts of the project to education performances at the village school, Explain, how
2. How has the electricity been useful into your teaching works, i.e preparatory works,
3. What have you been doing with the electricity at school? Has it been used as teaching tool?
4. How do you compare the school attendance and enrolment before and after the village is electrified, what have been the performances for the last 3 years?
5. What strategies do you have to ensure the education performance improves? i.e evening lessons etc?
6. What kind of energy used at dispensary before electricity and explain how you benefited from it
7. How do you compare and health services in the village before and after electricity?
8. What appliances do you have for diagnosis diseases? ?
9. How do you store the vaccinations, what have been your experience after electrification
10. What kind of diseases that are common and why? Can you associate them with / without electricity?
11. What experience do you have on working during the night? before and after electricity.
12. Can you explain whether there have been any security issue at your institution?

Thank you for your Attention!

Appendix V: Research Clearance Letter