DECLARATION

This project paper is my own original work and has not been presented for a degree in any other university.

Signature ___________________________ Date ______________

CAROLINE NDERITU

This project paper has been submitted for examination with my approval as the University Supervisor.

Signature ___________________________ Date ______________

PROF. SIMIYU WANDIBBA
DEDICATION

This project paper is dedicated to my dear husband Mr. David Ndwigia for continued support, encouragement and sacrifice to ensure all is well, and to my children Shana and Gabi for being understanding throughout the process. I also dedicate this work to my beloved parents Mr. and Mrs. Nderitu for their unrelenting support, encouragement and continued prayers towards successful completion of my course.
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ABSTRACT

This study was done in Bonchari sub-county of Kisii County. The general objective of the study was to explore the social-economic effects of pico solar energy on the households in that sub county. The specific objectives were: to determine the effects of pico solar energy on men and women Sub-County, Kisii county; to determine the barriers to the realization of socio economic effects of pico solar energy; and to investigate the extent to which the level of income of households influences the adoption of solar energy for domestic use in that Sub-County. A sample size of 100 households was used in this study, and data were collected using structured interviews, key informants interviews and focus group discussions. The findings indicate that the majority of the respondents agreed that the level of income affects the ability of a person to purchase Pico solar products. The respondents felt that the adoption of pico solar energy has had a positive income on their lives. It further found that insufficient and inappropriate management is one of the main barriers in the adoption of pico solar systems. The study concludes that solar energy results in great benefits such as improvements of health facilities, better health from cleaner air as households reduce the use of polluting fuels for cooking, lighting and heating, improved knowledge through increased access to television and better nutrition from improved knowledge. It also concludes that cost is a factor that has impacted on the installation and use of solar in Bonchari Sub County. The study, therefore, recommends that when a pico system is used to supply electricity to rural areas in low-income economies, different business strategies should be implemented compared with the high-income economies where it is often used as an alternative power supply.
<table>
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<tr>
<td>CSP</td>
<td>Concentrated Solar Power</td>
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<td>EMT</td>
<td>Ecological Modernization Theory</td>
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<td>IEBC</td>
<td>Independent Electoral and Boundaries Commission</td>
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<tr>
<td>MDG</td>
<td>Millennium Development Goals</td>
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<td>NGO</td>
<td>Non-Governmental Organization</td>
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CHAPTER ONE: BACKGROUND TO THE STUDY

1.1 Introduction

Although the rate of household electricity access in developing countries increased from 63 to 78% between 2002 and 2013 (World Energy Outlook, 2015), more than one billion people still lack basic electricity access. Economic studies often reveal that electricity access holds and is able to provide substantial potential to enhance household incomes in numerous ways and, in addition, enhance access to media, increase educational attainment, and increase convenience in everyday life (Independent Evaluation Group, 2008; Bernard, 2010:33). However, most of the households in secluded rural areas have not been electrified due to the high cost of extending the electricity grid in such areas. The high cost of electricity grid extension has provoked interest in off-grid solar power as an alternative. This is because solar power provision devices have continued to experience a rapid dwindle in the cost of both acquisition and installation and provide solar power that is more appropriate than fossil fuels (Alstone et al., 2015:305).

In remote rural communities, when capital cost, along with transmission and distribution losses in electricity grid extension is considered in full, the cost of solar power can dwindle below the specified cost (Mahapatra and Dsapphn, 2012). Expectations from the Global Tracking Framework of the United Nations Sustainable Energy for All (SE4ALL) initiative is that by 2030, 60% of new connections in rural areas will be provided by decentralized solutions, with almost two-thirds of these being provided through construction of micro grid (World Bank, 2014). Another recent study argues that:
This present day is unique in the historical moments of electrification because of the rapid spreading of decentralized energy networks which is based on low-cost photovoltaic and super-efficient end-use appliances disruptive technology systems are able to rapidly expand access to basic electricity services and directly address the various emerging Sustainable Development Goals (SDG) for quality of life, while simultaneously driving action towards, Earth-sustaining, low-carbon, inclusive energy systems (Alstone, et al., 2015: 305).

How beneficial is off-grid solar power for development? Technologies, such as microgrids, home systems and solar Pico grids, are now in use by millions of households around the world (Komatsu et al., 2011). However, despite the socioeconomic benefits of grid electricity access having already been established in various economic studies (Independent Evaluation Group, 2008), a recent study (Aklin et al., 2016:16170) suggests that simple household electrification is not enough as quality of supply is equally important.

In general, there is much less emerging effect of off-grid solar power that has been found or proven. Both academic studies and practitioners have suggested that there are various associated improvements encompassed in the use of technologies, such as solar home modus and micro-grids. These improvements include: higher household incomes, increased children’s study time, and reduced kerosene expenditure (Komatsu et al., 2011; Kirubi et al., 2009). According to these studies, substantial socioeconomic benefits can be generated from even a minimal increase in the availability of electricity. For example, a field experiment that was conducted in Rwanda came with findings that in 15 villages in rural Rwanda, a simple “solar kit” composed of mobile charger, radio and light, reduced the normal energy expenditures and enhanced productivity in addition to
enhancing convenience (Grimm et al., 2016). Existing researches suggest that off-grid technologies are able to provide socioeconomic effects similar to the ones from grid access, although on a smaller scale. However, all of these studies, except the small field experiment in Rwanda (Grimm et al., 2016), are observational, and so are not suitable for the estimation of causal effects.

One of the major constraints to growth and development in underdeveloped rural areas is the lack of access to electricity (Laufer and Schäfer, 2011). A large number of rural settlements still lack access to electricity, especially in developing Asian countries and in sub-Saharan Africa (Mondal, 2010). Due to high distribution and transmission costs in volatile areas, many households have not been integrated to the national electricity network. A good example is the rural areas of Bangladesh where more than 65% of the population lives, only 42% have access to the national electricity supply which is usually unreliable and faulty at times (Mondal, 2010: 1133).

Worldwide electricity production mainly depends on depleting fossil fuel sources followed by hydro, nuclear, and other renewable sources such as, wind, tidal wave, solar, and geo-thermal energy. Pollution emitted by coal and natural gas plants is linked to several types of health and environmental hazards (Burt et al., 2013). Moreover, carbon emissions contribute to global warming and climate change. Renewable energy is extremely important to ensure future energy security, stability, and prosperity. In addition, a switch to renewable energy can reduce global warming emissions. Being nearly inexhaustible, solar energy can also help stabilize energy prices, along with providing many other economic benefits (Samad et al., 2013). Solar energy has the greatest potential of any almost-continuous energy source.
Sunlight covers the electromagnetic spectrum ranging from ultraviolet, visible light, and infrared (heat). All may be utilized directly or indirectly through conversion into electricity (Samad et al., 2013). According to the National Renewable Energy Laboratory (NREL), the technical potential of photovoltaic cells and concentrated solar power (CSP) is as much as 200,000 GW in the United States alone; which is enough to generate about 400,000 TWh of energy annually (Shakir-ul and Rahman, 2012). Despite high initial investment costs, a solar home system (SHS) is an emerging alternative energy source for many rural areas in the developing world. Simplicity and emission-free conditions are key attractions of SHSs. Moreover, the cost of solar systems has declined significantly, while their efficiency has increased greatly with advances in technology. For example, the total module cost decreased from around $1.30 per watt in 2011 to around $0.50 per watt in 2014, almost by 80% (Shakir-ul and Rahman, 2012:2). Likewise, solar cell efficiency has improved constantly, e.g., from 11.4 to 17% using perovskite (Lopez et al., 2012:5). However, in developed countries, almost 100% of the population has access to grid electricity. Large-scale solar energy usage is found mainly in developed countries. In contrast, in the developing world, small-scale (40 to 100 Watt) domestic solar systems are more prominent. About 1.1 billion people, concentrated in Africa and Asia, are known to live without access to electricity (World Bank, 2017).

1.2 Statement of the problem

In Kenya, solar household systems are mainly used to a significant extent for lighting (Ng’eno, 2014). Most of the rural population use kerosene for lighting and charcoal or firewood for cooking. These are known to cause many health problems because of the smoke emitted and also due to burns caused by the open flames. There exists a big risk of house fires and suffocation from use of these traditional fuels. Less than 44% of the general population and 5% of the rural population in
Kenya have access to electricity (World Bank, 2010). Demand is growing fast for electricity from both on- and off-grid consumers. Evidence of this includes frequent blackouts due to insufficient supply and the growing popularity of off-grid solutions such as diesel-powered generators and small-scale hydro generation units found both in Kisii and the Mount Kenya highlands that are largely illegal and poorly regulated energy-wise (Ng’eno, 2014:5). In Kisii County, the use of Pico solar energy has resulted in a steady supply of electricity and this calls for a study to explore the impact of Pico solar energy on women and men with little or no income who are usually left off in grid connections as fixed grid connections and high subscription fees that provide them with less agency. The study focused on answering the following questions:

1. What are the social effects of Pico solar energy on the wellbeing of men and women of Bonchari Sub-County?

2. What are the barriers to the realization of the socioeconomic effects of solar energy by both men and women in Bonchari Sub-County?

3. To what extent does the level of household income influence the adoption of solar energy for domestic use in that Sub-County?

1.3 Objectives of the study

1.3.1 General objective

To explore the effects of Pico solar energy on the socio-economic welfare of rural households in Bonchari Sub-County.
1.3.2 Specific objectives

i. To determine the social effects of Pico solar energy on men and women of Bonchari Sub-County.

ii. To describe the barriers to the realization of the socioeconomic impact of solar energy in Bonchari Sub-County.

iii. To investigate the extent to which the level of income of households influences the adoption of solar energy for domestic use in that Sub-County.

1.4 Assumptions of the study

i. Men and women of Bonchari Sub-County who use pico solar energy have benefited socially.

ii. There are barriers to the realization of socioeconomic impacts of pico solar energy in the Sub-County.

iii. The levels of income of households influence the adoption of solar energy for domestic use in that Sub-County.

1.5 Justification of the study

This study is important to researchers and academicians as it forms a basis for future researchers interested in undertaking a study on the socio-economic effects of Pico solar energy in other parts of Kenya. The study findings should also be of benefit to the project planners and implementers. Finally, the study addressed the gender dimensions in energy politics and in so doing, it calls for a need to focus on energy justice so as to avoid entrenching gender bias and other forms of inequality.
1.6 Scope of the study

This study focused on the effects of Pico solar energy on the socio-economic welfare of rural households in Bonchari Sub-County. It explored whether the impact of Pico solar energy is gendered, and was guided by the ecological modernization theory. The target population of the study was 100 households, categorized by constituency wards.

1.7 Limitations of the study

Due to the sensitivity of some questions on gender, some of the limitations encountered included unwillingness of some respondents to respond to some questions. To overcome this problem, the researcher tried as much as possible to build rapport with the respondents for them to be willing to give honest responses. In addition, some questionnaires were translated into the local Kisii language. A key challenge that the translator encountered was the inability to translate the technical terms into the local language. The researcher solved this by collaborating with the people from the area to ensure that the questions were translated accurately.

1.8 Definition of key terms

**Pico solar:** These are devices that use small compact and light weight solar photovoltaic panels to generate just a few watts of power in a wide range of small and portable applications.

**Ecological modernization theory:** This is a school of thought in the social sciences that argues that the economy benefits from moves towards environmentalism.

**Photovoltaic:** A field of semiconductor technology involving the direct conversion of electromagnetic radiation as sunlight, into electricity.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature relevant to the research problem. The literature is reviewed using the following subheadings: overview of the solar power sector in Kenya; the effects hand of Pico solar energy; and barriers to the realization of the benefits of Pico solar energy. The chapter ends with a discussion of the theory that guided the study.

2.2 Literature review

2.2.1 Overview of the solar power sector in Kenya

According to KCIC (2016), Kenya has abundant solar energy resources, and it has become a hotbed for the solar PV market place. Although the sector started with donor-driven initiatives in the 1980s, today a vibrant private sector driven market exist. It is estimated that about 25,000 – 30,000 solar PV products are traded annually in the Kenyan market and that at least every household has owned at least one solar PV product. Both government and private sectors are making great strides towards energy access through increased adoption of solar PV. The rural electrification programe by the Rural Electrification Authority (REA) of Kenya, for example, had targeted schools and health centres with over 4000 schools installed and commissioned as at July 2015. Kenya Power, alongside off-grid electrification, has also engaged in the distribution of solar lanterns in Northern Kenya. Moreover, international NGOs such as SNV, Energy 4 Impact, and Lighting Africa, have contributed immensely to the creation of the solar PV market value chain through social enterprise that has used various approaches in the dissemination of Pico-solar PV for increasing adoption of alternative energy sources in rural areas. (KCIC solar survey 3,2016:7)
Increased dissemination of solar PV in the local market is influenced by four main factors, including more consumer choices; falling global solar PV products prices such as inverters, modules, batteries and SLP; and the government’s efforts through regulation, policies, and standardization to harmonize the sector. There are also more players operating in more niches, including pumping, designed systems, portable systems, and micro-grids, resulting in a trend for better systems. On the other hand, there exist embedded challenges and barriers such as: increasing number of non-trained technicians and installers giving false information and hopes to consumers; increasing levels of counterfeits and mimics thus consumer dissatisfaction; inadequate awareness and technical and financial capacities. However, although solar PV products supply is on the rise, the gains are outpaced by the rising population and industrialization.

Solar products present a market-ready opportunity for meeting the lighting needs of today’s off-grid rural and peri-urban consumers and rising population. These products have momentum and are reaching a tipping point in Kenya’s alternative energy market segment which justifies focused study and effort in commercializing their use. As such, the SLP market is poised for rapid growth in the coming years. Today SLP entrepreneurs are leading the solar lighting industry who often rely purely on market-based models, utilizing the latest technology, and designing based on its consumer tastes (Wright et al., 2015).

Technology is improving at a rapid rate, business models such as mobile phone enabled PAYG are maturing, and the focus by industry players and market facilitators on addressing key market failures means that the SLP market is ready for a substantial inflow of private sector investment.
and exponential growth. The impact of heightened campaign and awareness creation by lighting Global has seen the growth of SLP close to a million by 2014. Most of these modern solar lighting products incorporate features such as mobile charging and consumer credit systems such as the pay-as-you-go (PAYG). These products, which do not require a technician to install, retail for US$ 10 to about US$ 150. The SLPs are typically modular with the following key components.

- An electricity source, most commonly a solar panel/module.
- A modern rechargeable battery, increasingly lithium-ion.
- One or more lamps, usually with modern, energy-saving LED (light emitting diode) bulbs.
- A power control unit, in the case of solar home system kits.

With these components, SLPs have been differentiated to meet the growing need of a cheap source of renewable energy for lighting, radio and charging of phones by BoP consumers (KCIC, 2016:7-8).

2.2.2 The effects of Pico solar energy

Rural electrification was not considered as a basic human need like water and food in the past. However, a number of recent studies provide insights into how rural electrification helps in the betterment of rural societies in various ways. For example, a study by the World Bank in 11 countries reveals that rural electrification results in great benefits such as improvements of health facilities, better health from cleaner air as households reduce use of polluting fuels for cooking, lighting and heating, improved knowledge through increased access to television and better nutrition from improved knowledge and storage facilities from refrigerator (World Bank, 2008).

According to the Global Network on Energy for Sustainable Development (GNESD, 2007) without adequate supplies of affordable energy, it is impossible to improve health, education and reduction of poverty. About 1.6 billion of world populations have no access to electricity, 80 per
cent of whom live in rural areas of the developing countries of South Asia, Central America and South America. In 2001, the 9th Session of the Commission on Sustainable Development (CSD-9) gave special attention to energy. It concluded that “Energy is central in achieving the goal of sustainable development” (GNESD, 2007: 5).

Due to lack of electricity, use of kerosene as well as candles for lighting is common in rural areas. A study by Kaplan (2007) showed that burning of candles for a few hours in a closed room results in lead concentrations sufficient to cause foetal damage or to harm the mental development of children. Lead poisoning can lead to behaviour changes and damage internal organs, especially kidneys. Children in rural areas spend a significant portion of their time in household activities in day time. They do not have light to study at night. For a few hours of electricity to study at night students can attain major improvements in their performance. Women in rural areas spend 2-6 hours a day in collecting fire wood due to lack of electricity. Therefore, rural electrification may be considered as a basic necessity to improve socio-economic conditions in rural areas (Cabraal et al., 2005:119).

Focus on how the application of PV light for rural electrification helps in increasing rural incomes as well as the living standards of the rural poor. The basic applied forms of solar PV in rural Bangladesh are solar home-lighting systems installed in households and local markets/bazaars (haat). Seven solar modules of 50 WP each, divided into two groups, were installed in two suitable locations of the market. The battery banks and controllers accompanying each group were placed close to two respective solar panels. Similar systems were subsequently installed, serving
businesses such as grocery shops, restaurants, barber shops, tea houses and doctors’ clinics (Ahammed and Taufiq, 2008: 93-103).

The success of solar PV micro utilities is attributable to several factors. These include the acceptability of a daily tariff structure and the rate of five taka, as well as proper marketing that explains the solar-energy-based system capabilities, benefits, and constraints in comparison to other available options to potential users. Benefits of the system also accrue because of the use of local institutions. An agreement, which was signed with the Bazaar Management Committee, includes the terms and conditions of service, maintenance procedure, payment, and financial details of the users. The training of a technician to take care of the system on behalf of the collective was viewed favourably by users (Ahammed and Taufiq, 2008:93).

Ouwen(2006:5) explains the impact of renewable energy for changing the socio-economic status of women. It is not easy to improve the position of women in society, unless their level of income increases. Poverty alleviation can be realized by the introduction of renewable energy system in a sustainable way. The most important point is the possibility of income generation. This can take place in many ways. The activities may lead to the start of small- and medium-sized enterprises. One example could be picking up of seeds from oil bearing plants. The seeds can be sold in the market. Women can also do the processing and can make and valorize side products like soap.

A study by George et al. (1991:176) found that rural electrification plays a critical role in family planning, practice in rural Nigeria (Emeruem et al., 1991). Two communities of Bonny and Kula were chosen to study because of the similarity in their population, terrain and climate. Fishing is
the major source of livelihood of the people in both areas. In addition, small-scale farming activity is carried out in both places but on a part-time basis. There is neither processing nor manufacturing activity in the two areas. Bonny has regular electricity whereas Kula community does not have electricity at all. The findings reveal that family planning is practised more in the electrified community than the non-electrified one (Kula), and there has been a significant decline in fertility. Thus, the extent of electricity consumption of a country is one of the indicators of socio-economic development (Emeruem et al., 1991:168).

Jacobson (2007) provides an assessment of the social significance of rural electrification with solar energy in Kenya. In Kenya only about 4 per cent of rural households were connected with electrical grid in the early 1980s. As of now, solar electricity has emerged as a key alternative to grid-based rural electrification in Kenya. The significance of solar electrification in the country is, therefore, closely linked to its role in supporting rural–urban connections for Kenya’s rural middle class. The study highlights three findings. First, electric light from solar system plays a minor role in supporting direct income generation activities in rural Kenya. Given the distribution of ownership of solar systems, nearly all of these productivity gains are captured by rural middle class families. Secondly, solar photo-voltaic (PV) plays a more substantial role in supporting the use of electric light for key social activities such as evening time studying by children. Finally, solar electricity in Kenya is widely used for household applications such as television, radio and cellular telephone charging that helps improve communication (Jacobson, 2007:144).
A randomized control test conducted in Kenya found that solar lanterns increased study time and household savings but had no impact on educational outcomes. After observing and testing for evidence of spillover (control group users benefiting from lighting provided by experimental households), the researchers used treatment intensity in classrooms and found that solar lanterns had an impact scores in maths (Powering Education, 2014).

### 2.2.3 Barriers to the realization of the benefits of Pico solar energy

#### 2.2.3.1 Sociotechnical barriers

Although PV technology has advanced tremendously in the last decades, many studies show that there are still several sociotechnical barriers to adoption. The quality of PV systems is of vital importance for adoption. It can be influenced by not only the local conditions of the user's environment (Müggenburg et al., 2012) but also the political and financial arrangements that may change from country to country. A concrete example of such a phenomenon is given by Palit (2013), who states that Bangladesh and India have better quality standards for PV systems, especially for battery performance, than Sri Lanka. In China, there is a high level of dissatisfaction with the low performance of SHS. Although such performance may be caused by not only technical functionality but also improper usage, the dissatisfaction works against other potential adopters purchasing PV systems. In addition, damaged PV systems were common, which is partly due to having repair locations too far from the adopters (D’Agostino et al., 2011). In Ethiopia, there is growing skepticism towards products manufactured in Asia, especially those from China. Customers mistrust the goods and do not want to purchase them. Instead, they prefer other products, even with a higher price (Müggenburg et al., 2012:90).
The lack of adequate knowledge among both adopters and non-adopters is a crucial barrier. Such lack of knowledge by adopters may result in improper usage and inability to maintain the systems, as shown in China. This may create a negative perception and prevent potential customers making a decision to adopt the systems (D’Agostino et al., 2011). In the case of Nicaragua, rural inhabitants know too little about PV systems, which can be one of the barriers for adoption (Rebane and Barham, 2011). It has also been shown in previous research that the diffusion of new technologies in rural communities requires more effort in tailoring the information and educating people (Sriwannawit, 2012). In another case in the US, there was a lack of trust in the information that is widely and publicly available among some adopters. They felt uncertain about technology performance and lack of information that is relevant to their individual cases (Rai and Robinson, 2013). A study in Austria (Koinegg et al., 2013) also revealed that lack of knowledge is not only a matter of adopter-side but also the supply-side. It argue that architects and planners often have insufficient knowledge about the advantages of building integrated PV systems. This is the reason why they do not offer such systems to the potential adopters when planning a new building (Koinegg et al., 2013:39).

Another barrier can arise from the applicability of PV technology to individual cases. One study conducted in Ghana showed that the capacities of the system are too high for the affordability of target adopters. Only high wattage systems are available in the market and they are sold only as a whole package. This is too costly for low-income adopters (Bawakyillenuo, 2012). In the lower-income markets, it has been shown that repackaging the products in small portions can facilitate the sale because it matches with their affordability (Prahalad, 2009:).
2.2.3.2 Management barriers

Insufficient and inappropriate management is one of the main barriers in the diffusion of new technologies, not least for PV systems, especially when they are used in rural contexts. One of the main management barriers is the inappropriate company business portfolio for the target market. When a PV system is utilized to supply electricity access in rural areas in low-income economies, different business strategies should be implemented compared with the high-income economies where it is often used as an alternative power supply. In addition, implementing similar business models as for urban usage is not applicable in rural settings because of several conditions that differentiate this market from the higher income adopter. Appropriate financial schemes are required for the low-income markets. These are, for example, fee-for-service and microcredit (Pode, 2013:596).

Weak and neglected after-sales service has also been shown to be a barrier to the diffusion of PV systems in rural areas. Because of the remoteness of the areas where PV systems are being used for rural electrification, the adopters lack access to information, knowledge, communication channels, technical assistance, and other infrastructure. This emphasizes the need for a functioning service to continue monitoring and maintenance, even after the customers have already bought the systems. The need for this service, however, poses a challenge on cost and manpower to manage and guarantee the sustainability of the system (D’Agostino et al., 2011:3154).
2.2.3.3 Economic barriers

The adoption of PV systems faces several economic barriers. These barriers can be in different forms, based on both time and location. As is known in the literature on innovations, the cost of an innovation usually decreases with time and can vary depending on the location (Karakaya and Sriwannawit, 2015:91).

Economic barriers are usually related to the high cost of solar PV modules. The diffusion of PV systems is also affected by the cost of other energy sources in the region because the potential adopters might have to choose between PV systems and conventional sources of energy. If the costs of competing sources are low, these can constitute a barrier to PV adoption. The lower the installation cost of PV systems, the more likely that people will adopt them. As a result, high costs for investment in PV systems are often perceived as a barrier to adoption, e.g., in China (Yuan et al., 2011) and Japan (Zhang et al., 2011). The high costs of PV installation are mentioned in many studies that are based in several countries, such as South Korea, Greece, and the US. Examples are spread over both off-grid, e.g., in Ethiopia and Senegal, and on-grid applications, e.g., in Italy and the US (Karakaya and Sriwannawit, 2015). These discussions also include third-party owners. In addition, the perception of the high cost of PV systems can vary. Koinegg et al. (2013) argue that the perceived cost of PV systems can be a barrier to adoption. For building integrated PV systems, the cost is not necessarily as high as commonly perceived.

Based on the cases of off-grid systems in Kenya and Tanzania, Ondraczek (2013) analysed the residential SHS applications with a minor reference to other types such as small-scale commercial applications (including kiosk or mobile phone) and social institutions. In such a context, he conceptualized low purchasing power as a barrier to adoption. Based on several developing
countries in Asia and Sub-Saharan Africa, Pode (2013) emphasizes on economic affordability as a barrier to the diffusion of SHS in rural areas. The author incorporated this barrier in terms of high total cost, high up-front price, and payment inflexibility. In line with Pode (2013), Lay et al. (2013) identified the low income level of households to be a barrier for the adoption of SHS in Kenya. Moreover, a study by indicated that income alone cannot explain the SHS adoption in Bangladesh. In this study, the authors emphasize that non-income factors can also be crucial for the households’ decision making (Komatsu et al., 2011:284).

2.3 Theoretical framework

2.3.1 Ecological modernization theory
According to the ecological modernization theory (EMT), institutional action is not merely window dressing but is evidence that ecological modernization can and will occur within the institutional structure of advanced industrial societies. Ecological modernization theorists contend, by extension, that the use of solar energy technology is yet another step in the process of modernization in capitalist production processes, geared towards ecological sustainability for the sake of both profit and industrial longevity (Schelly, 2015:55).

EMT offers theoretical conceptualization of the relationship between industrialization and environmental protection. It allows for an analysis of “the necessary development of central institutions in modern societies to solve the fundamental problems of the ecological crisis” (Spaargaren and Mol, 1992: 334). According to EMT, achieving certain levels of advanced industrialization influences institutional capacity for considering ecological consequences and addressing ecological concerns. EMT contends that at a certain level of modernization, industrial growth and success will require an ecological rationality. Industry will thus consider ecological
impact as a major component of any cost-benefit analysis, will minimize environmental externalities, and will increase the efficiency of production to the maximum possible level, all because it will be rational to do so (Mol, 1995).

EMT identifies three specific realms of modern society and the relationship between these realms necessary to achieve ecological modernization. According to EMT, both the sociosphere (the social system) and the biosphere (the systems of the natural world) are, in modern society, related to and subjugated by the technosphere (the industrial system of production). An eco-social restructuring of the technosphere, through the process of super-industrialization, is what creates ecological modernization. Ecological modernization, characterized by super-industrialization, allows for industrial, social, and ecological considerations to be weighted equally without jeopardizing the longevity and success of the existing capitalist structure. (Mol, 1995).

2.3.2 Relevance of the theory to the study

The study sought to explore the effects of Pico solar energy on the socio-economic welfare of rural households in Bonchari Sub-County. Ecological modernization theory was relevant because it helped in comprehensive analysis of how Pico solar energy is a form of ecological modernization that generates positive socioeconomic impact from the perspective of the respondents. The theory was useful in conceptualizing the adoption of solar technology within the area of study and Kenya as a whole (Fig. 2.1).
2.4 Conceptual framework

The independent variable was the Pico solar energy lighting. Community awareness of Pico solar products was the moderating variable because in the absence of this awareness, community members cannot make efforts to access the solar products. The main impact of Pico solar energy is social income (the independent variable). It is comprised of variables such as literacy, income, health, and clean environment.

Figure 2.1 Conceptual Framework
CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter describes the research site, research design, study population and unit of analysis, sample population and sampling procedure, data collection methods and methods that will be used for data processing and analysis. This chapter also discusses the ethical considerations that were observed before, during as well as after the study.

3.2 Research site

This study took place in Bonchari Sub-County in Kisii County (Fig 3.1). According to the 2009 Population and Housing Census, the county population was 1,152,282 comprising 550,464 males and 601,818 females. With a growth rate of 2.1%, the population was projected at 1,362,779 with 650,982 males and 711,797 females by 2017. Kisii County has a child rich population, where 0-14 year olds constitute 45% of the total population. People in the 15-64 years age group make up 51.6 %, of the total population while those above 65 years make up 3.4%. This is due to high fertility rates among women as shown by the percentage household size of 4-6 members at 46%. Most of the population relies on agriculture. Their main produce are tea, coffee, bananas, tomatoes, vegetables, dairy products, maize, and sugarcane. Bonchari Sub-County is the least populated in the county with a population of 114,615. This is due to small coverage area of 127km² (Ngugi et al., 2013:6).
Figure 3.1 Map of Bonchari Sub-County
(Source: Independent Electoral and Boundaries Commission 2012.)

3.3 Research design

This was a cross-sectional study which employed both quantitative and qualitative methods of research. Data were collected using structured interviews’ focus group discussions and key informant interviews. Quantitative data from the structured interviews were analysed using the Statistical Package for the Social Sciences (SPSS) and the findings presented in tables of frequencies and percentages. On the other hand, qualitative data collected through focus group discussions and key informant interviews were analysed using content analysis and the findings presented using selected verbatim quotes.
3.4 Study population and unit of analysis
The study population consisted of all beneficiaries of the product aged 18 years and above. Each individual included in the study constituted the unit of analysis.

3.5 Sample size and sampling procedure
The sample size for the study was 100 respondents drawn from two locations in the Sub-County. Sampling was based on a list provided by the chiefs from the two locations, which served as the sampling frame. Individuals were selected from each of the locations using a simple random sampling method from the list of the beneficiaries using the lottery method.

3.6 Data collection methods

3.6.1 Structured interviews
The study used a questionnaire to collect data from the respondents. The questionnaire contained open and close ended questions (Appendix II), which sought the views, attitudes, and opinions of the respondents concerning Pico solar energy.

3.6.2 Focus group discussions (FGDs)
Two focus group discussions were held separately. One involved seven men aged 18 years and above and the other involved ten women aged 18 years and above. These were organized discussions facilitated by the researcher to gather more information from participants who use Pico solar products in their homes to get consensus on issues emerging from the structured interviews. FGD participants were selected based on their willingness to engage in the group discussion. At the end of the discussions, the data collected used to investigate barriers leading to adoption of pico solar energy.
3.6.3 Key informant interviews

These were face-to-face conversations with selected key informants who the researcher interacted with such as two chiefs at the location level in Bonchari Sub-County. A key informant interview guide (Appendix IV) was used to guide the process. The key informants were selected professionals from the leaders at the location level who interact frequently with the residents of the Sub-County, including a chief, community leader and rural group leader.

Data processing and analysis

Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS) version 20. This involved the use of numeric measures to the scores of various responses. The qualitative data collected through focus group discussions and key informant interviews were analysed in a narrative way in which the researcher has given interpretation of the responses received from the questions asked.

Ethical considerations

Ethical considerations were observed before, during and after the study. Informed consent was sought from all the respondents and only those willing to give their informed consent by signing a consent form (Appendix I) were recruited for the study. Every effort was made to inform the respondents about the project and their right to withdraw from participation, if they wished to. The respondents were also assured of confidentiality of the information that they provided and efforts were made to respect their desires and wishes. The ethical principle of anonymity and privacy for the respondent was observed by responses being used for the study alone and names of the respondents not being disclosed.
CHAPTER FOUR: EFFECTS OF PICO SOLAR ENERGY ON THE SOCIO-ECONOMIC WELFARE OF RURAL HOUSEHOLDS

4.1 Introduction

This chapter presents the findings of the study. The chapter starts by describing the respondents’ response rate. Thereafter, the findings as per the objectives of the study are presented.

4.2 Response rate

The total sample size targeted by the study was 100 respondents and out of the study was able to get a response rate of 88 which translates into 88% response rate. The non-response rate was only 12%. This high response rate can be attributed to the willingness of the respondents to take part in the study.

4.2.1 Gender of the respondents

The study sought to ascertain the information on the respondents involved in the study with regard to their gender. The findings indicate that 61% of the respondents were female while the remaining 31% were males. This gender disparity among the respondents can be attributed to the Bonchari Sub-County employing more women than men in informal sector.

4.2.2 Age bracket of the respondents

The study sought to obtain information on the respondents involved in the study with regard to their age. The findings were as shown in Table 4.1.
Table 4.1 Age bracket of the respondents

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 18-35 years</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Between 35-45 years</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Between 45-55 years</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Above 55 years</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The findings in Table 4.1 indicate that bracket of the respondents under 40% of the respondents were aged 35-45 years followed by 27% in the age bracket of 18-35 while those in the age bracket of 45-55 years constituted 18%. The respondents who were aged 55 years and above made up the least number of 15%.

**4.2.3 Highest level of education of respondents.**

The respondents’ education background is presented in table 4.2 below.
Table 4.2 Highest level of education of respondents

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Primary</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Secondary</td>
<td>40</td>
<td>46</td>
</tr>
<tr>
<td>Others</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The findings in Table 4.2 show that 46% of the respondents had secondary education, 20% had primary education, 31% had gone to colleges and University, while 3% indicated that they never attended school. Therefore the majority of the respondents had secondary and post-secondary level of education. This indicates that the majority of respondents in the Sub-County were probably employed and therefore had the ability to pay for the installation of the solar system.

4.2.4 Area of residence of the respondents

The study sought to ascertain the information on the villages where respondents involved in the study. The findings were as shown in Figure 4.1.
Figure 4.1: Villages where the respondents live

Figure 4.1 shows that 32% of the respondents indicated that they reside in Gesonso village, Bogiakumu ward, 20% reside in Matongo village, Bogiakumu ward, 27% in Nyauno village, Bomariba ward and 21% in Nyamerako village, Bomariba ward.

4.3 The social impact of Pico solar energy

4.3.1 Adoption of the use of solar products by respondents.

The researcher sought to find out whether the respondents used solar products in their homes or not. The findings indicate that 65% of the respondent stated that they used solar products in their homes while 35% of the respondents did not. This suggests that the majority of the respondents have adopted the use of solar products in their homes.

In the focus group discussions the women agreed that they had benefited from using Pico solar energy by extending business operating hours, less medical expenditure due to reduced respiratory related infections since they can afford modern cooking and heating methods. They all agreed that their children had better opportunity to do more studies in the evenings and the family unity was enhanced due to entertainment, e.g., by watching television together.
The participants in the men’s focus group discussions noted that their families benefited from using pico solar energy in terms of more lighting either during children doing studies, nursing mothers feeding their children at night or business hours extended which translate into better returns to the investor. The common motivator to acquire pico solar for most men was to have them spend more time with the family because of available entertainment e.g., watching television together, instead of them spending evening time away from the family to get entertained at the shopping centres. The men recommended that pico solar energy should be made more affordable to enhance the benefits.

4.3.2 How the respondents used solar energy

The researcher sought to determine how the respondents use solar energy. The findings are presented in Table 4.3

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household lighting</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Entertainment</td>
<td>42</td>
<td>47</td>
</tr>
<tr>
<td>Cooking</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Table 4.3 shows that 27% of the respondents indicated that they used solar energy for household lighting, 47% for entertainment, 23% for cooking, while 3% of the respondents indicated that they used solar energy for other purposes such as welding and heating bathing water. Therefore, almost half of the respondents indicated that they used solar energy for entertainment.

4.3.3 Effects of use of solar energy the lives of respondents in general

The use of solar energy has various associated improvements which include: higher household incomes, increased children’s study time, and reduced kerosene expenditure. Two the use of solar energy such as a simple solar kit composed of mobile charger, radio and light has reduced the normal energy expenditures and enhanced productivity in addition to enhancing convenience. The chiefs, noted that small traders who extended their working hours at night because of using pico solar have greater incomes compared to when they closed their businesses early. “There is increased availability of services and products to the people, hence better income and returns of investments to the business owners.” He added that there is high demand for solar energy in the community because of its affordability and maintenance.

His remarks were echoed by the community leader. This is what he had to say:

*Besides having more services given to the community members, there is also improved security because there are more business ventures hence the community leaders are keen on ensuring small-scale traders are safe to carry out their businesses.*

The rural leaders from selected villages echoed the community leader. One of them, Joan, a female in Nyamerako village, had this to say:

*Women have benefited from extended hours in their small businesses because they have extra income that they use to improve their children’s diet, upkeep for the family and have also experienced less medical attention since they can afford modern cooking and heating methods. Addition, solar energy is readily available because vendors find potential customers in the comfort of their homes.*
It was further established that 75% of the respondents who had benefited from using pico solar energy, had the knowledge to operate the devices in a cost effective way.

4.3.4 The Social barriers to the adoption of Pico solar energy

Although PV technology has advanced tremendously in the last decades, many studies show that there are still several sociotechnical barriers to adoption. The quality of PV systems is of vital importance for adoption. It can be influenced by not only the local conditions of the users’ environments but also the political and financial arrangements that may change from country to country. The lack of adequate knowledge among both adopters and non-adopters is a crucial barrier. Such lack of knowledge by adopters may result in improper usage and inability to maintain the systems, as shown in China. This may create a negative perception and prevent potential customers making a decision to adopt the systems. Another barrier can arise from the applicability of PV technology to individual cases. One study conducted in Ghana showed that the capacities of the system are too high for the affordability of target adopters (Bawakyillenuo, 2012). Only high wattage systems are available in the market and they are sold only as a whole package. This is too costly for low-income adopters. Insufficient and inappropriate management is one of the main barriers in the diffusion of new technologies, not least for PV systems, especially when they are used in rural contexts. One of the main management barriers is the inappropriate company business portfolio for the target market. When a PV system is utilized to supply electricity access in rural areas in low-income economies, different business strategies should be implemented compared with the high-income economies where it is often used as an alternative power supply. Economic barriers are usually related to the high cost of solar PV modules. The diffusion of PV systems is also affected by the cost of other energy sources in the region because the potential adopters might have to choose between PV systems and conventional sources of energy. If the
costs of competing sources are low, these can constitute a barrier to PV adoption. The lower the installation cost of PV systems, the more likely that people will adopt them.

4.3.5 Monthly level of income of the respondents

The researcher sought to find out the monthly income of the respondents. The findings are presented in Table 4.4

Table 4.4 Monthly level of income of the respondents

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below KES 5,000</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Between KES 5,000 and 10,000</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Between KES 10,000 and 15,000</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Above KES 15,000</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 4.4 shows that 18% of the respondents indicated that their monthly income was below KES 5,000, 25% had between KES 5,000 and 10,000, 45% had between KES 10,000 and 15,000 while 12% had above KES 15,000. Therefore, more than two-fifth of the respondents indicated that their monthly income was between KES 10,000 and 15,000.

4.3.6 Effect of level of income and ability to purchase Pico solar products

Figure 4.5 shows the findings on whether level of income affects the ability of a person to purchase Pico solar products. The findings indicate that 59% of the respondents agreed that the level of income affects the ability of a person to purchase Pico solar products while 41% disagreed.
Therefore, a majority of the respondents were of the opinion that the level of income affects the ability of a person to purchase Pico solar products.

4.3.7 Effects of adoption of solar energy on household incomes.

The researcher sought to determine whether use of solar energy improved the level of household incomes. The findings indicate that 68% of the respondents agreed that use of solar energy had improved their level of income since the cost of solar energy was cheaper compared to other sources of energy, while 32% of the respondents disagreed. Therefore, the majority of the respondents agreed that use of solar energy improved household incomes as compared to other sources of energy.

4.3.8 Effects of the use of solar energy on the income of the respondents

The respondents indicated that poverty alleviation can be realized through the introduction of renewable energy systems. The most important point is the possibility of income generation. This can take place in many ways. The activities may lead to the start of small- and medium-sized enterprises. One example could be picking up of seeds from oil bearing plants. The seeds can be sold in the market. Women can also do the processing and can make and valorize side products like soap. In addition solar lanterns have increased study time and household savings.
CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses the findings and then draws conclusions from those findings. The chapter ends with recommendations based on the findings as well as those for further research.

5.2 Discussion

The study findings indicate that use of pico solar energy in Bonchari Sub-County is visible due to availability and affordability of the solar system. Perhaps the highly rated social effect with the most significant statistical difference is the increased security. Previous studies by the (World Bank, 2011) have looked at the global trends in the effects of Pico solar energy on the socio-economic welfare of rural households. This approach is both communal and individual. From the study findings, the individual approach shows dramatic changes in the daily life of everyone who has experienced the transformation from the 'dark' to the ‘light’, not only in terms of practical changes like cooking and heating habits, hygiene and health, spare time, new education facilities, etc., but also in terms of changes within the epistemological dimension of thinking about life, anticipating the future, being connected to the outside world through the media, etc. For the majority of those interviewed, Pico solar energy has meant a tremendous change in their personal lives and lifestyles. Living in poor rural societies, some had felt 'neglected' before the introduction of Pico solar energy, especially those who had some experience of the 'outside world’ as labour migrants or as visitors to the national capital. For the most part, this feeling of 'forgotten remoteness' has now been replaced by a positive identification with the new conditions of village life after getting connected to the grid. These findings agree with studies in Costa Rica by Barnes (2004).
Rational decisions to power rural communities are often embedded in deep philosophies that households will use electricity for their livelihoods through the powering of basic appliances but most important is the ability for the communities to use electricity to improve their lives. This can be seen through industrial growth and the startup of income-generating activities and projects in the areas already connected. However, the findings from this study point out to the contrary. Many of the households use electricity mainly for lighting and powering electronic appliances. There is no much drastic change in the economic livelihoods of the communities that are connected. This is a clear indication that rural development and improvement in disposable incomes is much more than provision of electricity. Usually, the startup costs for mechanization of ventures such as agricultural farms are extremely high. This could point to the low uptake of economic ventures. This agrees with Ranganathan (1993:142), who pointed out that rural electrification programmes over-emphasize social benefits instead of being a production unit.

According to World Bank (2010), the societal approach involves two different areas of data interpretation. It is evident from this study that although households do not necessarily record a change in the household incomes resulting from projects implemented at the household, at the community level this is not the case. The empowerment at the community level follows a shared view that the communities with connectivity are more developed than those that are not connected. On the other hand, there is a shared view that land value has significantly increased over the last 6 years with the connections being prevalent in the last 4 years. The socio-cultural impact on the societal level is also tremendous since village life has changed not only individually but also collectively. Pico solar energy has empowered communities, resulting in more community activities and strengthening solidarity among members of the community. On the other hand, the socio-economic impact the macro-economic level is less evident. In the current situation
community economies are too weak to permit investment in new machinery or equipment that
could raise agricultural productivity. Very few farmers can afford to buy new electrically powered
rice-mills, for instance. As yet, the impact of rural Pico solar energy on the local economies cannot
be seen directly, in terms of higher family incomes through the use of new techniques, or greater
agricultural productivity. This is in agreement with findings by Fluitman (1983:11), who found
that electricity in the rural areas of developing countries had no major impact on the income
generation and employment of the rural poor. Having more spare time enables the villagers to
eengage in additional income activities like weaving, kitchen gardening, small services, etc. But
here it must be borne in mind that Pico solar energy electricity is a prerequisite for further
investments in the agricultural sector and that only two years at most had passed since electricity
was introduced in these villages. Once the density of monetization (the actual amount of money
circulating in local rural economies) increases, there will be more investments in new machines
and technologies to strengthen local agricultural productivity.

5.3 Conclusion

The study concludes that rural electrification results in great benefits such as improvements of
health facilities, better health from cleaner air as households reduce use of polluting fuels for
cooking, lighting and heating, improved knowledge through increased access to television and
better nutrition from improved knowledge. The study also concludes that insufficient and
inappropriate management is one of the main barriers in the diffusion of new technologies, not
least for PV systems, especially when they are used in rural contexts. One of the main management
barriers is the inappropriate company business portfolio for the target market.
The lack of adequate knowledge among both adopters and non-adopters is a crucial barrier. Such lack of knowledge by adopters may result in improper usage and inability to maintain the systems. This may create a negative perception and prevent potential customers making a decision to adopt the systems.

Finally, the study concludes that economic barriers are usually related to the high cost of solar PV modules. The diffusion of PV systems is also affected by the cost of other energy sources in the region because the potential adopters might have to choose between PV systems and conventional sources of energy. If the costs of competing sources are low, these can constitute a barrier to PV adoption. The lower the installation cost of PV systems, the more likely that people will adopt them.

5.4 Recommendations

5.4.1 Recommendations from the study

a) Poverty alleviation can be realized by the introduction of solar energy systems in a sustainable way. This should be considered as a basic necessity to improve socio-economic conditions in rural areas.

b) In low-income economies, different business strategies should be implemented compared with the high-income economies where it is often used as an alternative power supply. In addition, implementing similar business models as for urban usage is not applicable in rural settings because of several conditions that differentiate this market from the higher income adopter.
5.4.2 Recommendations for further Research

Some of the areas the researcher feels would benefit from further research are:

a) Comparative study of those using pico solar energy in the Sub-County with those on grid connection to determine the level of income generated and saved for a certain duration of usage.

b) An investigation of similar study to provide adequate information that can be used to sensitize adoption of pico solar energy in other sub counties in Kisii County.
REFERENCES


Global Network on Energy for Sustainable Development (GNESD), (2007). *Reaching the millennium development goals and beyond: access to modern forms of energy as a pre-requisite.* Brazil. GNESD.


APPENDICES

Appendix I: Consent Form

Effects of Pico solar consumers in Bonchari Sub-County, Kisii County

Hello, my name is Caroline Nderitu, a Master of Arts student from the Institute of Anthropology, Gender and African Studies at the University of Nairobi. I am here to collect data for my master’s project. You have been chosen purposively to be in the study about the effects of Pico solar usage in this sub-county. This study involves research whose purpose is to examine the effects of Pico solar usage for the time you have had it. This will take 20 to 30 minutes of your time. If you choose to be in the study, I will ask you a set of questions which I will record on paper and/or digitally audio-record and you will be expected to respond to them.

There is no foreseeable risk to your participation in this study. There is no cost or payment expected from you. If you have questions while taking part, please stop me and ask. I will do my best to keep your information confidential.

Your participation in this research is voluntary, and you will not be penalized or lose benefits if you refuse to participate or decide to stop. May I continue? Yes___ No___

Respondent’s Name: ______________________________________________Signature________________

Researcher’s Name: ______________________________________________Signature________________

Date: _______________________________________________________________________

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Appendix II: Structured questionnaire.

SECTION 1: BACKGROUND INFORMATION

1. What is your gender
   a. Male [ ]
   b. Female [ ]

2. Please tick your age bracket
   a. 18-35 years [ ]
   b. 35-45 years [ ]
   c. 45-55 years [ ]
   d. Above 55 years [ ] please specify

3. Please tick your level of education
   a. None [ ]
   b. Primary [ ]
   c. Secondary [ ]
   d. Other [ ] Please specify

4. Please indicate your village of residence ....................

   and Ward...........................................

SECTION 2: THE SOCIAL IMPACTS OF PICO SOLAR ENERGY

1. Do you use solar products in your home?
   a. Yes [ ]
   b. No [ ]

2. If your answer to Q.1 above is yes, how do you use solar energy? (Please tick where appropriate)
   a. Household lighting [ ]
   b. Entertainment [ ]
   c. Cooking [ ]
   d. Other [ ] Please specify.

3. How has the use of solar energy improved your life in general?
   a. ...........................................................................................................
       ....
   b. ...........................................................................................................
       ....
   c. ...........................................................................................................
       ...

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4. From your perspective, what are the social barriers to the adoption of Pico solar energy in this village?

SECTION 3: THE IMPACT OF HOUSEHOLD INCOME ON THE ADOPTION OF SOLAR ENERGY

1. What is your monthly level of income
   a. Below KES 5,000 [ ]
   b. Between KES 5,000 and 10,000 [ ]
   c. Between KES 10,000 and 15,000 [ ]
   d. Above KES 15,000 [ ] Please specify.

2. Does the level of income affect the ability of a person to purchase Pico solar products?
   a. Yes [ ]
   b. No [ ]

3. Has the use of solar energy improved your level of household income?
   a. Yes [ ]
   b. No [ ]

4. If your answer to Question 3 above is yes, how has your income improved?
Appendix III: Focus group discussions guide.

1. Benefits of Pico solar energy in this area.
2. How Pico solar products have benefited the men/women of this area.
3. Access to Pico solar products in this area.
4. Factors limiting the access to Pico solar energy products in this area.
5. What can be done to improve access to Pico solar energy products.
Appendix IV: Key informant interview guide.

1. Is there high demand for Pico Solar products in this location?

2. How do you access Pico solar products?

3. How have Pico solar products benefited you as well as the community at large?

4. In your view, what are the barriers to the adoption of Pico solar energy?

5. How can the adoption of Pico solar energy be improved?
# Appendix V: Budget

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUANTITY</th>
<th>PRICE PER UNIT (KES)</th>
<th>TOTAL COST (KES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accommodation</td>
<td>2</td>
<td>700 per night for 5 nights</td>
<td>7000</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>Printing and binding</td>
<td></td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>Internet</td>
<td></td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>Research Assistant and Translator</td>
<td>2</td>
<td>1500</td>
<td>3000</td>
</tr>
<tr>
<td>Meals</td>
<td></td>
<td></td>
<td>3000</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>25000</strong></td>
</tr>
</tbody>
</table>
PERMIT LETTER

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2011.

CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
5. The License does not give authority to transfer research materials.
6. NACOSTI may monitor and evaluate the licensed research project.
7. The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.

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P.O. Box 30673 - 00100, Nairobi, Kenya
TEL.: 020 400 7000, 0718 788707, 0735 404245
Email: info@nacostigov.ke, registry@nacostigov.ke
Website: www.nacostigov.ke

Serial No:A 22160
CONDTIONS: see back page

THIS IS TO CERTIFY THAT:
MISS. CAROLINE WANJIKU NDERITU
of UNIVERSITY OF NAIROBI, 0-100
NAIROBI, has been permitted to conduct
research in Kisii County

on the topic: **THE EFFECTS OF PICO
SOLAR ENERGY ON THE
SOCIO-ECONOMIC WELFARE OF RURAL
HOUSEHOLDS IN BONCHARI
SUB-COUNTY IN KISII COUNTY.**

for the period ending:
26th November, 2019

Applicant's Signature

[Signature]

Permit No: NACOSTI/P/18/37963/26807
Date Of Issue: 30th November, 2018
Fee Received: Ksh 1000