FACTORS INFLUENCING ADOPTION OF OFF-GRID COMMUNITY-BASED SOLAR PHOTOVOLTAICS IN CHIKWAWA DISTRICT, MALAWI

MPHIL (RENEWABLE ENERGY) THESIS

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UNIVERSITY OF MALAWI

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MPhil (Renewable Energy) Thesis

By

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DECLARATION

I, Collins Duke Namakhwa, hereby declare that this paper is my own work which has never been submitted for any other degree but only as thesis for the award of a Master of Philosophy in Renewable Energy at Polytechnic, University of Malawi.

CERTIFICATE OF APPROVAL

We, the undersigned, certify that we have read and hereby recommend for acceptance by the University of Malawi a thesis titled *'Factors Affecting Adoption of Off-grid Community-based Solar Photovoltaics in Chikwawa District, Malawi'*:

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Date : ___________________________________

DEDICATION

To my beloved wife, Rabecca Namakhwa, God bless. Then to Ryan, Eddie and Jordan – in that order!!!

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This paper has been made possible through the assistance of many friends, colleagues and family that space limits for mentioning their particular contributions and names. There were those that encouraged and exhorted, and then those that would provide a critical eye without which something unreadable and unfocused would have been produced.

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GIP is family from the word go and, much as we are ‘country’ bound, you have been the inspirational force from *shopilo* to *mwalamwalakhobwe* to REVIEW – awesome. Cecilia, Doreen and Vic’s skills in data collection cannot go without mention. Then there was that data entry stuff with Comrade M.D. (so-called) Inno while eating *dimba* and dreaming Brenda. The fruitage of all that dedication is hereby presented.

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Last, of course not least, sincere thanks to Poly and WASHTED for funding my study.

ABSTRACT

As there are limited opportunities for grid expansion in developing countries whose populations are growing and demand for energy increasing, rural electrification is slowly being achieved through use of off-grid technologies. Community solar photovoltaics (CSPVs) are being seen as the means through which off-grid electrification can be diffused to rural areas. The purpose of this study was to determine and analyse factors that influence adoption of CSPVs in Chikwawa, Malawi.

A **sample of 309 respondents** was drawn from 5 communities where CSPVs had been installed to collect quantitative data using a Likert-type questionnaire on the five attributes that influence adoption in Roger's Diffusion of Innovation Model: relative advantage, trialability, compatibility, observability and complexity. Qualitative data from in-depth interviews and desk research provided insights into the CSPV market and project policies.

The study found that adoption of CSPVs in Chikwawa was facilitated by relative advantages derived from using the CSPV, compatibility with their occupations and social norms and observability effects. **It is concluded that a rural CSPV adoption strategy that uses Roger's Model is modulated by gender and occupational differences of the target market in perceiving the attributes that influence *relative advantage, observation* and *compatibility*.**

It is therefore recommended that CSPV adoption strategies should include rural market segmentation in gender and occupational lines.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

BARREM	Barrier Removal to Renewable Energy in Malawi
BUI	Bottom-up initiative
CCODE	Centre for Community Organisation and Development
CRED	Community Rural Electrification and Development
CSPV	Community Based Solar Photovoltaic
DEA	Department of Energy Affairs
EPIA	European Photovoltaic Industry Association
ESCOM	Electricity Supply Corporation of Malawi
ESMAP	Energy Sector Management Assistance Program, World Bank
FISP	Farm Input Subsidy Programme
GDP	Gross Domestic Product
GoM	Government of Malawi
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
MGDS	Malawi Growth and Development Strategy
MREAP	Malawi Renewable Energy Acceleration Programme
NEP	National Energy Policy
NGO	Non-Governmental Organisation
NIMBY	not-in-my-backyard
NSO	National Statistics Office
PV	Photovoltaic
RE	Renewable Energies
RET	Renewable Energy Technologies
SHS	Solar home system
SPSS	Statistical Package for the Social Sciences
TAM	Technology Acceptance Model
TV	Television
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme

WASHTED	Center for Water, Sanitation, Health and Appropriate Technology Development, Polytechnic

1. INTRODUCTION

1.1 Energy in Sub-Saharan Africa

The recent upsurge in the supply of and demand for solar photovoltaics (PVs) worldwide indicates a determined move to circumvent a looming energy crisis that has been steadily blossoming due to a heavy reliance on non-renewable energies (Ondraczek, 2014). In developing countries, energy insufficiency is a cause of great concern because of growing populations that are increasing the demand pressure for domestic and industrial electricity services, market forces are forcing developing countries in Sub-Saharan Africa to explore extra means for expanding their power sectors (Ondraczek, 2014).

Sustained development and economic growth within countries hinges on availability, sustainability and abundance of energy at affordable cost (Sriwannawit, 2015). Yet until recently, fossil fuels and hydroelectricity have been the major thermal and electric energy sources over the past century (Chaurey & Kandpal, 2010). In Sub-Saharan Africa, they have been the developmental workhorse of the countries' industrial sectors (Eberhard, Shkaratan, Rosnes & Vennemo, 2010).

But fossil fuels are neither sustainable nor clean; and, while hydroelectricity is clean, the technology is archaic and, especially in developing countries, extension opportunities are narrow (Collier & Venables, 2012). Yet, of the 7 billion world population, the International Energy Agency (IEA, (2014) reported that 1.3 billion had no electricity services at their disposal, with nearly all of them residing in developing countries.

The bulk of this group, argues Pode (2013), lives either in South Asia or in Sub-Saharan Africa. Brew-Hammond (2010) and Ondraczek (2014) went further to state that of the two regions, Sub-Saharan Africa is the worst hit with 69% of the population not accessing the grid. Researchers as early as Zerriffi (2011) and, more recently, Smith and Urpelainen (2014) pointed out that in these two regions, grid is being expanded at a worrying, slow pace due to the sparse rural population distribution and low incomes that make grid expansion not economically feasible (Onyeji, Bazilian, & Nussbaumer, 2012).

Nonetheless, as pointed out by Bugaje (2006), mitigating energy challenges will provide the basic driver for health and education development in Africa. It is therefore imperative that energy mobilization should target Sub-Saharan Africa amidst contending political, economic, social, sustainability and environmental concerns that drive energy decisions (Deichmann, Meisner, Murray, & Wheeler, 2011; Ondraczek, 2014; Sriwannawit, 2015).

As grid expansion has its own challenges which include spatial challenges and economic infeasibility, off-grid renewable alternatives such as biomass, wind and solar technologies are promising to provide a way out (Taele, Gopinathan, & Mokhuts'oane, 2007). These decentralized systems have been supported by various researchers due to their flexibility, little or no carbon footprint, ease of mobilization, low running costs and renewability (Brass, Carley, MacLean, & Baldwin, 2012; Smith & Urpelainen, 2014; Zerriffi, 2011).

In fact, Reinoso, Paula and Buitrago (2014) observed a growing trend in the generation and application of these renewable energy technologies (RET) for the past 20 years driven by climate change concerns and oil price increments. With plummeting price trends, stand-alone systems are being spurred on by the push for environmentally-friendly technologies coupled with a recent surge in their promotion by different social quarters to address the energy situation (Kebede, Mitsufuji, & Choi, 2014).

With such a turn-around in the energy sector, I assert that Sub-Saharan Africa might be poised for a better experience in rural electrification and economic growth. As pointed out by Ondraczek (2014), developing countries are seeking to harness energy through sources that are both sufficient and sustainable.

1.2 Solar Photovoltaics in Sub-Saharan Africa

Quaschning (2005) defined renewable energies (REs) as those resources for generating energy that cannot be exhausted within humanity's timeframe and that these could be grouped into solar, planetary and geothermal. Of these three, "solar energy is by far the most abundant" (da Rosa, 2009, p. 23). Kim, Park, Kwon, Ohm and Chang (2014) define solar energy technologies as "the technologies which directly use energy from the sun to produce electricity, and to replace fossil fuel generation at the point of end-use employing active means" (p. 524).

Solar photovoltaics, also called solar cells, are electronic devices that convert sunlight directly into electricity (International Renewable Energy Agency (IRENA, 2012; Poullikkas, 2010). Because these systems are usually based on silicon for conversion of solar radiation into electricity (Basnet, 2012), their availability is somehow limited where otherwise it ought not to have been because the abundance of solar energy is guaranteed, non-excludable and non-rival. Indeed, only 0.2% of the fraction of solar energy that touches the earth is all that is required for use to produce energy for the whole world (Aartsma et al., 2008; Tao, 2008).

As claimed by Kebede, Mitsufuji and Choi (2014), the forerunning RETs in promotion terms for rural electrification are solar photovoltaic technologies. Worldwide, its market has strongly grown over the past few years, especially for hybrid systems that combine PVs and wind technologies or PVs with the grid (European Photovoltaic Industry Association (EPIA, 2012). As a result, by the year 2014, PV production had within a decade increased 40 times, thus becoming the leading RET worldwide in distribution (Hansen, Pedersen, & Nygaard, 2014).

Solar energy is a leading alternative energy attraction for Africa because naturally it is not centralized, is abundant in supply and therefore has a cheap source, is experiencing steadily falling costs over time, does not suffer from supply and demand fluctuations and is supported internationally for carbon emission reduction programs (Deichmann et al., 2011; Guidolin & Mortarino, 2010). It leaves no carbon footprint and therefore is the friendliest energy to the environment (Kim et al., 2014).

But, in spite of these advantages and "despite several efforts to develop and promote such technologies, uptake remains so low and sluggish" in Sub-Saharan Africa (Kebede, et al., 2014, p. 3124). In light of this, Bazilian et al. (2013) and Ondraczek (2014) wondered why albeit the gains from cost reduction of PV production – with a 50% global reduction within the 2008 and 2009 one-year period alone – Sub-Saharan Africa uptake still remains low.

Bazilian et al. (2013) blamed a persistent market information lag as a major factor for sustained low uptake of PVs, the changing market landscape notwithstanding. Furthermore, Ondraczek (2014) theorized that decision-makers and researchers might be relying on outdated information that does not appreciate the recent cost leaps favourably made within the past 5 years. He expressed optimism, however, by taking special note that there is a near unanimity amongst experts and policy makers that rural health centres, households and others should benefit from off-grid technology systems.

Indeed, much as absolute uptake is low, the rate of uptake is positively upward. About a decade ago, Gustavsson (2007a) reported increasing adoption of PVs in the sub-Saharan Africa countries of Kenya, with the largest installed capacity; South Africa, with a large national PV project; Zimbabwe, Ghana and other countries. Malawi is one of the countries in sub-Saharan Africa also taking steps to adopt RETs and PVs through different public and private-sponsored projects, one of which is in Chikwawa District.

1.3 Background to Chikwawa

Chikwawa is one of the 27 districts in Malawi. Its population was 438,895 (NSO, 2008) representing 3.4% of Malawi's total population. Although its population density has steadily grown over the past three decades, its density of 92 people/km^2 is third lowest in the Southern Region (NSO, 2008). Literacy levels are very low: it registered an 84.3% primary school attendance ratio, which was the third lowest ratio in the whole country after Mangochi and Dedza (NSO, 2010).

1.4 Malawi's Energy Situation

By reason of poverty in Malawi, there is a high use of biomass in both urban and rural areas. Kerosene, fuelwood and charcoal are the primary energy sources for heating, lighting and cooking taking up to 90% of total energy consumption due to their affordability and accessibility (Government of Malawi [GoM]; Jumbe & Angelsen, 2011; Kambewa & Chiwaula, 2010; Tchereni, 2013).

The energy consumption distribution in Malawi, according to Owen, Openshaw, van der Plas, Matly and Hankins (2009), is as shown in Figure 1.1 (adapted):

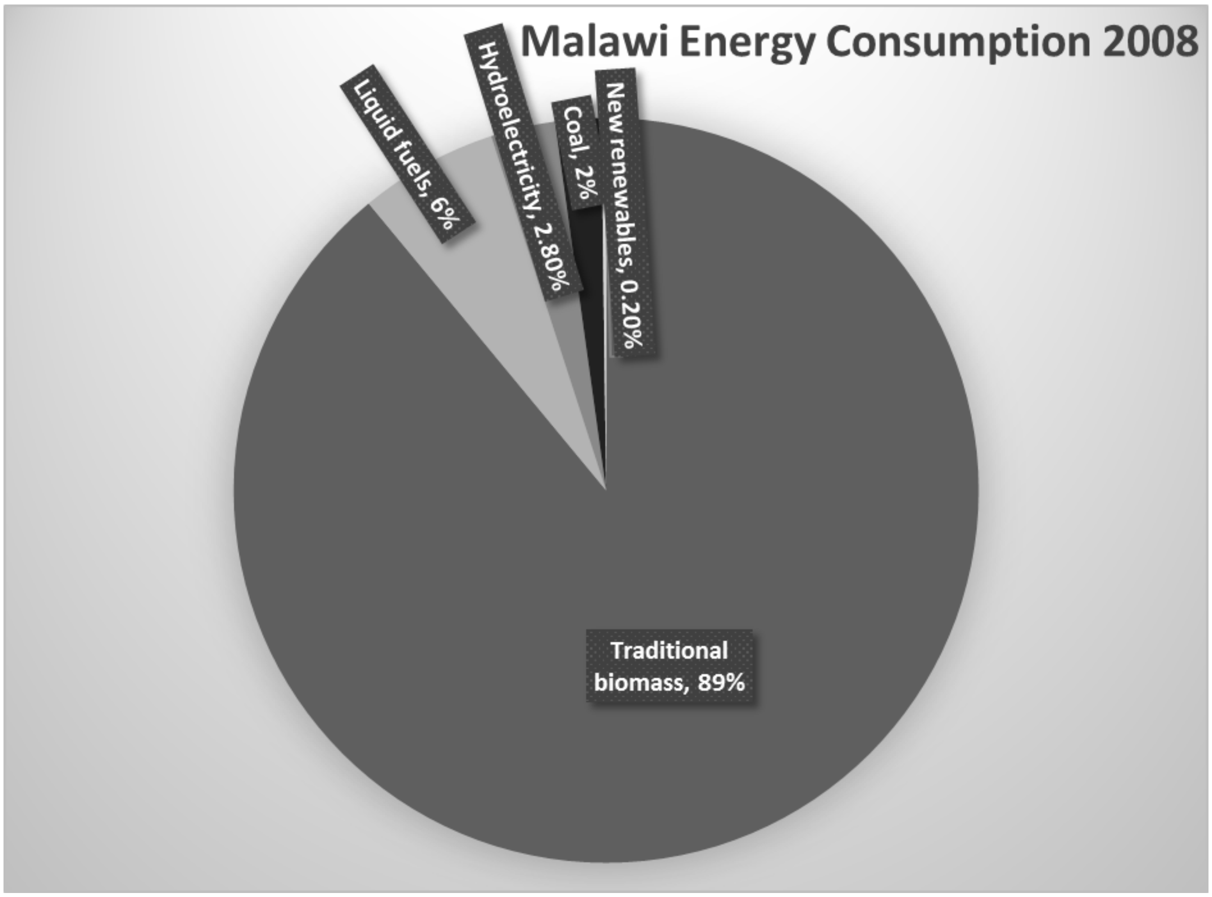

Figure 1.1: Energy Consumption for Malawi in 2008

Source: (Owen et al., 2009)

Figure 1.1 shows that in 2008, biomass was the primary source of energy with 89% consumption; and the second highest used energy source was liquid fuel such as paraffin, petrol and ethanol at 6%, followed by hydroelectricity at 2.8%. Use of new renewables such as solar and wind was close to zero at 0.2%.

Malawi faces the highest recorded rate of deforestation in Africa which by 2011 was standing at 2.8% per year, with the majority of residents getting their energy supply from charcoal or firewood (Barry, Steyn, & Brent, 2011). Biomass accessibility and affordability notwithstanding, energy is next highest to food on the expense ladder, accounting for 12% of total consumption expenditure (United Nations Development Programme (UNDP, 2007). If the externality costs of deforestation were included, the cost would be significantly higher.

The installed generation capacities of energy technologies were broken down by Zalengera et al. (2014) and are shown as adapted in Table 1.1:

Table 1.1: Installed Generation Capacities of Energy Technologies

Technology	Installed Capacity
Large-scale hydro	**345.5MW**
Small-scale hydro	**5.8MW**
Thermal electricity (fossil fuel driven turbines)	**2.15MW**
Solar Photovoltaics	**~1MW**
Wind	**~1MW**
Biogas	**40MW**
Biomass	**18MW**
Ethanol	**18**

Source: (Zalengera et al., 2014)

Table 1.1 shows that grid hydroelectricity dictates the installed energy generation capacities in Malawi trailed by biogas and biomass. New renewables have quite a negligible installed capacity as of 2014 approximating 2MW altogether. Such current status explains further the findings that Malawi's electrification is as low as that of Uganda in Sub-Saharan Africa, being below 9% by the year 2011. (Deichmann et al., 2011; Onyeji, Bazilian, & Nussbaumer, 2012).

The country's main provider of hydroelectricity is Electricity Supply Corporation of Malawi (ESCOM) which provides nearly 95% of Malawi's electricity supply (Morton, 2013). The daily need for electricity across the country stands at 700MW but ESCOM can only provide less than 50% of that at 346MW without accounting for transmission losses (Lapukeni, 2013; Zalengera et al., 2014).

Annual hydroelectricity consumption for domestic use alone had risen from 134 million kWh to 480 million kWh in 16 years between 1992 and 2008, representing more than 300% increase in demand (NSO, 2009). This demand escalation, it can be seen, has not been matched with increases in supply. As the population continues to grow, the demand is expected to soar.

By 2013, only 20% of urban households and 1% of rural households had hydroelectricity supply marred by daily load shedding; the rest of the transmitted electricity being supplied for industrial use to commercial institutions (Tenthani, Kaonga, & Kosamu, 2013). With a growing Malawian population, this energy demand and supply gap is enlarging and putting pressure on the grid (Kaonga, Tsokonombwe, & Kamanga, 2014).

This understanding might therefore have been the rationale for the recommendations in the Malawi Growth and Development Strategy (MGDS (GoM, 2011) which refocused government policy towards rural industrialization driven by rural electrification. Since the turn of the millennium, government focus is on rural industrialization that will allow for minimization of direct and environmental costs. This has led GoM to heartily explore new renewable energies (GoM, 2003).

1.5 Solar Photovoltaics in Malawi

In Malawi, the average solar irradiation on a horizontal surface is 5.8 kWh/day/m^2. The maximum irradiation is between 6.5 kWh/day/m^2 and 7.0 kWh/day/m^2 received from September to October and the minimum irradiation is from 4.3 kWh/day/m^2 to 4.6 kWh/day/m^2 received from January to February or from June to July depending on the location. In total, 3000 hours of sunlight are experienced which has the potential to replace kerosene use for 2.6 million households for lighting, pumping, refrigeration and heating (Kamanga, Mlatho, Mikeka, & Kamunda, 2014; United Nations Environmental Programme [UNEP], 2013).

Frame (2011), however, believed that electrification programs intending to expand grid infrastructure in developing countries only benefit those who have the means to pay for both the installation and service costs. Thus, in order to achieve the objective, an alternative, low-cost means of energy must be identified and supported. New renewables like PVs is new territory for Malawi with uptake of solar and wind technologies very low as already shown in Figure 1.1. As noted earlier, the installed capacity for both solar and wind is approximately 2MW which is less than 1% of hydroelectricity (see Table 1.1).

In light of its infrastructural and financing challenges, the Department of Energy Affairs (DEA) in 2000 projected a steady uptake of RETs from the year 2000 to 2050 as shown in Table 1.2:

Table 1.2: Energy Mix Projections 2000-2050

	Year			
Source	**2000**	**2010**	**2020**	**2050**
Biomass	93.0	75.0	50.0	30.0
Liquid fuels& Gas	3.5	5.5	7.0	10.0
Electricity	2.3	10.0	30.0	40.0
Coal	1.0	4.0	6.0	6.0
Renewable Technologies	0.2	5.5	7.0	10.0
Nuclear	0.0	0.0	0.0	4.0
TOTAL (%)	**100.0**	**100.0**	**100.0**	**100.0**

Source: (Gobede, 2011)

When Table 1.2 is compared with the 2008 energy consumption figures in Figure 1.1, the picture for the future seems not to be encouraging. According to Table 1.2, it was expected that by 2010, hydroelectricity should rise from 2.3% to 10% of the consumption mix, but it only moved to 2.8% by 2008.

In terms of RETs, its proportional contribution remained stagnant at 0.2% by 2008, certainly defying the 5.5% consumption projection of 2010 as shown in Table 1.2. Thus, despite government declaring solar, wind, solar-wind hybrid systems, gas and briquettes as the most important RE sources, their contribution remained disturbingly low by 2009 (GoM, 2009).

By the beginning of 2013, only 31 out of 214 installers would be given renewable energy permits to operate in Malawi (Malawi Energy Regulatory Authority (MERA, 2012)). This shows that most of the applicants did not meet the specified standards of the permission requirements. In addition, it indicates that the market structure is subject to strict government control.

As was demonstrated by Girdis and Hoskote (2005) most of the RET projects in Malawi have been large-scale and donor-funded. A notable RET and PV programme was that by the Centre for Community Organisation and Development (CCODE), a NGO working in rural Malawi. It established solar villages in Salima, Dedza and in Zomba districts.

In addition, government through MERA implemented the Barrier Removal to Renewable Energy in Malawi (BARREM) programme supported by UNDP whose objective was to pilot rural solar/wind electrification of five villages in Thyolo, Nkhotakota, Mzimba, Ntcheu and Nkhata Bay districts.

One of the largest programmes, however, was the Scottish Government-funded Community Rural Electrification and Development (CRED) project; and Malawi Renewable Energy Acceleration Programme (MREAP) to implement community-based solar photovoltaic (CSPV) projects through the Polytechnic's Center for Water, Sanitation, Health and Appropriate Technology Development (WASHTED) in selected rural communities of Chikwawa and Chiradzulu Districts (University of Strathclyde, 2014).

Besides these, there are spontaneous small-scale solar home systems (SHS) installed privately by individual households for domestic use. Thus, the RET and CSPV industry in Malawi remains a virgin industry whose infrastructural support, regulatory framework, supply, demand and information networks are in their infancy with most projects being donor-funded. The market has a small number of consumers, buyers are mainly large-scale, suppliers are few and total consumption is on the whole negligible.

The efficiency of CSPVs has been demonstrated in Malawi through projects like CRED (University of Strathclyde, 2014) and CCODE (Gobede, 2012). For example, in Salima District, availability of an off-grid CSPV enabled households to bring to zero expenditure for buying candles and kerosene from a monthly mean spend of between K800 and K1,200, which is equivalent to $5.70 and $8.50 respectively in real 2012 figures (Gobede, 2012).

In addition, Adkins, Eapen, Kaluwile, Nair and Modi (2010) observed in a solar lantern project that school children in Mbayani, Blantyre, were provided with lighting for school work at night. Thus, the systems have improved the social welfare of recipient communities covering such areas as information access and education.

But according to Currie et al. (2012) uptake has overall remained low in Malawi despite the positive benefits as mentioned above. Government, however, is looking for ways of diffusing sustainable energy resources to rural communities through off-grid electrification, among which is community solar photovoltaics (GoM, 2003).

1.6 Problem Statement

A clear analysis of the implementation policies and perceived factors that influence beneficiaries' adoption of CSPVs would assist government in its rural off-grid electrification diffusion plan. Malawi has its own unique social issues that differ from those of other countries; for example, its literacy levels, cultural values and poverty levels; and these issues may influence the way targeted communities perceive CSPVs and whether or not to adopt them.

Therefore, there was a need to study the factors that influence adoption of CSPVs in Malawi. This study attempted to partly address the information gap on factors influencing CSPV adoption by learning from community dwellers of a rural district within which such a programme has been implemented by CRED and MREAP.

1.7 Purpose and Objectives

This study was purposed to investigate factors that influence adoption of CSPVs among community users in Chikwawa District in Malawi. The main objective of the study was to determine and analyse factors that influence adoption of CSPVs within Mikolongo, Chilongoma, Ndakwera, Gumbwa and Chithumba solar villages of Chikwawa District. Therefore, the specific objectives of this study were:

i. To determine factors enhancing adoption of CSPVs among community users in Chikwawa.
ii. To analyse the strength of relationship between each CSPV adoption factor and the perceived adoption of the CSPV in Chikwawa.
iii. To analyse the extent to which demographic factors (occupation and gender) in Chikwawa CSPV users are related to the factors that influence their adoption of the CSPVs.
iv. To review government's renewable energy policy and Chikwawa CSPV project policy and practice in relation to adoption of CSPVs among community users in Chikwawa.

1.8 Significance of the Study

The study findings can contribute information that stakeholders need in determining the factors that impact on social acceptance of CSPVs. Such information may assist project implementers and government when considering investing in similar communities in Chikwawa or other areas in Malawi; and may demonstrate areas to enhance for easier and quicker adoption.

The results are expected to fill in some of the information gaps related to the CSPV market in Malawi for use by researchers, stakeholders and policy makers. It will enrich the existing body of knowledge available in Malawi on the adoption factors impacting adoption of CSPVs in Malawi. The study has identified the factors facilitating CSPV adoption and the demographic influence on such factors. These findings can therefore be used as action points for developing the CSPV market. It opens up opportunity for further research in attempts to gain a broader understanding of the market.

1.9 Organisation of the Study Report

The thesis has been arranged in this manner: Chapter 1 gives the background to the study, the problem statement and the study objectives. Chapter 2 is a review of relevant literature on elements impacting on the adoption of PVs in different markets and the lessons learnt. An appraisal of the model used for this study and the theoretical framework is given in this chapter. Chapter 3 is a detailed explanation of the method by which this study was conducted including the population studied, sampling procedure, types of data collected, data collection methods and analysis.

Chapter 4 covers the concise results of the study with an in-depth discussion of the findings. The last one is Chapter 5 which draws conclusions and recommendations from the analysis and discussion of the results and makes suggestions for further research.

1.10 Chapter Summary

Energy is a major challenge to economic development of Sub-Saharan Africa, and Malawi is one of the negatively affected countries. The pace at which grid expansion is being done is slow when compared to the proportion of increase in the demand for energy in recent times. CSPVs are increasingly being adopted as an alternative, sustainable, off-grid solution to the lighting and charging problems faced mainly by rural community dwellers.

In Chikwawa, Malawi, CSPV projects installed under the MREAP and CRED programmes are providing learning opportunities through which further rural electrification might be realized. One of the learning aspects was to determine the factors that may facilitate or hinder adoption of CSPVs in the rural communities.

The purpose of this study was to investigate factors influencing the adoption of CSPVs in the communities where these installations were done. It was essential for this study to be conducted to provide information that might assist in policy making and identifying areas for further research.

2. LITERATURE REVIEW

2.1 Structure of the Chapter

In this chapter, I review briefly adoption of innovation theories and the factors that impinge on rate of innovation adoption, with special focus on Rogers' Diffusion of Innovation Model. Thereafter, an appraisal of adoption of PVs in various contexts will be done with emphasis on facilitating and impeding factors to adoption.

2.2 Hägerstrand's and Rogers' Diffusion of Innovation Models

An innovation is defined by Rogers (2003) as "an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (p. 12). Whereas diffusion is the "process by which an innovation is communicated through certain channels over time among members of a social system" (Rogers, 2003, p. 13).

Hägerstrand (1953) earlier proposed a Monte Carlo approach to diffusion when he studied spatial diffusion patterns in agriculture, automobiles and telephones. He then suggested five rules of diffusion, namely: diffusion originates from a single person; adoption is immediate once heard; pairwise meetings are the only means through which information can spread; information transmission happens at specific intervals and times; and geographical distance influences pairing between the adopter and imitator – what he termed, the neighbourhood effect (p. 372, 373).

Reviewing the book after it was translated from Swedish to English (Hägerstrand, 1968), Rogers (1969) pointed out that Hägerstrand was the first researcher to empirically demonstrate that diffusion is a process that happens over time. However, Rogers (1969), and later Messier (2013), noted that Hägerstrand's work focused on spatial variables in the diffusion process to the exclusion of sociological variables. In other words, the actors themselves were ignored in the studies, but rather the processes of diffusion were stressed (Messier, 2013).

My study, however, applied Rogers' model of diffusion of innovation which, in contrast to Hägerstrand's, has a sociologist focus (Messier, 2013). Furthermore, according to Sriwannawit and Sandström (2015), the diffusion of innovation model developed by Rogers (1962) is the most widely applied diffusion theory in research.

Before Rogers, Griliches (1957) had already postulated that innovations will normally take S-shapes to diffuse. This has been the bell-shape that normally-distributed adoptions will take; hence, Rogers' Bell being the apt name given to his Diffusion of Innovation Model (also called, Rogers' Model). Due to the bell-shape, Rogers defined consumer profiles of innovators (being the earliest adopters of the innovation), early adopters, early majority, late majority and finally laggards (being the latest adopters).

Rogers looked at diffusion as a process of communication that involves uncertainty as the new idea may be rejected, partially or slowly accepted or fully adopted because it implies change of the social setting; hence later postulating, "When new ideas are invented, diffused, and are adopted or rejected, leading to certain consequences, social change occurs" (Rogers, 2003, p. 13). Due to the social change, a not-in-my-backyard (NIMBY) effect may sometimes modulate the strength of adoption.

Rao and Kishore (2010) expounded further on the theory that due to the impact of technological, social, institutional and economic factors, which are dynamic to different contexts and tend to feed into each other, adoption cannot be determined with perfect accuracy as these are hinging drivers of the rate at which the innovation is accepted. In addition, since consumers pass through the stages from awareness, interest, evaluation, trial to adoption, anything can hinder the realization of the adoption goal midway.

In the Rogers' Bell, the rate of adoption is said to be influenced by five attributes of the innovation, namely: *(1)* the relative advantage of the product compared to its rivals, *(2)* compatibility with the prevailing norms and experiences, *(3)* the complexity and simplicity of use of the innovation, *(4)* its trialability before committing expense to it, and *(5)* the observability of its performance by others and user (Rogers, 2003; Sahin, 2006).

More recently, another attribute was proposed by Kelly (2012), being the *(6)* reinvention of the innovation for adaptation to the needs and capacity of the user.

The product is said to have a relative advantage over its rivals if it has some marginal value superseding other products fulfilling the same need. It is compatible if it matches the values of the adopter, his behavior or his attitudes. It is also compatible when it fits into the cultural norms of the society into which it is marketed. Observability of the product indicates the extent to which others perceive the advantages of owning the product; while its complexity is the difficulty associated with using or understanding the workings of the product. It is finally said to be trialable if there is easy access to test it before purchase. (Faiers & Neame, 2006).

2.3 Appraisal of Innovation Adoption Models and Rogers' Model

Closely following the work of Rogers was Bass (1969) whose study led to development of the Bass Model that follows an innovation from launch to decline and forecasts its development over time following adopters' decision to purchase. The crux of the model is the information factors influencing those purchase decisions. In one study for example, Guidolin and Mortarino (2010), in their study of 11 countries, applied this model to analyze and predict future adoption patterns for solar PVs in each of the studied nations.

Bass identified two distinct groups of adopters: innovators influenced by external sources of information and imitators influenced by word-of-mouth. Thus, the model argues that information and its source is a crucial factor in influencing adoption. But this argument made the Bass Model limited in scope for this study since it looks only at information as a diffusion factor. Roger's Model encompasses a broader perspective and was more fitting to my context.

MacVaugh and Schiavone (2010) proposed an integrative model by which they demonstrated that limits to adoption of an innovation could be twofold: a) the ease by which the technology can be adopted given the technological, social and learning contexts; and b) the usefulness of the innovation to the individual, community or industrial domains. Their conclusion was that suppliers should therefore consider both the internal merits of the product and the external dimension which can facilitate/hinder adoption.

The Integrative Model I consider to be a summation of Rogers' Model and would have made this investigation miss out on the comprehensiveness afforded by Roger's Model. Such was the experience of Peter, Ramaseshan and Nayar (2002) who found Rogers' Model as a sufficient conceptual theory for identifying diffusion factors in the marketing of solar PVs in developing countries.

The Integrative Model, in its definition, closely resembles the dimension dubbed as technology readiness, which, according to Parasuraman (2000) is the "people's propensity to embrace and use new technologies for accomplishing goals at work and in home life" (Lin, Shih, & Sher, 2007, p.643). Technology readiness thus explains the extent to which people are willing to adopt new technologies, just as Rogers looked at the factors that impact on diffusion.

Using the technology readiness dimension, Davis, Bagozzi and Warshaw (1989) and Davis (1989), as cited in Lin, et al. (2007, p.643), developed the Technology Acceptance Model (TAM) which theorises that user acceptance of a new system is a function of that user's intention to use it, and that this is also a function of the user's perception on the usefulness and user-friendliness of the system.

In other words, a user is readily willing to use a technology if he finds it useful; and that he will only find it useful if it assists in the accomplishment of his objective and if it is easy to use in achieving that objective. As such, the user's perception of usefulness of the innovation can be coupled with the innovation's relative advantage and observability over its rivals; whereas the ease of its use compares well with its compatibility, complexity and trialability in Rogers' Model.

Innovation diffusion models have been reviewed by various researchers and Faiers and Neame (2006) concluded that the reviews on these models have been generally favourable albeit their pro-innovation bias and their inability to accurately predict adoption. Rogers' Diffusion of Innovation Theory, in particular, was hailed as practical having been trialed in different business contexts spanning the agriculture industry, the medical sector and the solar sector.

This, nonetheless, does not mean that it is applicable to all contexts; for Pedersen (2000) and Laroche, Bergeron and Barbaro-Ferleo (2001) found that the model has limited application to the 'green' consumer who is concerned about environmental products. They discovered that such 'green' consumers map out their own adoption patterns hitherto undemonstrated in other sectors such that the consumer profiles of innovators, early adopters, early majority, late majority and laggards, as defined by Rogers, do not consistently apply.

In addition, Mallett (2007) proposed a more 'active' social acceptance approach for innovations on top of the 'passive' means by which innovations diffuse. She suggests that Rogers' Model is limited in expectation although it usefully explains innovation acceptance. She, however, postulates that it ignores the notion of technology cooperation, whereby the society is actively involved through an interactive process from across relevant sub-sectors in the technology design thereby enhancing the innovation's adoption.

Nevertheless, despite its shortcomings, Roger's model has been found to be useful and not confined to a particular business sector in application (Sriwannawit & Sandström, 2015). As earlier discussed, it takes a sociological approach – an essential factor that is lacking in Hägerstrand's model which looks at spatial variables. Further, the itemized factors in Roger's model enhance the ease of its applicability in research.

For that matter, this study applied Rogers' Diffusion of Innovation Model in yet another context within the solar energy sector from quite a unique, culturally rich but economically impoverished society in Chikwawa, Malawi. Suffice to say, however, that the investigation was not designed to test Rogers' Model but that the needs of the study were thought to be best met by its use after reviewing the other models of similar bearing. This was the main model but the study went beyond mere investigation centering around Roger's Model: it also looked, in a small measure, at the external influences affecting adoption of solar PVs that are not attributes of the system.

2.4 Solar PV Adoption Research in Sub-Saharan Africa

Malawi has its own political, economic, social and technological environment, just as any country. However, it has many areas by which its circumstances are similar to those of its neighbours within the region. For example, it is a former colony of Britain similar to Zambia and Zimbabwe, hence has the cultural trappings of an Anglo-African bent similar to those of Zambia and Zimbabwe.

It relies heavily on agriculture just as the latter two and other sub-Saharan countries. Most of these countries are donor-dependent, have passed through dictatorial regimes, have many tribes within, are heavily indebted and lag in technological innovation. This part of the review is confined to such countries, as their experiences may provide applicable lessons to Malawi.

Gustavsson (2007a) carried out his study in Lundazi, Zambia. He first noted that it was not until the 1990's that a wider adoption of solar PVs was experienced, although the teething stage could be traced back to the 1970's. In his study, he noted the relative advantage that the community, especially school-going children, had in the use of off-grid solar. They were able to study into the night more than could the kerosene-lamp using neighbours.

Similar results were observed in Salima, Malawi by Gobede (2012) when rural dwellers were able to eliminate their expenditures on kerosene due to solar lanterns. Further, Adkins et al (2009) observed better schooling effects for students in a market-driven solar lantern project for more affluent community members in Mbayani, Malawi.

According to Gustavsson (2007a), notable barriers to adoption included poor knowledge and technical skills in maintaining the solar systems. It was noted that knowledge transfer was happening only at the installation phase, thereby hindering local involvement in the planning phase. Such local involvement with industry was found in an earlier study (Harford, 1998) in Zambia to be a crucial catalyst to diffusion of community solar systems because best practice could then be experienced and learnt together (Chaurey & Kandpal, 2010).

In Zimbabwe, effective marketing skills were found to be a critical element for the adoption of solar PVs (Bawakyillenuo, 2012). The strategy centred on effectively segmenting the market and targeting affluent rural dwellers who would then become the early adopters of the product and whose purchase would produce observability effects on the early and late majority to influence their purchase as well. This approach, which was found to also work in Kenya (Lay, Ondraczek, & Stoever, 2013), was not used in Ghana, which led to a slower adoption process in that nation (Bawakyillenuo, 2012; Karakaya & Sriwannawit, 2015).

Furthermore, Bawakyillenuo (2012) found that consumers' future expectations could become a barrier to adoption. This was the experience of Ghana where affluent rural dwellers would put off the purchase of solar home systems (SHS) due to the expectation that grid electricity would be installed in the near future. But such expectation was found not to be a hindrance in Kenya because Kenyans would take SHS as a complementary energy source and not as a substitute source (Lay, Ondraczek, & Stoever, 2013).

In a comparative study of Kenya and Tanzania, Ondraczek (2013) related similarities and differences between the PV markets of both countries. He noted matching drivers such as the need for off-grid electrification by rural dwellers and the growing rates of affluence among rural dwellers. As grid expansion is unlikely to happen in the near future, especially in Tanzania, SHS demand is expected to increase.

On the other hand, the Kenyan market was found to be different from the Tanzanian market. Institutional off-grid installations, for schools and health centres for instance, were observed to have been the initial entry points for solar but were seen to be surpassed by individual SHS from market demand. The market was shown to be driven not by government help but more by market forces unlike that of Tanzania. Tanzania was shown to have a subsidy tradition, which tradition has contributed to low adoption rates. (Ondraczek, 2013).

A study by Pode (2010) had earlier shown that in Mwanza, Tanzania, the PV market faced major barriers of lack social prioritization of energy due to the country's socialist inkling with an apparent lack of business pursuance in most rural areas, poverty, poor technical skills and high installation and maintenance costs. The Tanzanian PV market was therefore still in its infancy, with main installations being community solar and the SHS market spurred on by Kenya's market, donor-driven market programmes and government programmes (Ondraczek, 2013).

The findings of Girdis and Hoskote (2005) for Malawi were more similar to the case of Tanzania than that of Kenya. Malawi PV installations are mostly community based and donor-funded. The SHS market is still developing. Similar to Tanzania, industry investors are put off by the low incomes and the costly distance for investment in rural areas. Both markets are therefore smaller than that of Kenya.

Taele et al. (2007) gave a glimpse of the Lesotho PV market. In their study, they reported a 3% national electrification and a 0.9% renewable energy use with a high dependence on biomass at 69%, followed by petroleum at 23%. The main barriers to wide adoption were postulated to be high installation costs, lack of government policies to enhance adoption, a fossil-dependence culture and lack of technical knowledge and skills for local market development of the PV sector. This study showed that Malawi's PV market was somehow more advanced than that of Lesotho.

Pode (2010) further investigated the market of Botswana and found a government-initiated programme for promoting solar PVs. Pilot solar villages were rolled out whereby industry service providers, in conjunction with government, would install subsidized SHS in the rural area for a monthly fee that needs regulation. Low rural incomes for sustaining the projects and complaints about the cost-recovery framework have been the major adoption barriers. That notwithstanding, the government interventions have spearheaded quicker adoption patterns that would not have been realized if market forces were left to themselves.

Up North in Ethiopia, an incompatible market structure, poor infrastructure, a lack of a comprehensive institutional framework, financing issues and lack of technical skills were the main barriers to adoption (Kebede et al., 2014). The researchers reported that due to high costs, consumers would want to get installation on credit, while suppliers would need high levels of capital to stay in business and that financing quandary has hindered progress. However, a NGO marketing strategy was found to have enhanced diffusion of PVs through after-sales service and local supplier presence within the market. This allowed for prompt after-sales service, resulting into exponential demand for SHS (Kebede et al., 2014).

The Ethiopian example could be one of the strategies to pattern after by Malawi's local industry. A reluctance to supply rural markets with after-sales service is noticeable even in the financial sector, with a high banking concentration in cities and towns that leads business captains to stay where their financiers and main customers are. Low incomes and the inability of solar PVs to replace firewood again makes the rural market to be not a viable option (Tchereni, 2013).

Wamukonya (2007) studied on the viability of SHS as a technology option for use in the development of Africa. A number of impediments to diffusion were revealed, notably: their use for lighting with limited options for income generation; high capital costs but low investment returns, markedly welfare benefits such as extended lighting hours for study; their incapability to replace firewood for heating, with most Namibian women saying that even if SHS could replace firewood, they would use the freed-up time for doing domestic work and not for income generation (Wamukonya, 2007).

In the case of rural Namibia, as in Malawi, the underlying barrier to translate solar PV presence into creation of economic activity and income was the lack of business opportunities and capital. However, Wamukonya (2007) still showed that not all was lost, for certain entrepreneurs were taking advantage of SHS for doing business, albeit from donated or subsidised systems that would not recover the full cost.

Recent work by Smith and Urpelainen (2014) attempted to profile the nature of solar PV adopters in Africa by looking at the case of Tanzanian consumers. They reported that the bigger the household, the higher the tendency to adopt; and that those who have had grid electricity tend to adopt off-grid PV, perhaps having experienced in person the benefits of electricity. They also reported that "poor households are less likely to own a system, but the effect is modest, deviating somewhat from previous studies" (p. 19); and that both rural and urban households are likely to consume SHS, a finding that contradicted earlier suggestions that solar PVs are only for rural dwellers.

The researchers (Smith & Urpelainen, 2014) agreed with Ondraczek (2013) that clustered populations are more likely to experience speedy adoption than sparse populations as is the case of Tanzania. However, their findings that education and income were not a significant factor in the SHS diffusion contradicted those of Ondraczek (2013) who earlier noted for Tanzania that one modulating factor against speedy adoption was education and low rural incomes.

Since the findings of Ondraczek have been repeated in other research works discussed above (Kebede et al., 2014; Pode, 2010; Taele et al., 2007; Wamukonya, 2007), it might be concluded that education and incomes do have a significant influence on adoption of solar PVs. Indeed, Mills and Schleich (2009) reviewed various studies and found that education and household income are positively correlated with adoption of energy-saving technologies.

In terms of policy, it can be noted then that countries like South Africa (Gustavsson, 2007a) and Botswana (Pode, 2010) are making serious attempts through government support to expand the market. It therefore could be the reason why researchers, such as Peter, Dickie and Peter (2006), are recommending that government policy should be the springboard for enlarging the market, as this was the case of Kenya (Ondraczek, 2014); and that of Germany and Japan, the world's leading solar PV consumer countries (Guidolin & Mortarino, 2010). This is mainly due to the high set-up costs associated with solar PVs which might best be mitigated by government intervention in most countries, especially poorer ones.

In conclusion, the general finding from literature is that other sub-Saharan countries are passing through quite similar challenges in the adoption of solar PVs. Kenya looks to be on a higher plane than the rest and its success has stemmed from the vibrancy of its open market structure for SHS and government investment in community solar. Other countries have more or less comparable problems, such as financial, institutional, infrastructural, political, economic and social.

Having explored the anecdotal experiences of sub-Sahara, a deeper review of the factors influencing adoption of solar PVs will next follow. This will not be confined to the regional experiences alone, but will intend to draw lessons from different geographical contexts around the world.

2.5 Influences on adoption of Community and Household Solar PVs

2.5.1 Market Factors Influencing PV Adoption

Various researchers have written on the market factors influencing adoption. For example, Mirhassani, Ong, Chong and Leong (2015) argued that local authority policies have an influence on the size of the PV market, its profitability and the rate at which the market grows. While a well-defined policy shapes the energy governance of the country, it also protects the poor especially in developing countries where the gap between the rich and poor is huge (Thiam, 2011). Thiam noted that if the policy does not comprehensively address the social-economic dynamics, programme failure is often the result.

A study by Dusonchet and Telaretti (2010) corroborated these findings when an analysis of PV policies in Germany, Spain and Greece was undertaken. A strong correlation was noted to exist between diffusion and policy risk. For example, sudden policy changes and led to low diffusion in Spain despite having better financial incentives than Germany. Chaurey and Kandpal (2010) showed that United Nations (UN)-sponsored projects have been a catalyst for solar PV diffusion in some developing countries. Other global investors have been the World Bank which has been promoting solar PV lanterns and other off-grid systems to the needy areas (Smith & Urpelainen, 2014).

The researchers report that one such policy by the UN has been to institute solar demonstration sites or solar villages. In the end, these have stimulated SHS demand from domestic dwellers after witnessing the benefits thereof. Another example of policy could be to have quality standards for solar systems that would in the end tend to encourage purchase, as was the successful case of India and Bangladesh; while poor quality standards became a barrier in Sri Lanka and Ethiopia (Karakaya & Sriwannawit, 2015). Richter (2014) reviewed literature from different countries and concluded that in all countries with the highest installed PV capacities such as Germany, Italy, USA, Japan and China, the primary factor for quick adoption was government policy, especially feed-in tariffs. Palmer, Sorda and Madlener (2013) state that in Italy alone, government incentives propelled PV generated electricity from 35 GWh in 2006 to 10,796 GWh in 2011. Similarly, in Algeria (Stambouli, Khiat, Flazi, & Kitamura, 2012) and Morocco (Arce, Mahia, Medina, & Escribano, 2012) political will saw a quick adoption of RETs.

Earlier research work by Barry et al. (2011), complemented by the findings of Stambouli et al. (2012) and Arce et al. (2012), had shown that incentives and government initiative are indispensable. Barry et al. (2011) then concluded that government should lead through policies such as licensing, standardization, tariffs, subsidies, capacity building, public awareness, legislation and its enforcement and monitoring and evaluation.

However, Richter (2014) noted that this government support was temporary in all cases and consequently concluded that public support should be aimed at kick-starting the market but not for sustaining it. In that case, market mechanisms must be built in to ensure competitiveness. Where government continues to support the market without a proper exit strategy, failure eventually results.

These findings gave impetus to what Ondraczek (2013) earlier reported about Kenya's success story and Tanzania's lag. Both had initial government support but it was eventually reduced in the Kenyan case. Furthermore, Zhang, Song and Hamori (2011) reported that Japan became a leading PV market when its government took the initiative to invest in it. As PV costs were going down, the government's assistance was being minimized until it was finally withdrawn.

The above research works indicate that government support must be thoroughly planned and its impact measured since it can also result into a negative outcome. As for incentives to use, most researchers agree on the need thereof but fail to agree on the nature of those incentives or how they should be implemented.

For instance, Tchereni (2013) recommends trade and tax policies such as zero import duties on all RE facilities with the aim of reducing the price thereof. This is supported by researchers like Sultana, Khan and Ahmed (2010), Reuter, Szolgayová, Fuss and Obersteiner (2012) and more recently de Jongh, Ghoorah and Makina (2014) who all recommend tariffs, subsidies, tax credits and systems or support to foreign investors.

Other researchers like Liao, Ou, Lo, Chiueh and Yu (2011) propose the removal of subsidies and incentives on fossils and the introduction of taxes on the same as another way of ensuring the development of REs. Such subsidies led to 25% growth rate of the Tunisian solar market for several years (Olz, 2011).

But such an incentive policy must have measurable results for assessing impact and adapting when needed. In Ghana, RE tax policy could not show positive development impact because the exemptions wording was not quite clear, the cost exemptions were too minimal to achieve the desired impact and the policy did not incorporate the substitution effect of available alternatives (Attachie & Amuzuvi, 2012).

In addition, although Richter (2014), following Rode and Weber (2011), concludes that government interventions have a significant positive impact on diffusion of PVs across countries worldwide. Caution is recommended nonetheless. Implementation of incentive regimes must first demonstrate that adoption of the PVs will eventually continue without subsidies. This agrees with Haselip (2011) whose study recommended for a continual annual rate decline in feed-in tariff support and a readiness to reduce support when technological advancement for a specific technology has resulted into a major cost decline.

Therefore, government policy and incentives do have a modulating effect on the adoption of solar PVs. Government support however must relate well to the circumstances of the particular country, having had a given goal to accomplish, a timeframe and clear outcomes that can eventually be taken over by the market system. A perpetual government support seems to hinder market development of PVs.

But government policy is not the only factor influencing adoption. Actually, Mani and Dhingra (2012) suggested four factors: *(i)* identification of initial users who can lead others to adopt; *(ii)* the communication message to enhance adoption; *(iii)* relative advantage in terms of perceived cost, compatibility, simplicity and observability; and *(iv)* the channels used to diffuse – which includes government policy and support.

Augmenting these results, Shah, Rashidi, Bhutto and Shah (2011) and Mondal, Kamp and Pachova (2010) add that the market structure or the institutional framework, financial systems for funding and the communication channels and messages are critical in influencing adoption. By looking at how critical communication is to adoption, Tchereni (2013) suggests civic education programmes that would show the essence of the RE.

2.5.2 Observability and Compatibility

Compatibility perceptions could be influenced by social and technological practices, norms and beliefs. Pasqualetti (2011) recounts the resistance to a large-scale CSPV project by environmental groups who were poised to resist installations that would take up about 61,000 square miles of land in Arizona, Nevada, California, and New Mexico in USA.

After looking at the power of the social factor, Reinsberger, Brudermann, Hatzl, Fleiß and Posch (2015) recommend learning from Austria. The researchers argued for 'bottom-up inititiatives' (BUIs), which are "social movements and other forms of civil engagement in energy transition at a local or regional level" (p. 178). They noted various organizational forms BUIs can take; for instance, social networks, informal associations or community groups. It was concluded by Reinsberger et al. (2015) that the diversity of form and the breadth of scope of these BUIs opens up considerable opportunities for adoption of PVs.

Reinsberger's study confirmed earlier results reported by Brudermann, Reinsberger, Orthofer, Kislinger and Posch (2013) which showed that meetings among Austrian farmers and word-of-mouth communication influenced adoption and minimised the NIMBY effect. BUIs could also explain the skewed distribution of PVs in Germany due to the advocacy and informative effect that formalized networks engendered for their locality (Dewald & Truffer, 2012).

From the foregoing studies in the preceding paragraph, it can be observed that social acceptance is a critical instrument in the adoption process. In a recent Moroccan study, Hanger et al. (2016) found that the NIMBY effect is influenced by "the expected costs and benefits, social, economic and environmental risks, trust and perceived fairness, distance to the proposed power plant and the regulatory context" (p. 81). Their findings suggest that there should be proper communication of expected positive effects and the minimization of negative ones.

The NIMBY effect can be reduced by taking advantage of peer or observability effects. In a German study, Rode and Weber (2011) found that observability, which they termed as the social effect, has a significant impact on PV. They attribute this to the high visibility of solar panels to passers-by which leads to learning possibilities that do not involve direct social interaction.

Bollinger and Gillingham (2012) collaborated these results in a California study and found a daily 0.78% increase in PV installations following nearby adoptions. However, Richter (2014) showed that this social observability effect on diffusion of PVs in UK was small, though statistically significant.

In addition, Graziano and Gillingham (2014) showed that the primary determinants of the patterns of diffusion of PV systems in Connecticut were spatial neighbor effects and built environment variables. This showed that peer effects were more influenced by the closeness and the way the locality was built. Further to that, Graziano and Atkinson (2014) reported that the spatial effect on peers is within a radius of 1 mile and that the effect is noticeable within a year.

Peer effects can be passive or active (Palm, 2016). Passive peer effect is when the adopter does not advocate for the PV but observation encourages potential adopters to adopt; whereas, active peer effect is when the adopter vigorously takes part in influencing adoption.

In their study, Rai and Robinson (2013) found that both passive and active peer influence by early adopters was necessary for diffusion to later adopters in Texas, America. But even though this was the case, Schelly (2014) argued that the active peer effect is more important for later adopters than is the passive effect as these later adopters will want to make a decision based on the reported experience of the early adopters.

Thus, the literature shows a link that observability and peer effects lessen the barriers to PV adoption. Peers can aid in perceiving the relative advantage of PVs and their compatibility with current lifestyles. Especially when it is active then can complexity be lessened in later adopters who may learn from peers. Solar PVs have a high passive effect due to the visibility of panels which, by observation, influences adoption to later adopters.

Most rural areas in Malawi are without electricity, hence rely on fossil fuels and biomass for lighting. Solar PVs were found to provide such electricity thereby impacting on children's ability to study at night, charge phones, listen to the radio, refrigerate items and watch TV; thus accessing information and improving livelihood on health, education and agriculture (Adkins et al., 2009; Cook, 2013; Gobede, 2012; Gustavsson, 2007b). Such observed benefits would encourage non-owners to adopt.

2.5.3 Relative Advantage

Schultz and Doluweera (2011) recognized that CSPVs present savings in service costs and fuel making them efficient and competitive in the long-run compared to fossils. Gobede (2012) illustrated this point in his study whereby kerosene costs were effectively eliminated due to PV installations. Tenthani et al. (2013) highlighted the environmental impact of these systems and their ability to leave no carbon footprint resulting into positive externalities unlike the widely used fossil fuels.

Moreover, Guidolin and Mortarino (2010) noted that the fact that PVs convert sunlight directly into electricity makes them to circumvent the production and transportation expense associated with traditional methods and other RETs. In addition, PVs do not necessarily need to be connected to the grid for them to be used, hence can be geographically spread in spite of the grid to reach millions of people without the grid connection expense. Further to that, since peak solar irradiation is noon, which is the time of high electricity demand for households to prepare lunch, the applications can coincide with demand (Zalengera et al., 2014).

These cost advantages are on the micro-level. At national level, the savings are again evident. Arce et al. (2012) studied the economic impact of the Moroccan government in liberalizing the electricity sector and adopting use of photovoltaics and wind energy technologies forecasted up to the year 2040.

They concluded that GDP would increase annually by 2% and there would be a job creation impact of up to 500,000 if RE component imports could be reduced within the timeframe. Abanda, Ng'ombe, Keivani and Tah (2012) corroborated these findings by showing a direct correlation between RE production and GDP in all African blocks except Southern Africa where adoption is lagging and data cannot be easily correlated.

Thus PVs are being shown to have a positive externality output to the environment, reduced running costs, increased GDP and employment correlated effects and zero interconnection cost. These cost advantages enhance the efficiency possibilities of PVs, but for the documented high set-up costs.

Indeed, the persistent problem with solar technologies is the initial high cost of installation and components. UNEP (2012) asserts that due to relatively high transactional costs, RE installation projects tend to be smaller compared to conventional grid projects as cost per household is higher for investors than for a central energy source that distributes to many households; and this makes investors and private sector actors wary of RE investments.

Other researchers have corroborated these findings. For example, Adkins et al. (2009) reported that a solar lantern project that was not subsidized in Mbayani, Malawi, was likely to have a positively skewed adoption towards the wealthier community members than on their poorer counterparts. Tchereni (2013) argued that biomass was considered cheaper by the poor residents of South Lunzu, Malawi, than electricity although they were willing to discard it with improved income.

Furthermore, Siegel and Rahman (2011) found that the primary barrier to adoption of PVs in rural Bangladesh was cost. This was similar in Argentina and Chile (Guzowski &

Recalde, 2010), in China (Cherni & Kentish, 2006) and in Turkey (Nalan, Murat, & Nuri, 2008).

It should be noted, however, that the high cost of RETs has been rapidly falling over the years. Popp, Hascic and Medhi (2011) note that PV costs have fallen 5 to 10 times since the 1980s thereby closing the cost difference with conventional energy sources. They contend that this is a result of policy changes supporting RET development, research and tariff policies.

One issue that again places PVs at a disadvantage is that of intermittence and site specificity that makes supply hence unreliable and uncertain, thereby varying output amounts according to weather and site (Kamanga et al., 2014; Reuter et al., 2012). This and other factors render the REs relatively disadvantaged economically due to low energy intensity and amount derived from a unit area measured against the heavy cost of installation (Nalan, Murat, & Nuri, 2008).

This gives a negative perception against REs in general which, if not dealt with using an appropriate communication strategy, exacerbates the barrier to adoption already felt due to the relatively high cost (Birgisson & Petersen, 2006). Such a perspective was evident in South Africa where Eskom, the electricity company, had a subtle campaign discouraging use of RETs, in particular wind, due to its unpredictability compared with coal (Sebitosi & Pillay, 2008).

2.5.4 Complexity and Trialability

Complexity is another important aspect of adoption. In a study comparing the diffusion of PVs in Uganda, Kenya and Tanzania, Hansen et al. (2014) found out that Kenya was ahead of the others because it had a localized PV components market which reduced imports and ensured a thriving market that created jobs. In other words, the technology had been adapted, simplified and made compatible with the social context of Kenya thereby having an advantage over fuel imports and making it easy to adopt.

Industry localization can again be achieved, for example, by training community members on how to manage, service and repair the systems (Gobede, 2012). A parallel market can be developed to supply localized components as happened in the case of Kenya whereby the market was spurred on by the knowledge transfer to local technicians who could adapt the product.

Bailis and Hyman (2011) recommend early and on-going information dissemination programmes that are sensitive to cultural and gender norms. Jager (2006), for example, found that information provision lessened the perceived technical and bureaucratic barriers. Furthermore, Zhang et al. (2011) reported that information and awareness of the environmental impact of installing PVs influenced adoption by offsetting the perceived high capital cost associated with PVs.

The lack of trialability for PV installations is another adoption barrier. Supporting the findings of Labay and Kinnear (1981), Jager (2006) concluded that due to the varying specifications in systems, size, price and returns and the impossibility to trial the system for a limited period before purchase, the buyer has to make the purchase decision without testing it. This problem is significant for early adopters than imitators who can observe performance of the early adopters' systems.

Additionally, Jager (2006) continues, poor trialability increases the complexity problem due to lack of familiarity with the technology as most buyers are not technically competent and do not possess the level of knowledge necessary to guide the purchase decision unless an expert is present for consultation.

2.6 The Study's Research Model

The literature on Malawi had limited information about the factors that influence CSPV adoption (Adkins et al., 2009; Gobede, 2012). With its unique background and slow adoption that relies heavily on donor projects, the method of PV entry has been to use demonstration sites in selected villages for learning purposes.

The original contribution made by this study is the determination and analysis of the extent to which compatibility, complexity, trialability, relative advantage and observability factors are perceived to influence community PV adoption in Chikwawa, Malawi. The research model for this study was as is shown in Figure 2.1.

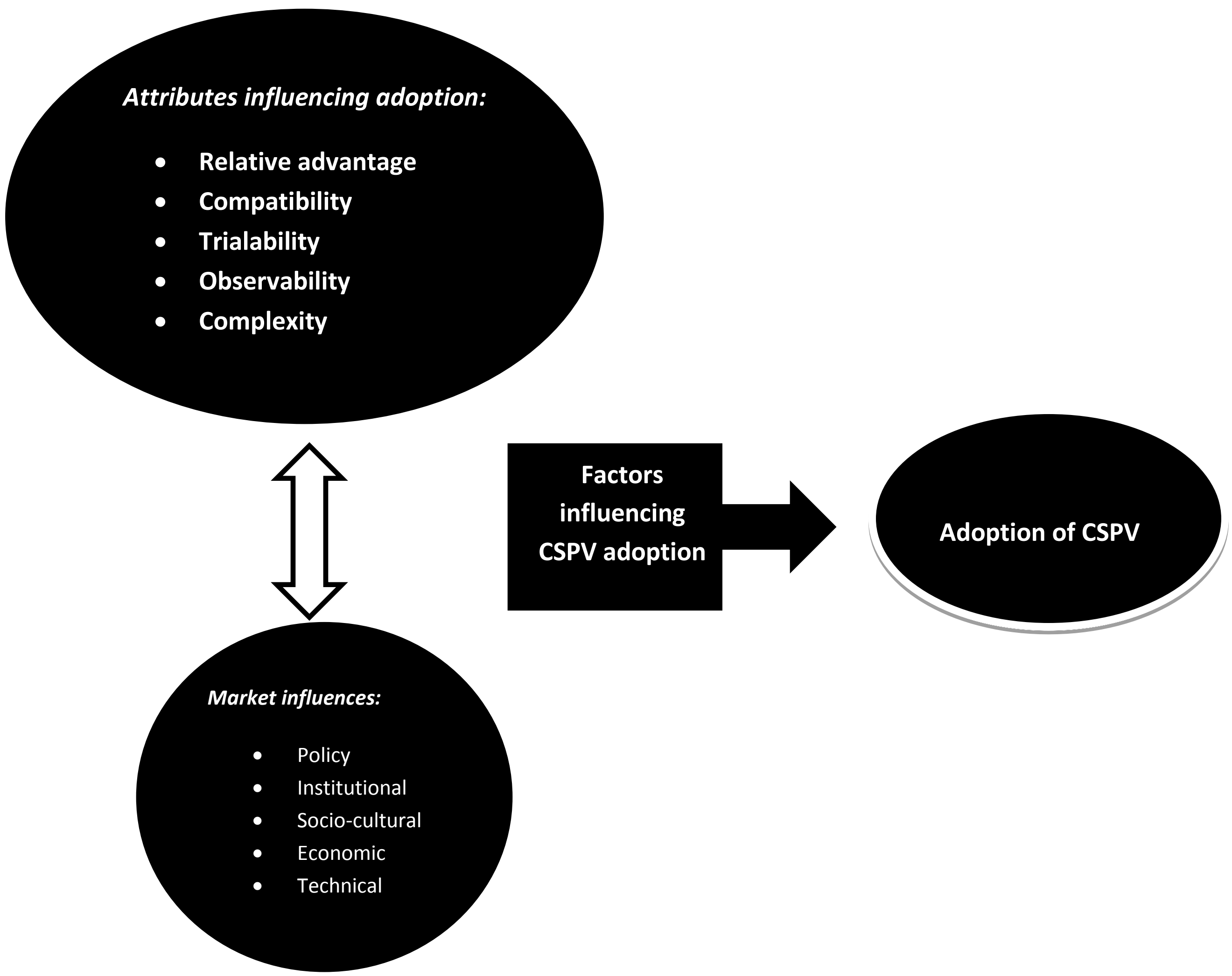

Figure 2.1: The Research Model

Figure 2.1 shows that adoption is influenced by both the PV attributes and market forces. For this study, however, the study focused more on the attributes, which is why the circle of market influences is relatively smaller than that of the attributes.

2.7 Chapter Summary

Rural electrification is being viewed as a driver for sustainable development amongst developing countries. Due to country limitations of grid extension, photovoltaics are being embraced in many countries in sub-Saharan Africa although the region is lagging in adoption rates. Kenya is a country with the highest, localised adoption rate while Malawi's adoption levels remains low.

The literature supports the importance of relative advantage, compatibility and less complexity of PVs to facilitate adoption. In addition, the institutional framework must be in place with proper government incentives to help the market take off. A clear communication strategy is essential in removing prejudice and misconceptions. Both active and passive peer effects influence adoption; and so does localization of the PV technology.

Poor communication and lack of informative networks may slow down adoption rates. Other barriers were the high set-up costs for stand-alone solar installations; lack of supporting national policy framework and infrastructure ; an improper exit strategy for initiating governments; intermittence and low unit voltage against cost compared to grid electricity; other social-economic factors such as low education and poverty; lack of opportunity to try the product before purchase, although this is modulated by peer effects and demonstration sites; and inability to localize the technology.

3. METHODOLOGY

3.1 Introduction: Research Design

This chapter outlines the methods used for collection of data and justification behind the approach; the types of data collected; instruments and methods used to collect the data; the sampling techniques that were used; and the means by which collected data was recorded and analysed.

Research is shaped by philosophy which can be positivist, constructivist or pragmatist in a majority of cases. According to Creswell (2009) the positivist view questions generally accepted norms and notions and gathers data to deduct theory. In constructivism, the researcher develops theory by observing how human experiences relate to each other.

The pragmatist approach, however, fuses the positivist and constructivist approaches by being problem-solving oriented. It seeks to find solutions to the problem using various approaches thereby leading the researcher to take a mixed method approach (Lodico, Spaulding, & Voegtle, 2006; Walliman, 2006).

This study took a pragmatic approach that largely had a positivist bent. Its intention was not to develop theory but to apply known theory to a specific situation. Roger's Diffusion of Innovations Model was the main theory that was applied for researching about the PV market in Chikwawa.

Since models have their limitations, data gathered had to be augmented by other data, but this additional data was collected for review and auxiliary purposes. The additional data was collected through both desk research and primary collection in in-depth interviews with key informants. The study was therefore mainly quantitative, with auxiliary qualitative data collected in prospect and retrospect against quantitative findings.

3.2 Secondary Research

Throughout the research, relevant historical data was collected, which was a key to shaping the direction of this study and its method. The aims of the desk research were to understand the general environment of the community PV market around the world and in Malawi, and to gain insights into the general social context of solar PV investment programmes.

The desk research was wide-ranging covering the central focus of this study to include such dimensions as the regulatory framework, policies, social dimensions surrounding solar PVs, adoption factors, and the general backgrounds of PV markets, particularly in sub-Saharan Africa. This was done to understand the market.

Data was obtained from review of official documents with the DEA, MERA, and other government reports, CRED and MREAP reports, research reports especially from peer-reviewed journals and any other documents relevant to the study. The results of the desk research have been concisely reported under the Literature Review chapter above. The review showed the gap in the body of knowledge that needed to be filled through Malawian data.

3.3 Primary Research

Due to the absence of specific data on adoption factors from the Chikwawa sites, it was necessary that field research be done. This was mainly descriptive and quantitative, but the findings were validated by qualitative data collection for triangulation in order to ensure that "the data are telling you what you think they are telling you" (Saunders, Lewis, & Thornhill, 2009, p.177). The details of the population, sample and data collection techniques that were used are explained in the sections below.

3.3.1 Population

In this study, population meant "the full set of cases from which a sample is taken" (Saunders et al., 2009). Hence, the population for this study was PV community users under the CRED and MREAP projects in Chikwawa District.

Apart from them, data was collected from government officials at the DEA and project site officers. Government officials were included purposively due to their knowledge of the energy environment in Malawi and their experience with BARREM, the government pilot CSPV project.

3.3.2 Sample and Sampling Technique

The sites where CSPV projects were being implemented were 7, namely: Mwanayaya, Mwalija, Mikolongo and Chilongoma schools under CRED Project; and Ndakwera and Chithumba health centres and schools; and Gumbwa school under MREAP.

Due to the spatial proximity of the sites and their number, it was initially planned to study all the sites. However, Mwanayaya and Mwalija were eliminated from the study due to poor road access. The other sites: Mikolongo, Chilongoma, Chithumba, Gumbwa and Ndakwera are located more than 50km from Blantyre and are within the Central and Western sides of Chikwawa in Traditional Authorities Chapananga, Kasisi and Katunga.

Respondents were taken from a crossing between the solar PV committee users' timesheets and the recalled list of CSPV users. Committee members identified the respondents from which the sample was chosen. In some cases, however, respondents were those found onsite using the CSPV at the health centre and school. There were in all sites no complete written records of users, hence no sampling frame of users. It was deemed that village headman household lists were not appropriate sampling frames for the study as they were not complete, being registries of social security beneficiary members.

Therefore, although the plan was to have a stratified sample, it was difficult to obtain such a sample due to the lack of a valid sampling frame in some cases. In that case, a quota sampling technique was used. It was determined to have strata and quotas according to age group and sex, but this was modified due to the differing distributions of users at each site. Thus, the main technique used turned out to be quota sampling.

The population size of all the communities was not verified but an average population of 300 benefiting households per community was assumed with the initial 7 sites giving a total of 2100 households. Saunders et al. (2009, p. 219) tabulated rough estimates of minimum sample sizes for populations of given sizes within certain confidence levels.

A population of 2000, thus, gives a sample of 322 at 95% confidence level, while that of 5000 gives a sample of 357. At an estimate of 2100, a sample of 325 would have been sufficient, but it was deemed necessary to add on to this sample an extra 25 respondents in anticipation of non-response encountered during pilot testing. Therefore, it was decided that a sample of 350 community respondents should suffice.

Mwanayaya and Mwalija became inaccessible, therefore 5 sites remained of which a quota of 70 respondents was expected in each case. The distribution of actual respondents was as shown in Table 3.1. Total response rate turned out to be 88.2% consisting 309 respondents, which was very acceptable (Saunders et al., 2009). The sample was thus distributed according to gender, age, occupation and installation site.

The demographic distribution of the respondents was as is shown in Table 3.1:

Table 3.1: Respondents' Demographic Distribution

Demographic Distribution of Respondents		
Where CSPV was installed	Ndakwera	21%
	Mikolongo	20%
	Gumbwa	19%
	Chilongoma	21%
	Chithumba	19%
Gender of respondent	Male	59%
	Female	41%
Age group of respondent	Under 20	10%
	20-29	33%
	30-39	28%
	40-49	18%
	50-59	10%
	60 or over	1%
Occupation of respondent	Student	9%
	Farmer	45%
	Business/Self-employed	24%
	Salaried Employment	21%
	Other	1%
N	=	309

Table 3.1 shows a more or less even respondent distribution across the communities of Ndakwera, 21%; Mikolongo, 20%; Gumbwa, 19%; Chilongoma, 21%; and Chithumba, 19%. Of all these, 59% were male and 41% were female. The highest age group was that between 20 and 29 years at 33%, followed by the 30-39 years age group at 28%. Most of the respondents, 45% were farmers; 24% were self-employed; 21% had salaried jobs while 9% were students.

Adding on to this sample, key informants were subjected to in-depth interviews. These were MREAP and CRED project officers at each visited site and 2 DEA officials sampled through referral. These were treated as key informants to provide background information related to the PV industry and the Chikwawa PV project, to verify data provided by user respondents and to gather data that could not be otherwise provided by users. However, the data obtained from key informants to validate user responses was treated with caution by comparing it with project policy documents due to possibility of error arising from conflict of interest on the part of officials.

3.3.3 Data Collection Methods and Instrumentation

The data was collected from community respondents benefiting from the CSPV. Quantitative data was collected through survey using a Likert-scale type semi-structured questionnaire patterned after attributes of diffusion proposed by Rogers (2003). As postulated by Peter, Dickie and Peter (2006), the "superiority of multi-item scales to measure a construct rests in its ability to decrease measurement error and increases reliability/internal consistency" (p. 2274).

The questionnaire was adapted from survey instruments by Stachewicz (2011) and Ntemana and Olatokun (2012) used in similar studies that applied Roger's Model. The study by Stachewicz (2011) was measuring perceived attributes of capacitive switch technology in automobiles, while Ntemana & Olatokun (2012) analysed diffusion attributes on lecturers' attitudes towards information and communications technology. As such, the questionnaires were modified to specifically address local CSPV-related issues (see *Appendix 1*).

Stachewicz (2011), however, added more attributes to his questionnaire than Roger's five factors, such as image, voluntariness and perceived risk by Moore and Benbasat (1991), and perceived resources by Dupagne and Driscoll (2005). Due to the nature of my study, which applied only Roger's attributes, I left these additional factors out, adapted the other questions to a CSPV study and modified the demography questions.

The questionnaire by Ntemana & Olatokun (2012) was again modified on demographics and research questions. After a pilot test, some questions were again re-written, irrelevant ones removed and others added. The initial questionnaires by Ntemana & Olatokun (2012) and Stachewicz (2011) are shown in *Appendix 3* and *Appendix 4* respectively.

Adoption factors used in this study were therefore: relative advantage, observability, complexity, compatibility and trialability.

The survey instrument was also used to gather some qualitative data on a minor scale through open-ended questions. Other additional data to provide background information about the project setting was collected through discussions with MREAP or CRED project officers and DEA officials in in-depth interviews using an unstructured question guide (see *Appendix 2*) and a recorder that took verbatim for easy transcription of the discussion. In total, 7 key informants were interviewed. Project documents supplemented the data collected from key informants.

The survey questionnaire was interpreted into vernacular, *Chichewa*, to ensure proper communication. Trained enumerators were employed to assist in conducting the face-to-face interviews for survey data collection but the in-depth interviews were conducted without the help of enumerators.

3.3.4 Instrument Reliability and Validity

A pilot survey was first done to validate the questionnaire for this study. The respondents at this time were asked to assess each question if they understood it or if it confused them or if they found it ambiguous. In the end, corrections were done by eliminating some questions that were thought to be redundant, while others were rephrased. External reliability was thus ensured after detecting ambiguous and confusing points, and then modifying the questionnaire to ensure precision (see *Appendix 1*).

Cronbach's Alpha was used to test internal reliability and consistency of the scale for measuring the abstract constructs that were factors of adoption. A score of 0.7 is acceptable for scale reliability, based on the analysis by Moore and Benbasat (1991); but this is arbitrary.

A less than 0.5 alpha indicates a high level of independence between items. For this study, an alpha of at least 0.65 was accepted. Items with inter-correlation equal to 1 indicated uniform measurement without broad variability and were thus removed from the scale. Also, since inter-correlations between items affect the alpha, items that significantly reduced the alpha due to low inter-correlation were removed. The alpha measurements for the construct scales were as given in Table 3.2:

Table 3.2: Construct Scale Reliability

	Reliability Statistics		
	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Adoption	0.849	0.867	5
Trialability	0.751	0.77	4
Relative advantage	0.856	0.878	6
Compatibility	0.846	0.833	7
Observability	0.712	0.703	4
Complexity	0.652	0.628	4

The alpha for *adoption* was 0.849, as shown in Table 3.2, which indicated a strong level of inter-item correlation. The alpha for *trialability* was 0.751 after removing 1 item. *Relative advantage* construct needed an elimination of 2 items before the alpha of 0.856 was reached. The reliability test for *compatibility*, using 7 items, was 0.846; while the *observability* scale turned out an alpha of 0.712 after eliminating 2 items. *Complexity* had an alpha of 0.652, which could not be further improved with deletion of items. This was deemed to be fair, though weak.

Consequently, the internal consistency of the items in each construct was found to be strong enough, but the least consistency was in the items measuring *complexity*.

3.4 Data Analysis

Data was coded and entered in SPSS 20 before descriptive statistics were run. The Likert scales showed the extent to which respondents felt about an attribute of the solar PV. The strength of feeling was marked along a continuum that ranged from strongly agreeing with the statement describing the attribute to strongly disagreeing with it. Some items were reverse coded to reflect the same direction of meaning within a construct; for example, a positive one.

To get deeper results from the data, constructs were statistically formulated in order to determine bivariate correlations between constructs. The constructs were then correlated with each other and with the *adoption* construct, being the dependent variable. This explored the magnitude of relationship between the constructs. The constructs were then cross-tabulated with the demographic profile of respondents in order to explore significant underlying demographic patterns deriving the factors of adoption.

Qualitative data from in-depth interviews using a discussion guide, and open-ended questions in the questionnaire were thematically analysed. Data from in-depth discussions was recorded using an electronic recorder from which it was transcribed by note takers for analysis in Microsoft Word. Other qualitative data from the questionnaire was copied into the same software package for thematic analysis.

The analysis was accomplished by analyzing recurrent wording patterns of issues related to adoption of the CSPV. The issues were then grouped into themes that synchronized with the constructs of compatibility, trialability, relative advantage, complexity and observability. Microsoft Word was used for the analysis and for coming up with concise reports. Both qualitative and quantitative data were then triangulated in order to draw conclusions about the observations in relation to the study objectives.

3.5 Research Limitations

This study focused on factors that influence adoption of CSPVs in Chikwawa District only and these results may not be applicable to other areas in Malawi which have different social-economic demographics. Hence, caution should be taken in generalizing and making inferences from the results.

The study did not attempt to establish causation. Confounding variables that might affect attribution of causation to a given independent variable were not explored and controlled. Further research needs to be done in order to establish how each construct influences the adoption of the community PVs independently after controlling for any confounding variables.

Further to that, the study was primarily targeting community solar users and not SHS users. Apart from that, the results do not apply to other CSPV projects in Malawi whose running strategy is different. This study did not take comparative data from other projects. Its design was to deliberately allow for a more focused study of particular cases, narrowing down the scope and expanding the sample size so as to enhance the reliability of results related to those cases.

Roger's Model was applied to a large extent in this study and was overly useful in guiding on the dimensions of adoption factors. However, since it was the adoption of CSPVs being investigated, and not the influence of CSPV installations on SHS adoption, the scope of its applicability was found to be limited to within the demonstration community. It was noted that due to the low incomes of surrounding communities, further CSPV installations were more dependent on future choices of the donor, and not specifically on, say, observability effects.

Thus, in using Rogers' model, the following assumptions were made:

i. It was assumed that installation of CSPVs in a community might not result into actual purchase of CSPVs in other surrounding communities due to poverty limitations. Nonetheless, it was assumed that CSPV installations would influence SHS adoption, or would make surrounding communities apply to donors for consideration of their particular communities.

ii. It was assumed that the model would apply to community technologies because it has been shown that it had thus far been applied to different industries more than any other diffusion model (Sriwannawit & Sandström, 2015).

iii. It was assumed to use only the 5 items of compatibility, relative advantage, observability, complexity and observability. The recent sixth attribute of reinvention (Kelly, 2012) was not used because it was not relevant to the study. In CSPVs, the community does not have the opportunity to reinvent the technology as there is a lack of knowledge transfer due to the donor nature of the CSPV.

Thus, the community is not in a position to find means of reworking the technology in order to use local resources to sustain it.

3.6 Chapter Summary

The study took a pragmatist approach that heavily leaned towards positivism. Data that was collected was largely quantitative from 309 respondents of benefiting CSPV communities using a Likert-type questionnaire. Additional qualitative data was collected through in-depth interviews with 7 key project and DEA informants. Quota sampling was used to determine the questionnaire respondents, whereas that for key informants was purposive through referral.

Quantitative data was analysed using SPSS 20 to produce descriptive statistics, cross-tabulations and bivariate correlations of constructs. Qualitative data was analysed in themes using Microsoft Word; and the report was done using Microsoft Word after triangulating both the qualitative and quantitative data.

4. RESULTS AND DISCUSSION

4.1 Organisation of the Chapter

This chapter presents a detailed report of analysed findings. The results are organized following the constructs from Roger's Model. Items in the Likert scales of each construct were analysed and responses summarized in descriptive statistics. After describing the constructs, correlation statistics were done to give insight into the inter-relation of the constructs. The first sub-section reports on the extent of usage; that is, the respondent's adoption level. The discussion of results is done in the last section of the chapter.

4.2 Descriptive Analysis of CSPV Adoption and Factors Influencing Adoption

4.2.1 Adoption of CSPVs

Respondents under this construct were to disclose the extent to which they had embraced the CSPV. There were five items in this section plus an additional item investigating the specific purpose for which the CSPV was applied. After taking off the item that measured the specific uses for which respondents applied the CSPV, overall adoption was statistically computed by combining summary responses to all the five items under this construct. The responses are given in Table 4.1.

Table 4.1: Respondents' CSPV Usage and Adoption Perceptions

Statement	Response category	Frequency	Valid Percent
I use at least once a week	Strongly Disagree	34	11.1%
	Disagree	36	11.8%
	Neutral	31	10.1%
	Agree	59	19.3%
	Strongly Agree	146	47.7%
	n =	306	
Purpose(s) for which respondent uses the CSPV	Studying	93	30.6%
	Charging phones and gadgets	95	31.3%
	Refrigeration	32	10.5%
	Other	84	27.6%
	n =	304	
I have responsibility to take care of the CSPV	Strongly Disagree	36	11.8%
	Disagree	37	12.1%
	Neutral	32	10.5%
	Agree	56	18.4%
	Strongly Agree	144	47.2%
	n =	305	
I regard the CSPV as my own	Strongly Disagree	119	39%
	Disagree	80	26.2%
	Neutral	15	4.9%
	Agree	72	23.6%
	Strongly Agree	19	6.2%
	n =	305	
Loss of CSPV detrimental to me	Strongly Disagree	10	3.2%
	Disagree	29	9.4%
	Neutral	32	10.4%
	Agree	75	24.4%
	Strongly Agree	162	52.6%
	n =	308	
I wish to have CSPV forever	Strongly Disagree	43	14%
	Disagree	28	9.1%
	Neutral	96	31.2%
	Agree	60	19.5%
	Strongly Agree	81	26.3%
	n =	308	
Overall adoption	Disagree	16	5.4%
	Neutral	123	41.4%
	Agree	151	50.8%
	Strongly Agree	7	2.4%
	n =	297	

When asked to affirm if they used the CSPV at least once a week, a total 67% respondents agreed. Only a cumulative 22.9% disagreed. This showed that most of the respondents used the CSPV in their community.

Asked as to how they used the CSPV, the respondents who used the CSPV for studying and charging electronic gadgets accumulated to 61.9%. In health centres, refrigeration of some medical supplies and other uses such as lighting during infant deliveries at night were also reported by 38.1% of the respondents. 65% of the respondents cumulatively were of the view that they were responsible for taking care of the CSPV. On the other hand, 23.9% at least disagreed to bear the responsibility of care.

When the respondents were asked regarding their sense of personal ownership towards the communal CSPV, it was surprising to note that respondents totaling 65.2% disagreed to viewing the CSPV as their own. Respondents felt that project officers were not managing the system to their satisfaction. The project officers were perceived as not transferring tactical responsibility to the beneficiaries. Only 29.8% agreed to viewing the systems as their own. Yet when the respondents were asked to state their attitude towards loss of the CSPV from the community, a total of 77% viewed that loss of the CSPV would be detrimental.

The respondents were then asked to state if they were hoping to have the CSPV forever. The results showed that 45% agreed and 23.1% disagreed. Therefore, even though the respondents valued the CSPV highly in such a way as to feel at a loss without it, they did not feel a high sense of owning the system while they had it, and not many wished to have it forever. It might have been due to the communal aspect of the PV or the managerial dynamics that reduced the sense of ownership, while the wish to own a personal SHS or the limited use to which the CSPVs could be put might have negated the value of having the CSPV forever.

From these results, an *adoption* construct was computed. The overall adoption on average therefore indicated that 53.2% agreed to have adopted the CSPV, 41.4% were neutral respondents, and 5.4% had not adopted.

Due to the improvements they have realized in charging electronic gadgets, the lighting for primary education study and health centre night service delivery, community members feel that their livelihoods have been improved in education, health and welfare.

This agreed with earlier work by Gustavsson (2007a, 2007b), Gobede (2012) and Adkins et al. (2010), all of whom articulated on the uses to which CSPVs are put by community members.

Although respondents highly valued the CSPV, they did not have a high sense of regarding it as their own, and but few expressed the wish to have it forever in the community. A plausible explanation could be that although the users valued the CSPV, they could not afford to fund it and therefore expected the government or the donor to own the project. This corroborated the findings of Pode (2010) and Ondraczek (2013) that communities in Tanzania and Botswana expected government or donors to fund the PV projects, without which the projects would discontinue.

4.2.2 Trialability of the CSPV

Respondents were asked to indicate their perceived level of agreement with statements about the *trialability* of the CSPV in their community. There were 4 items out of which an overall construct of *trialability* was computed. The tabulated results are given in Table 4.2.

Table 4.2: Respondents' CSPV Trialability Perceptions

Statement	Strongly Agree/Agree	Neutral	Strongly Disagree/Disagree	N	Mean score
Trial of CSPVs is necessary before adoption	74.3%	12.1%	13.7%	307	3.85
Trying CSPV out has enhanced my desire to have it here	66.4%	30.7%	2.9%	309	3.85
A trial convinced me CSPVs are better than other technologies	46.9%	31%	22.1%	303	3.38
Frequency of using CSPV is due to ease of use at trial	8.2%	4.2%	87.5%	306	1.92
Overall Trialability	41.6%	51.7%	6.7%	298	3.35

Table 4.2 shows that 74.3% respondents found it necessary to first try the CSPV before adopting it. In addition, 66.4% agreed that trying out the CSPV had enhanced their desire to have it. However, with a mean score of 1.92, it was found that 87.6% disagreed that the perceived ease of using the system after trial had impacted on their frequency of use. Overall, 41.7% respondents agreed that the CSPV was trialable and 6.7% disagreed. In summary, respondents moderately agreed to the system's *trialability* aspects and believed that trial had no influence on frequency of use.

4.2.6 Complexity of the CSPV

Respondents then related their perception on the complexity of the system, making them unable to use the system or to be restricted from using or applying the CSPV. If the system was complex, training prior to use or being assisted when they wanted to use would then be of essence. The results are shown in Table 4.3.

Table 4.3: Respondents' CSPV Complexity Perceptions

Statement	Strongly Agree/Agree	Neutral	Strongly Disagree/Disagree	Mean Score
No training is needed on how to use CSPV	57.2%	10.8%	32%	3.37
CSPVs are more complex than thought by many	36%	7.1%	56.8%	2.53
The CSPV system requires expertise to use	33.6%	14.2%	52.1%	2.52
The CSPV is easy to repair, manage and maintain	16.5%	12.2%	71.3%	2.1
Overall Complexity	47.4%	39.6%	13%	2.66
N = 309				

57.2% thought that there was no need for training on how to use the CSPV while 32% thought there was need. On top of that, only 16.5% viewed that the system was easy to technically manage, repair and maintain; while 71.3% disagreed with that assertion.

These results seemed contradictory to the item where 56.8% believed that the system was not as complex as many thought, yet 71.3% believed that the system was complex for repairing, maintaining and managing. The explanation however could be that the respondents found the system easy to use, but not easy to maintain. Indeed, none of the local residents was allowed to maintain or repair the system when it was down.

Then a collated *complexity* construct was computed from the 4 items. Overall, it was noted that most respondents viewed the system as complex. In other words, 47.4% would be dissuaded from adopting the CSPV due to its complexity while 13% thought it was not complex. These results indicated that a knowledge transfer was lacking in all the solar villages studied, and that this had produced a perception of complexity in the minds of most respondents.

The results indicate a lack of an elaborate institutional framework for training of rural technicians. The results support the findings of Hansen et al. (2014) that Kenya excelled in the PV market compared to Tanzania and Uganda due to localization of the market. It also supports what Gobede (2012) earlier found for the need to train community members on the management, service and repair of the CSPV.

A fresh insight from the study was that although most respondents believed that the CSPV system was not as complex as many others thought, they did not view it easy to maintain, repair and manage.

4.2.3 Relative Advantage of the CSPV

Respondents were then asked to profess their perception of the relative advantage of the CSPV. There were 6 items under this construct out of which an overall *relative advantage* construct was computed as shown in Table 4.4.

Table 4.4: Respondents' CSPV Relative Advantage Perceptions

Statement	Strongly Agree/Agree	Neutral	Strongly Disagree/Disagree	N	Mean Score
CSPV has reduced my cost of living	96.4%	0.6%	2.9%	309	4.71
With CSPV, I can access services I could not access before	91.6%	8.4%	0%	309	4.44
The CSPV is much better than other energy sources we use	76.4%	10.7%	12.9%	309	3.95
CSPV benefits outweigh its drawbacks	74.8%	11%	14.2%	309	4.07
I think the community cannot afford to maintain the CSPV	66%	10.4%	23.7%	303	3.78
The CSPV is much better than grid electricity	45.4%	28.4%	26.2%	306	3.38
Overall Relative Advantage	91.7%	8.3%	0%	300	4.16

According to Table 4.4, 96.4% agreed that the CSPV had reduced their cost of living. Another 91.6% agreed, and none disagreed, that the CSPV had ensured that they got access to other services hitherto inaccessible. Thus, it is likely that the reduced cost of living that respondents experienced was due to the new services that could not be accessed before introduction of the CSPV.

The summarised *relative advantage* construct was then computed and the average response extracted. Overall, a total of 91.7% agreed to the assertion and none disagreed. Thus, most respondents in the study agreed that the CSPV system presented relative advantages to their livelihoods. These were felt in the education and health areas with prolonged study hours and lighting in health centres, refrigeration and gadget charging.

These findings support earlier findings of Malawian research by Gobede (2012) in Salima and Adkins et al (2009) in Mbayani. It also corroborates findings in other sub-Saharan countries such as the cases of Zambia (Gustavsson, 2007a) and Zimbabwe (Bawakyillenuo, 2012). These cases translated to cost advantages for the benefiting communities.

In terms of cost disadvantage, the study adds to past findings that PV set-up and maintenance costs are so high as to render them not affordable to many people. Findings by Tchereni (2013) for dwellers in South Lunzu, Malawi; and by researchers like Siegel and Rahman (2011) in Bangladesh; Guzowski and Recalde (2010) in Argentina and Chile; and Nalan et al. (2008) in Turkey are hereby corroborated in that high costs are relatively high in the sector, despite experiencing a falling trend.

4.2.4 Compatibility of the CSPV

The study touched on the *compatibility* aspect of adoption. 7 items under this construct were included. The items covered such aspects as compatibility with the respondent’s occupation, values, relationships and customs. The results are given in Table 4.5.

Table 4.5: Respondents' CSPV Compatibility Perceptions

Statement	**Strongly Agree/Agree**	**Neutral**	**Strongly Disagree/Disagree**	**Mean Score**
My work (occupation) has been enhanced with the CSPV	98%	1.9%	0%	4.37
I do not need the CSPV in my line of work	48.2%	10.4%	41.4%	2.82
I think CSPV is not necessary for our community	20%	3.9%	76.1%	1.93
I worry about the safety of using the CSPV	19.1%	9.7%	71.2%	2.04
CSPV introduction has brought in social disorder	15.5%	1.3%	83.2%	1.85
CSPV introduction has improved social relationships in our community	10.4%	8.4%	81.2%	2.11
CSPV introduction has made my life change undesirably	9.1%	6.5%	84.5%	1.73
Overall Compatibility	63.7%	30.7%	5.5%	3.71
N = 309				

With a mean score of 4.37, 98% of the respondents agreed that the CSPV had enhanced their work and none disagreed. Consequently, a *compatibility* construct was computed from the items. The indicative average results showed that 63.7% agreed that CSPVs were compatible with their values, norms and society. 30.7% were neutral and 5.5% generally disagree.

The findings suggest that most of the users in Chikwawa found the system to be compatible with their occupation. This again corroborates earlier research by Kebede et al. (2014) who noted that an incompatible market structure in Ethiopia was a barrier to adoption. Since the system in Chikwawa is being used for lighting and other needs, its application is compatible with the study needs of students and electricity needs of the other members.

4.2.5 Observability of the CSPV

To determine if the respondents had been influenced to adopt the CSPV through the *observability* attribute, items were included that covered the dimension. The results are shown in Table 4.6.

Table 4.6: Respondents' CSPV Observability Perceptions

Statement	Strongly Agree/Agree	Neutral	Strongly Disagree/Disagree	Mean Score
CSPV benefits to the community are observable since launch	99.4%	0.6%	0	4.58
I was persuaded to love CSPVs after seeing how others benefited	96.5%	2.9%	0.6%	4.44
My friends have expressed wish to have the same in their village	91.6%	3.2%	5.2%	4.33
I changed my way of using the CSPV after observing how others use it	27.2%	16.2%	56.6%	3.26
Overall Observability	99.4%	0.6%	0	4.27
N = 309				

Up to 99.4% agreed that the benefits of using CSPV were observable in their community and none disagreed. In addition, 96.5% agreed that their love for the CSPV had been influenced by seeing how others had benefited from it with only 0.6% dissenting. Then the respondents were asked to state if their friends from other communities that did not have the CSPV had expressed wish to have the CSPV in their community. This would show if observation had an impact on members of other communities. 91.6% agreed that their peers had expressed wish to have the CSPV in their village.

After collating the items, a construct of *observability* was computed. Overall, 99.4% agreed that the system had *observability* effects. This was shown in their own lives and in the reported wishes of members of surrounding communities.

Earlier research on observability is supported by this study. Findings by Richter (2014) in UK; those by Rode and Weber (2011) in Germany; Bollinger and Gillingham (2012), Graziano and Gillingham (2014) and Rai and Robinson (2013) in California, Connecticut and Texas, America, respectively, are again supported. Observability effects were educative to community members and those of other communities as to encourage desire and usage.

This study has shown that the type of peer effect was both passive and active, with benefiting members reporting to have discussed with colleagues on the benefits of their CSPV. As was noted recently by Palm (2016) and Schelly (2014), such active peer effect would be an instrument for later adopters to make the decision to buy at a faster rate than would passive observability. For Chikwawa, this effect could not be effectively established as low community incomes limited further CSPV adoption.

4.3 Correlation Analysis of Factors Influencing CSPV Adoption

The descriptive statistics in section 4.2 for each construct demonstrated wide differences in overall level of agreement. The influencing factor to which most overall agreement was observed was *observability*, followed by *relative advantage*, then *compatibility*, *complexity* and *trialability*. It was thus necessary to run a bivariate correlation computation for each construct against *adoption* in order to test if there was a statistically significant relationship between each construct and *adoption*. The results are shown in Table 4.7.

Table 4.7: Correlation between Each Construct and Adoption

		Adoption	Observability	Relative Advantage	Compatibility	Trialability	Complexity
Adoption	Pearson Correlation	1	.854*	.741*	.626*	.553**	-.174
	Sig. (2-tailed)		.037	.017	.029	.010	.204
	N	297	297	288	297	287	296

Table 4.7 indicates that the strongest relationship with *adoption* was that of *observability*, which was positive at 0.854, significant at 95% confidence level (*p=0.037*). *Relative advantage* correlation coefficient was strong at 0.741 (*p=0.017*), followed by *compatibility* at 0.626 (*p=0.029*); while *trialability* coefficient was fairly good at 0.553 significant at 99% confidence level (*p=0.01*).

Complexity had a very low and negative relationship with *adoption* at -0.174 which was not statistically significant, negating the probability of existence of a relationship. In summary, strong relationships were established for *adoption* with *observability* and with *relative advantage*. There was no correlation between *adoption* and *complexity*.

These results were generally consistent with the pattern of overall descriptive results for the constructs except for *complexity*. Similar to the descriptive, *observability, relative advantage* and *compatibility* followed each other in strength of correlation. It was thus deemed essential to compute contingency tables in order to observe further if the overall observations had statistically significant demographic influences underlying them.

4.4 Demographic Cross-tabulation of Factors Influencing CSPV Adoption

Respondents were grouped by gender, occupation, location and age group. The cross-tabs based on these categories were tested using Cramer's V due to their not being 2x2 matrices and their having nominal demographic categories. Since there was no established correlation between *complexity* and adoption, then *complexity* was not included in the analysis. Only within occupation and gender categories were strong and significant relationships established.

4.4.1 Influence of Occupation on Factors Affecting CSPV Adoption

Table 4.8 shows the cross-tab computations of occupation and the constructs.

Table 4.8: Occupation and Influencing Factor Cross-tabulation

Construct	Occupation	Strongly Agree/Agree	Neutral	Strongly Disagree /Disagree	Count		Cramer's V
Relative Advantage	Student	100.0%			28	Value	0.747
% within occupation	Farmer	97.7%	2.3%		133	Approx. Sig.	0.000
	Salaried Employment	78.1%	21.9%		64	N	300
	Business/Self-employed	69.4%	30.6%		72		
	Other	66.7%	33.3%		3		
Compatibility	Student	100.0%			28	Value	0.677
% within occupation	Salaried Employment	98.5%	1.5%		65	Approx. Sig.	0.000
	Business/Self-employed	93.2%	5.4%	1.4%	74	N	309
	Other	66.7%	33.3%		3		
	Farmer	64.7%	7.2%	28.1%	139		
Observability	Farmer	100.0%			139	Value	0.211
% within occupation	Salaried Employment	100.0%			65	Approx. Sig.	0.001
	Other	100.0%			3	N	309
	Business/Self-employed	98.6%	1.4%		74		
	Student	96.4%	3.6%		28		
Trialability	Salaried Employment	80.0%	4.6%	15.4%	65	Value	0.118
% within occupation	Student	78.6%	21.4%		28	Approx. Sig.	0.102
	Business/Self-employed	64.4%	30.1%	4.5%	73	N	298
	Other	50.0%		50.0%	2		
	Farmer	46.2%	46.2%	7.6%	130		

According to Table 4.8, there were significant differences in the perception of *relative advantage* according to occupation of respondents, with Cramer's V value of 0.747. *Compatibility* showed moderately strong significant differences with a V value of 0.677. However, occupational differences were weakly reflected in *observability* perceptions, but no differences were established for *trialability* perceptions according to occupation.

For instance, students and farmers were slightly different in their reported perceptions of *relative advantage* but widely different in their perceptions of *compatibility*. Students perceived that the CSPVs were more compatible with their livelihoods than did the farmers. This difference was statistically significant.

4.4.2 Influence of Gender on Factors Affecting CSPV Adoption

Table 4.9 shows the cross-tab computations of gender and the constructs.

Table 4.9: Gender and Influencing Factor Cross-tabulation

Construct	Gender	Strongly Agree/Agree	Neutral	Strongly Disagree/Disagree	Count		Cranmer's V
Relative Advantage	Male	100.00%	0.00%		176	Value	0.864
	Female	75.80%	14.20%		124	Approx. Sig.	0.000
						N	300
Observability	Male	56.04%	43.96%		182	Value	0.861
	Female	70.57%	20.13%	9.30%	127	Approx. Sig.	0.024
						N	309
Compatibility	Male	73.1%	26.9%		182	Value	0.707
	Female	63.0%	37.0%		127	Approx. Sig.	0.001
						N	309
Trialability	Male	24.60%	74.60%	0.80%	176	Value	0.293
	Female	53.40%	35.80%	10.80%	122	Approx. Sig.	0.001
						N	298

In Table 4.9, there were highly significant differences in perceptions between males and females on *relative advantage* and *observability* attributes. Cramer's V value was 0.864 and 0.861 respectively, with *observability* significant at 95% confidence level. Strongly significant differences based on gender were also noted for *compatibility* perceptions at 0.707 Cranmer's V value, but the gender difference was not reflected in *trialability* perceptions.

Based on this analysis, it can be summarized that males experienced a higher relative advantage of using the system and found the system to be more compatible with their occupation and social norms than did females. However, females were more influenced by observability effects than were males.

4.5 CSPV Policy

During the study, policies followed in managing the projects were investigated through project officers. In addition, government policy on renewable energies was also studied. This sub-section summarises the findings.

4.5.1 Chikwawa CSPV Project Practice

Project officers at the study sites were interviewed to understand how the projects were being implemented. MREAP and CRED project documents were studied to validate the information from project officers. Besides, interviews with community members verified statements made on how the projects were being implemented.

It was noted that the practice was modified according to the area's context but policy was determined from source; that is, by the project managers. However, my interest was on how the principles were being implemented in practice onsite, as this would facilitate or hinder adoption of the CSPV in the given community.

As such, the following practices were highlighted:

i. Use of the PV was limited to certain functions, like lighting, charging and refrigerating. Functions like ironing and cooking were prohibited.

ii. Besides initial training at installation on how to manage the system, there was almost a complete lack of technical knowledge transfer. It would therefore take a long time for repairs to happen, even for minor technical issues. Project officers perceived a lack of trust between the managers and the implementers. However, this practice was industry-wide. According to government officials, community leaders and users would sometimes abuse the system such that when control was left in their hands, the system would soon be down with no one willing to take responsibility.

iii. There were almost similar cost-recovery mechanisms. In most cases, those using the system other than for study would be required to pay for the service supplied. For example, a service to charge phones could cost MWK50.00 (equivalent to

$0.07) per phone. It was however noted by all respondents that the fee could not yield enough returns to cover the costs. In addition, due to having personal solar charging systems, called power banks, use of the CSPV for charging phones was declining over time.

iv. At some schools, not everyone was allowed to use the system for study. Due to capacity limitations, fuller access was given to those awaiting national examinations; that is, Standard 8 pupils. At one school, girls were not allowed to study at night due to cases of immorality that had sprung up after introduction of the extended study period. After consulting with the community leaders and parents, it was agreed by the community members to restrict girls from accessing.

v. Community committees were set up to manage the CSPV operations, mostly headed by the Headmaster at the school, or the Clinical Officer at the health centre. These committees managed the fee structure and collection, restricted PV access to non-qualifying individuals such as those known to vandalise, called for community meetings when needed and gave feedback to the project managers. Whenever a working committee was lacking, it was noted that there were many complaints from beneficiaries, such as accusations of monetary collection theft.

To summarise, the policies were context-specific though guided from source. The expensive nature of the CSPV necessitated implementation of some of the policies, such as its management. Other policies, however, came as a result of the need for proper management of the system; while others were due to the social context of the community.

4.5.2 Malawi Government Policy

At the writing of this report, Malawi's National Energy Policy (NEP) (GoM, 2003) had not yet been modified to incorporate changes occurring in the energy environment since 2003. The policy dwelt much on fossils, biomass and hydroelectricity, but recognized that although RET appropriation was then at 0.2%, there was need to enhance its use.

In it, the barriers faced in RET adoption in Malawi were spelt out, as follows:

i. *Technical:* Production is not yet localized such that everything is imported.
ii. *Financial:* Taxation, high set-up costs, investor recoil, poor business skills and lack of credit facilities and proper financing mechanisms. Further discussions with government officials and project officers revealed that high product and spare part costs bar further installations beyond those donated. For example, it was reported that a replacement battery would cost up to MWK50,000,000.00 (equivalent to $70,000.00).
iii. *Institutional:* Absence of regulatory framework, small number of suppliers, lack of competent RET technicians, absence of regulatory standards and codes of practice, lack of proper policy. Further inquiry showed that most products were of poor quality and buyers had no recourse for redress as transactions are cash-based with no after-sales service
iv. *Socio-cultural:* Some RET solutions, such as use of human biomass, are not acceptable to most citizens

4.6 Chapter Summary

The study results have shown that some of earlier research findings are corroborated and some contradicted. On adoption, respondents did not feel a high sense of owning the system although they felt responsible for it. It was perceived to have reduced costs of living of the respondents and had improved their access to other services.

The system was found to be compatible with the respondents' various occupations of respondents. The *trialability* of the system produced learning effects though not resulting into improved frequency of use. After trial, they believed the system easy to use but not easy to repair and maintain.

Adoption was strongly correlated with *observability* and *relative advantage*. Furthermore, there were significant differences in perceptions about *relative advantage* and *compatibility* according to occupation of respondents. There were also perceptual differences on *relative advantage* and *observability* according to gender.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter draws on the findings and discussion to present the conclusion from the study. An overview of the study and a summary of the findings will first be presented before a conclusion is drawn. Next will be recommendations and directions for further research.

5.2 Overview of the Study and Summary of the Findings

This study was aimed at determining and analysing factors that influence adoption of CSPVs in Chikwawa. It applied diffusion attributes defined in Roger's Model. The study population from which a quota sample of 309 respondents was drawn was the communities where CSPVs had been installed under CRED and MREAP programmes.

The findings showed that adoption of CSPVs in Chikwawa was being facilitated by the new services users were enjoying in forms of lighting and charging; the observability of its benefits to others within and without the community; its compatibility with their work; and its ease of use. *Observability* and *relative advantage* were found to have the highest positive correlation with *adoption* of the CSPV.

The adoption of CSPVs was being hindered by the high installation and maintenance costs; lack of knowledge transfer to community members that made it complex to repair and maintain; and the limited use to which the system could be applied. There were significant differences reflected by occupation and gender on perceptions of *relative advantage, observability* and *compatibility*.

5.3 Conclusion

The data showed that the constructs of Roger's Model that influence adoption of CSPVs could not be generally applied to the users of Chikwawa. While *complexity* and *trialability* had no and weak correlation with *adoption* respectively, *relative advantage*, *observability* and *compatibility* were correlated.

Due to the varied roles that traditionally devolve within gender confines and the wide differences occupations engender, it follows that there were significant differences in the perceptions respective to each construct. Therefore, it can be concluded that a rural CSPV adoption strategy that uses Roger's Model is modulated by gender and occupational differences of the target market in perceiving the attributes that influence *relative advantage*, *observation* and *compatibility*.

5.4 Recommendations

Following the conclusion of the study, I recommend first that when strategizing for diffusion of solar PV in communities and homes, the rural market should be segmented in gender and occupational lines. As it was found that there was significant difference in occupation and gender patterns on respondent inclinations to adopt, this may have implications on marketing of CSPVs. For instance, when targeting homes for diffusion of CSPVs, the message should be tailored according to the occupation of the household. Homes with students might be more inclined to purchase SHS unlike merely a farming home, due to the perceived relative advantage accorded to the students by extra lighting.

Secondly, when promoting the adoption of off-grid CSPV solutions, the compatibility, relative advantage and observability aspects of the system should be emphasised. From this study, it has been shown that trialability and complexity aspects are not significant factors that influence adoption. In contrast for SHS, trialability and complexity might be factors worth emphasis in promotion; for it was shown that users in communities were not allowed to maintain the CSPVs. In the case of SHS, the buyer is responsible for using and maintaining the system, which might necessitate the need for training.

In light of the second point above, I recommend that there must be implemented deliberate programmes to train local technicians in repairing and maintaining CSPVs and SHS. This will reduce the perceptions of complexity and remove trialability barriers in the use and maintenance of both CSPVs and SHS.

Further, I recommend that CSPV policy should have feed-in from targeted community members before implementation. This will smoothen implementation and tailor policy to local challenges that can affect effective implementation. For instance, it must be tailored towards real needs of the community. With the coming in of power banks, for example, communities will need community solar to address social energy needs beyond mere lighting and charging of phones.

5.5 Directions for Further Research

i. Further research should look at the adoption of SHS in the communities where CSPVs were installed and in their surrounding communities. Since studies have shown that observability effects stimulate purchase within a 1-mile radius (Richter, 2014), then further study should focus on relative increase of SHS in surrounding areas to the community compared to communities further off.

ii. Related to (i) above, further research should investigate if there will be significant differences in perception of adoption attributes due to gender and occupation in the adoption of SHS.

iii. Further research should establish causality of the factors of *relative advantage, observability* and *compatibility* with *adoption.* This should aim at determining the strength of each factor in influencing adoption in order to explore means of strengthening the highest impacting factors.

iv. The study mainly focused on factors influencing CSPV adoption using Rogers' model. Other models, such as the TAM can be used in further research so as to make these findings more robust.

v. The research model taken was to focus only on community factors influencing adoption. Market-related factors influencing adoption, such as financial, technical and institutional have not been thoroughly investigated in this study. Further research can establish the market-related factors influencing adoption in Malawi.

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APPENDICES

Appendix 1: Questionnaire for Chikwawa CSPV Users

QUESTIONNAIRE ADMINISTERED TO CHIKWAWA CSPV USERS

Dear Respondent,

This questionnaire is designed to collect data on a study entitled, "*Factors Influencing Diffusion of Off-grid Community-based Solar Photovoltaics in Chikwawa District, Malawi*". Kindly fill out your responses as frankly as possible. The data you provide will be treated in **strict confidence**, used **only for purposes of this research** and **generalised**. Please, **do not write down your name** on the questionnaire. Thank you for your anticipated cooperation. It will require about 30 minutes of your time.

Section A. Your demographic characteristics (***Tick*** *as appropriate*)

1. *Gender* [ ] Male [ ] Female
2. *Age Group* [ ] Under 20 [ ] 20-29 [ ] 30-39 [ ] 40-49 [ ] 50-59 [ ] 60 or over
3. *Occupation* [ ] Student [ ] Farmer [ ] Business/self-employed [ ] Employed [ ] Other (*state*)……………………………..

Section B.

Please read the following statements and ***circle the number*** that best describes your view of the CSPV, where *Strongly Disagree (SD) = 1; Disagree (D) = 2; Neutral (N) = 3; Agree (A) = 4;* & *Strongly Agree (SA) = 5*.

4.	**Adoption of CSPV**	**SD**	**D**	**N**	**A**	**SA**
i.	My family uses the CSPV at least once every week	1	2	3	4	5
ii.	I want to have the CSPV forever	1	2	3	4	5
iii.	Loss of the CSPV will be detrimental to me	1	2	3	4	5
iv.	I regard the CSPV with the same care as I would my own thing	1	2	3	4	5
v.	I have responsibility to take care of the CSPV	1	2	3	4	5

5. I use the CSPV for… (*Tick all that apply*)

[ ] Studying
[ ] Charging phone and other things needing charging
[ ] Refrigeration
[ ] Other business (*state*)

……………………………………………………………………………………

Section C.

Please read the following statements and ***circle the number*** that best describes your view of the CSPV, where *Strongly Disagree (SD) = 1; Disagree (D) = 2; Neutral (N) = 3; Agree (A) = 4;* & *Strongly Agree (SA) = 5.*

6. **Trialability of CSPV use**	**SD**	**D**	**N**	**A**	**SA**
i. Frequency of using CSPV is due to ease of use at trial	1	2	3	4	5
ii. A trial convinced me that CSPVs are better than other technologies	1	2	3	4	5
iii. Trial of CSPVs is necessary before adoption	1	2	3	4	5
iv. Trying CSPV out has enhanced my desire to have it here	1	2	3	4	5

7. **Relative advantage of the CSPV in use and performance**

	SD	**D**	**N**	**A**	**SA**
i. The CSPV has reduced my cost of living	1	2	3	4	5
ii. I think the community cannot afford to maintain the CSPV	1	2	3	4	5
iii. The CSPV is much better than grid electricity	1	2	3	4	5
iv. The CSPV is much better than other energy sources we use	1	2	3	4	5
v. With CSPV, I can access services I could not access before	1	2	3	4	5

Explanation:

……………………………………………………………………………………………………

vi. CSPV benefits outweigh its drawbacks	1	2	3	4	5

8. **Compatibility of CSPV use** **SD D N A SA**

i. My work (occupation) has been enhanced with the CSPV 1 2 3 4 5

Explanation:

……………………………………………………………………………

ii. I do not need the CSPV in my line of work 1 2 3 4 5

iii. The CSPV has made my life change undesirably 1 2 3 4 5

Explanation:

……………………………………………………………………………

iv. I worry about the safety of using the CSPV 1 2 3 4 5

v. The coming of the CSPV has enhanced our social relationships 1 2 3 4 5

vi. The coming of the CSPV has brought social problems with it here 1 2 3 4 5

Explanation:

……………………………………………………………………………

vii. I think the CSPV is not necessary for our community 1 2 3 4 5

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9. **Observability of CSPV use**	**SD**	**D**	**N**	**A**	**SA**

i. My friends have expressed wish to have the same in their village 1 2 3 4 5

ii. CSPV benefits to the community are observable since launch 1 2 3 4 5

Explanation:

……………………………………………………………………………

iii. I was persuaded to love CSPVs after seeing how others benefited 1 2 3 4 5

iv. I changed my way of using the CSPV after observing how others use it 1 2 3 4 5

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10. **Complexity of using the CSPV**	**SD**	**D**	**N**	**A**	**SA**
i. The system requires expertise to use	1	2	3	4	5
ii. No training is needed on how to use CSPV	1	2	3	4	5
iii. CSPVs are more complex than thought by many	1	2	3	4	5

iv. The CSPV is to manage and maintain 1 2 3 4 5

End of questions. Thank you so much for taking your time to answer the questions.

Appendix 2: Discussion Guide for Key Informants

Dear Respondent,

This question guide is designed to collect data on a study entitled, "*Factors Affecting Diffusion of Off-grid Community-based Solar Photovoltaics in Chikwawa District, Malawi*". The bulk of the data will be collected through survey from community users. Your responses, however, are essential for purposes of understanding the environment of CSPVs in Malawi and projects thereof. Please respond as frankly as possible. The data you provide will be treated in **strict confidence**, used **only for purposes of this research** and **generalised**. Therefore, **your name is not needed** as part of the interview information you provide. Thank you for your anticipated cooperation.

---

1. Introduction of study focus and developing rapport with respondent
2. Respondent role and how he fits into the energy environment
3. Respondent experience and view of energy and PV policy and practice
4. PV programme/project respondent is or has been involved in, its objectives, diffusion strategy, rationale and role of respondent
5. Observations as to outcomes
6. Challenges project is facing impacting on PV diffusion
7. Programme response to challenges to diffusion
8. Lessons learnt
9. Conclusion

Appendix 3: Questionnaire by Ntemana and Olatokun (2012)

QUESTIONNAIRE DISTRIBUTED TO LECTURES AT THE NATIONAL UNIVERSITY OF LESOTHO.

Dear Respondent,

This questionnaire is designed to collect data on a study titled, "Analyzing the Influence of Diffusion of Innovation (DOI) Attributes on Lecturers' Attitude toward Information and Communication Technology." Kindly fill out your responses as frankly as possible. The data you provide will be treated in confidence. Thank you for your anticipated cooperation.

Section A. Demographic characteristics of Respondents (Tick as appropriate)

1.Gender	[ ] Male [ ] Female
2.Age Group	[ ] Under 25 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55-64 [ ] 65
3.Academic Rank	Assistant Lecturer [ ] Lecturer [ ] Senior Lecturer [ ] Associate professor [ ] Professor [ ]
4.Department ________________ ________________ ________________ ________________	

Section B. The influence of the five constructs of Diffusion of Innovation theory on your adoption and use of ICTs. This section aims at finding out your opinions about the statements listed below.

5. Please read the following statements and circle the number that best describes your use of ICTs, where Strongly Disagree (SD) = 1: Disagree (D) = 2: Agree (A) = 3 and Strongly Agree (SA) = 4).

Relative advantage and ICT use	**SD**	**D**	**A**	**SA**
ICTs improve my efficiency when I use them.	1	2	3	4
Mistakes with ICT transactions are easier to correct than manual ones.	1	2	3	4
There are enough	1	2	3	4

advantages of ICTs for me to consider using them.				
Mistakes are more likely to occur with ICT usage than with manual operations.	1	2	3	4
ICTs help me to better manage my time.	1	2	3	4
Compatibility and ICT use				
I do not need ICT in my work.	1	2	3	4
ICT makes lecturers redundant.	1	2	3	4
It bothers me to use ICTs when I could do my work manually.	1	2	3	4
I worry about the privacy of my information when using ICTs.	1	2	3	4
I worry that ICTs are not secure enough to protect my personal information.	1	2	3	4
Trialability and ICT use				
It was easy to use ICTs more frequently after trying them out.	1	2	3	4
A trial convinced me that using ICTs was better than using manual systems.	1	2	3	4
I do not need a trial to be convinced which ICTs are the best for me.	1	2	3	4
It did not take me much time to try ICTs before I finally accepted their use.	1	2	3	4
It is better to experiment with ICTs before adopting them.	1	2	3	4

Appendix 4: Questionnaire By Stachewicz (2011)

Project Title: ***Consumer Adoption of Capacitive Switch Technology in Industrially Designed User Interface Controls: A Pilot Study Using Perceived Attributes of Innovations.***

Purpose of the Study: The purpose of this research study is to gain a better understanding of the relationships between of a consumer's perception of using capacitive switch technology in industrially designed user interface controls. This is an attempt to look at predictors or relationships that could provide new tools for the development of marketing campaigns. If a certain consumer segment is willing to accept capacitive switch innovation in industrial designed user interface controls, it is possible that using the instruments could increase sales of capacitive switches and new vehicles. Also, due to the competition for development budgets research such as this can be used to help justify the allocation of funds and human resources for developing better car interiors.

Survey Instrument Divided by Construct
Note: All responses from Question 1 to Question 43 were Likert Scales having the following choices: A. Strongly Agree, B. Agree, C. Not Sure, D. Disagree, E. Strongly Disagree.

Relative Advantage

1. Switch B is not any better than switch A.
2. Switch A works just as well as switch B.
3. Switch B is less valuable than switch A.
4. Using switch B enables me to accomplish tasks more quickly.
5. Using switch B improves the quality of the outcome compared to a switch A.
6. Using switch B makes it easier to do the task.
7. Using switch B enhances my effectiveness to complete the task.
8. Using switch B gives me greater control over the task.

Compatibility

9. I feel that switch B can help me maintain my lifestyle.

10. I feel that switch B meets my social needs.
11. Capacitive switches are compatible with my day-to-day needs.
12. Using switch B is compatible with the way I operate an automobile.
13. I think that using switch B fits well with the way I like to complete a task.
14. Using switch B fits into the way I operate an automobile.

Trialability
15. Experimenting with switch B in a vehicle before purchasing is very important.
16. It is important to ask questions about switch B before buying a vehicle with it.
17. I do not need to see switch B before I buy a vehicle with it.

Demonstrability
18. I would have no difficulty telling others about the results of using switch B.
19. I believe I could communicate to others the consequences of using switch B.
20. The results of using switch B are apparent to me.
21. I would have difficulty explaining why using switch B may or may not be beneficial.

Visibility
22. In my vehicle, one sees switches on the overhead console.
23. Switch B is not very visible in my vehicle.

Ease of Use
24. My interaction with switch B is clear and understandable.
25. I believe that it is easy to get switch B to do what I want it to do.
26. Overall, I believe that a capacitive switch is easy to use.
27. Learning to operate switch B is easy for me.

Image
28. People in my circle of friends who use switch B have more prestige than those who do not.
29. People in my circle of friends who use switch B have a high profile.
30. Having switch B is a status symbol among my friends.

Voluntariness
31. Nobody requires me to use switch B.
32. Although it might be helpful, using switch B is certainly not compulsory in my life.

Perceived Risk
33. Acquiring switch B is risky because they may not work correctly.
34. I am afraid that new switch B will break down frequently.
35. I have no doubt that switch B products will work as expected.

Perceived Resources
36. Switch B cost too much.
37. The cost of buying switch B switch is too high.
38. The price of new switch B is beyond my financial means.
39. I have the financial resources to purchase switch B.
40. Switch B is affordable.

Consumer Acceptance
41. I do not have a preference between switch A and switch B.
42. I would prefer to have switch B only if it did not increase the cost of the automobile.
43. I would be willing to pay extra for an automobile with switch B.

Demographics
44. What is your gender?

A. Male
B. Female

45. What is your age group?

A. 18-26
B. 27-35
C. 36-44
D. 45-54
E. 55-64
F. 65 or over

46. What is the highest level of education that you have completed?

A. Grade School/Middle School
B. High School
C. Associate Degree
D. Bachelor's Degree
E. Master's Degree
F. Doctorate
G. Other – DD, Several college years

47. What is your marital status?

A. Single
B. Married
C. Widowed
D. Divorced

48. Number of children in household?

A. No Children
B. One Child
C. Two Children
D. Three Or More Children

49. What is your level of income?

A. <$34,900
B. $35,000 - $49,900
C. $50,000 - $74,900
D. $75,000 - $99,000
E. $100,000+

50. What is your race/ethnicity?

A. American Indian or Alaska Native (Not Hispanic or Latino) a person having origins in any of the original peoples of North or South America (including Central America), and who maintains tribal affiliation or community attachment.

B. Asian (not Hispanic or Latino) a person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent, including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.

C. Black or African American (not Hispanic or Latino) a person having origins in any of the black racial groups of Africa.

D. Native Hawaiian or Other Pacific Islander (Not Hispanic or Latino) a person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.

E. White (not Hispanic or Latino) a person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

F. Hispanic or Latino a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin, regardless of race.

G. Two or More Races (Not Hispanic or Latino) all persons who identify with more than one of the above races.