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THE DETERMINANTS OF HOUSEHOLD'S ADOPTION OF SOLAR ENERGY IN RURAL ETHIOPIA: THE CASE STUDY OF GURAGE ZONE

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The Determinants of Household's Adoption of Solar Energy in Rural Ethiopia: The Case Study of Gurage Zone

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This is to certify that the thesis prepared by Christian Anteneh, entitled: *The Determinants of Household's Adoption of Solar Energy in Rural Ethiopia: The Case Study of Gurage Zone* and submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Economics (Resource and Environmental Economics) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Declaration

I hereby declare that this thesis entitled "The Determinants of Household's Adoption of Solar Energy in Rural Ethiopia: The Case Study of Gurage Zone" was carried out by me for the master's degree of economics under the guidance and supervision of Dr. Tewodros Negash, Addis Ababa University, College of Business and Economics.

The interpretation put forth are based on my reading and understanding of the original texts and they are not published anywhere in the form of books, articles and reports. The other books, articles and websites, which I have made use of are acknowledged at the respective place in the text.

For the present thesis, which I am submitting to the University, no degree or diploma or distinction has been conferred on me before, either in this or in any other University.

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ABSTACT

In rural Ethiopian traditional fuels like kerosene and firewood are the main sources of energy used for lighting purpose. They are a major factor for environmental problems and health risks that affect the wellbeing of low-income rural households. However, Ethiopia has a vast potential for renewable energy resources like solar energy that have not fully utilized. The main aim of the study was to assess the determinants of household adoption of solar energy in the Gurage zone. In order to achieve the objective of the study, data were collected from 384 households using a survey questionnaire from Cheha and Ezha woredas. The collected survey data were analyzed by descriptive statistics and econometric model (probit model). The result of the probit model reveals that the adoption of solar energy has a positive and significant relation with household income, remittances, education, marital status and ownership of cattle. But the adoption of solar energy has a negative and significant relation with household size, sex, and age. Based on the findings, the study recommends that the government should enhance in poverty alleviation program in rural areas and improve rural household wealth, increase access to education and encourage women by giving especial service like credit access and creating awareness, to increase the adoption of solar energy technology.

Keywords: Solar energy, Adoption, Determinants, Rural, Households, Ethiopian

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List of Acronym

CSA- Central Statistical Agency of Ethiopia

DBE-Development Bank of Ethiopia

ESS- Ethiopia Socio-economy Survey

ETB- Ethiopian Birr

FDRE-Federal Democratic Republic of Ethiopia

IDT-Innovation Diffusion Theory

ITF- International Trade Forum

Kwh- Kilo watt hour

Km-Kilometer

PV-Solar photovoltaic

ST- Solar thermal

SHS- Solar home system

SPLs- Solar portable lights

UNDP-United Nations Development Program

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Solar energy technologies harness the energy of direct solar irradiance to create electricity using photovoltaics cell and concentrating solar power to create thermal energy to meet direct lighting requirements as well as to produce fuels that might be used for transport and other purposes which might include heating and cooling (Hemmen, 2011). There are two types of solar technology; ‘Photovoltaic’ systems (PV) which convert light energy to electricity and ‘Solar Thermal’ systems (ST) that utilize solar thermal energy to heat water which is then typically used for washing within the household (Irene, 2018). Kearney, 2014 categorize solar energy technologies based on their technical specification, such as (solar portable lights (SPLs), solar home systems (SHSs) and large SHSs). As solar home systems are a self-contained technology that means all the processes production, conversion and distribution take place in the household (Mala et al, 2009). It consists of PV modules, batteries, and a charge controller are used and the batteries are usually designed to give two-thirds days of self-sufficiency if there is a possibility of inadequate solar radiation (Chaurey et al, 2010).

Given the slow growth of electrification, the global lighting crisis increasingly separates those with reliable lighting from those who lack it, further leaving a substantial proportion of the world’s population further behind (Jakobson et al., 2010). Solar energy can provide people disconnected from the global economy and unconnected to electric grids the opportunity to light their homes and businesses in places where grid power can either be extremely expensive or unreliable (International Trade Forum (ITF), 2011; The Economist, 2012a).

According to UNDP (2014), the primary constraints as to why a large number of people in the world remain unconnected to the grid are typically financial and physical. While the latter deals with the challenges of geography such as hilly areas or large tracts of the dense forest the former refer to the economic challenges which developing countries face in investment funding, service costs, and revenues & collection. Due to these factors, about 1.1 billion people in the world concentrated in Africa and Asia, are living without access to electricity (World Bank, 2017).

Around 600 million of them living in Africa rely on expensive and inefficient sources of energy such as candles and kerosene to power their businesses and homes (ITF, 2011; Karekezi & Kithyoma, 2002). This lack of access to electricity energy disproportionately affects the poor and limits opportunities for economic development (Megen et at, 2009). According to the International Trade Forum (ITF, 2011), nearly 700 million people in Africa will still be unconnected to electricity by 2030 the majority in Sub-Saharan Africa unless the infrastructure and financial barriers trend are reversed. The Africa panel report 2015 states, that halving the cost of inefficient lighting sources would save $ 50 billion for the people living below $ 2.50 per day. Hence, it can be estimated the monetary saving from cost reduction would be sufficient to reduce poverty by 16-17 million People (Kat et al, 2016).

This astounding scope of global energy poverty has motivated organizations to offer solar energy solutions for lighting needs in an off-grid setting in low and middle-income countries (Hannah and Subhrendu, 2018). In recent years many government and non-government organizations are engaged in providing off-grid solar products for those living without national grid connection. In Ethiopia, the Lighting Africa program is working closely with the government and the private sector to create sustainable off-grid energy supply, which the support of the program about 4 million People have bought solar products but only 2 million of them are quality verified and the total amount of GHG emission avoided is 490.5 thousand tons (Lighting Africa – Ethiopia, 2018).

Ethiopia is known for its abundant solar energy resources. The yearly mean average daily solar radiation reaching the earth is around 5.2 KWh/m^2 with the minimum being in July (4.55 KWh/m^2) and the maximum in February and March (5.55 KWh/m^2) (Stutenbaumer et al, 1999 cited by Alemshet, 2010). However, the country still hasn't fully exploited the resource. According to Lighting Africa 2018, the government's recently launched National Electrification Program envisions that by 2025, 65% of the population will be connected to the grid as they place a strong emphasis on scaling up connections in areas within short-term reach of the grid. The other 35% or around 7.7 million households will need an interim off-grid solution, most of these households rely predominantly on kerosene and spend about 4.5% of their total household consumption expenditure on lighting. While waiting for grid expansion, or even a permanent one where appropriate, such as in very remote areas where grid access will remain too costly and logistically challenging even in the long term. In Ethiopia, off-grid solar PV is a highly attractive energy source for rural populations due to the scattered rural settlement and abundant solar energy resources (Alemshet, 2010). For those living without national grid connection, an off-grid PV system can provide electricity to remote located households and villages that are not connected to the main grid (Zahedi, 2006; Nieuwenhout, 2004).

1.2 Statement of the Problem

In the 21st century access to electricity is a critical part of human civilization. A number of studies show that electrification is linked to a range of development improvements, such as higher income, employment, and better health and educational outcomes (Adinal et al,2017). Lack of access to electricity is a major constraint on growth and development in rural areas of developing countries (Laufer and Schafer, 2011). This is due to high transmission and distribution costs in remote areas, many households are not connected to the national electricity network (Mondal, 2010). Similarly, in Ethiopia, the rural energy problem will continue to be one of the major causes of slow economic growth and poverty unless actions are taken to overcome this problem (Wolde-Ghiorgis, 2002).

According to Lighting Africa 2013, over 85% of rural households in Ethiopia rely on fuel-based light sources, predominantly kerosene, the fumes of which can cause serious health problems and damage to the environment. A study shows the consumption of kerosene lamps, emit substantial amounts of fine particulates, carbon monoxide (CO), nitric oxides (NOx), and sulfur dioxide (SO2), all of them adversely affects indoor air quality (Epstein et al,2013). For instance, the net carbon emission offset by one solar PV system over a 20year lifetime is estimated to be approximately 6 tons of CO2 (Mukherjee and Gosh, 2014). Therefore, solar lights provide a clean and cost-effective solution to provide poor households with access to lighting (Adina et al, 2017).

The traditional perspective toward women role in the household in rural Ethiopia has lead women to become the primary victims of energy poverty. In rural Ethiopia, women and children spent their time searching for firewood and the urban poor also spend a large amount of their income to satisfy their energy demands (Mulugetta, 2008). According to Yemenzwork Girefe, Director of the Export Credit Guarantee & Special Fund Administration at the Development Bank of Ethiopia (DBE), “For households at the base of the economic pyramid, off-grid solar energy can dramatically boost the quality of life,” (Lighting Africa, 2018).

In Ethiopia by 2016, electricity use had increased to 26%, whereas kerosene and firewood used for lighting had dropped to under 8 %(CSA and ESS, 2016). Ten years ago, the penetration of solar systems in rural areas was negligible, whereas today these are used by more than 16% of the population (ERG, 2017).

It is a fact that different factors affect the adoption of solar energy in rural areas. There are many studies about the determinate of the adoption of solar energy technology at the household level worldwide. Similarly, in Ethiopia, different researchers have found socioeconomic and demographic factors such as household head age, education level, gender, marital status and household income, ownership of cattle, farmland and household location from market service that determine household adoption of solar energy in a different part of rural areas in Ethiopian. However, there has been no evident comprehensive research done on determinates of household adoption of solar energy specifically on the Gurage zone. This paper investigates the factors that determine the adoption of solar energy at the household level in the Gurage zone specifically on Ezha and Cheha woreda. It provides relevant information on how household characteristics and the socioeconomic factors affect the adoption of solar technology in the region.

1.3 Objectives of the Study

The main objective of the study is to identify factors determining the adoption of solar energy technology in the Gurage zone.

The specific objectives of the study are

- To identify which socioeconomic factors and household characteristics determine the adoption of solar energy.
- To determine the extent of economic factors and remittances sent from other household members affects the adoption of solar energy technology.

1.4 Significant of the Study

This research contributes to the understanding of factors that determinants the adoption of solar energy in the Gurage zone. In addition, the study includes remittances send by household members living in other areas as one of the economic factors that determine the adoption of solar energy technology. Thus, the study findings further provide relevant and valuable information that can be used to come up with policies that enhance solar energy distribution in Gurage rural areas. It also provides companies and product distributors the most up to date data to align their business appealing to the society they serve.

1.5 Scope and Limitation of the Study

The scope of the study focuses on the determinate of household adoption of solar energy technology in the Gurage zone. This study targets Ezha and Cheha woreda whose total rural population are 234,089 people (54,037 households). The main limitation of the study is the lack of data collected by an organization related to the study objective, the study used cross-sectional data from Ezha and Cheha woredas. The sample size is also limited to 385 households because of time and budget constraints. But it would be more relevant if the sample size consists of a large number of households and additional woredas to represent the Gurage zone.

1.6 Organization of the Paper

The remaining part of the study is organized as follows. In chapter two theoretical and empirical literature is reviewed. This is followed by data and methodology, which is chapter three of the paper. Chapter four presents and discusses the results of both the descriptive and econometrics analysis. The last chapter five presents conclusions and recommendations of the paper.

CHAPTER TWO

LITERATURE REVIEW

This chapter focuses on reviewing both the theoretical and empirical literature on the concept of the determinants of household adoption of solar energy. The theoretical literature review focus on the construction of theories based on the study. The empirical literature focuses on empirical evidence from developing countries in general and Ethiopian particular.

2.1Theoretical Literature Review

2.1.1 Solar Energy Sector in Africa

In the first decade of the 21st century, solar energy emerged from the shadows and the gloomy picture of Africa's geological environment to become not only a major source of power, but also a platform on which new businesses and opportunities flourish (Bradford, 2006; Kulichenko & Wirth, 2011; The Economist, 2011a; World Bank, 2008). For decades, many African cities and villages relied largely on environmentally unfriendly products such as kerosene lamps to power their homes (Coster, 2011). Indeed, Africans spend around $10.5 billion a year on kerosene to provide lighting for their off-grid businesses and homes (ITF, 2011).

There is increasing evidence that solar household systems are contributing to several development goals, including income poverty reduction, better education, and improved health. There is a potential of more than 63 million households for solar home system markets in sub-Saharan Africa (Girona et al, 2006). The potential of off-grid PV in Kenya, Uganda, Tanzania, Somalia, Sudan, Ethiopia, and Eritrea. Even though the use of solar PV in sub – Saharan Africa is limited due to the high cost of solar PV as they have low income; it is widely promoted in different countries and many systems have been built (Karekezi et al, 2003). In the last few years, this perception has changed fundamentally with the burgeoning technologies in solar energy such as thin-film PV cells and the increasing diffusion of those technologies to developing countries (Walsh, 2008; Wu & Mathews, 2012). This technology is associated with low defects, greater flexibility and low costs in comparison with the crystalline ones commonly used in most solar panels (Walsh, 2008).

The emergence of these technologies and their availability to developing economies means that the cost of solar panels has declined to an all-time low in recent years relative to alternatives (Blackburn & Cunningham, 2010). However, the costs are often complicated by numerous tax reliefs, loan guarantees and subsidies offered by governments not only in emerging economies such as China and Brazil but also in advanced economies including Germany and the United Kingdom (Powers, 2010; Rosenthal, 2010, cited by Joseph, 2015). In 2010, total investment in Africa's renewable energy, including solar, increased to 3.6 billion a record high, largely due to a surge in countries such as Egypt and Kenya (KPMG, 2012).

2.1.2 Solar Energy Sector in Ethiopia

Ethiopia has abundant solar energy resources. According to Melessaw (2009), the Ethiopian solar energy market is at its early stage of development. For about ten years, since the commercial market started in the early 1990s, annual sales growth was under 5 %. However, in the following four years, significant sales growth at an average rate of 15 % to 20 % has been reported by major PV suppliers. According to FDRE 2015 report, under the country's Growth and Transformation Plan (GTP II), the Government of Ethiopia has set ambitious targets for expanding access to off-grid energy through solar technologies, including 3.6 million lanterns, 400,000 solar house systems and 3,600 solar photovoltaic (PV) systems for rural health centers, schools and other government service centers by 2020.

Off-grid electricity is currently used for lighting, charging mobile phones, and the provision of electric power to rural health centers, schools, and water pumping systems, among other uses, and has seen remarkable growth in the past five years (Hilawe et al, 2017). While the markets for off-grid lanterns and solar household systems have grown, the technical services infrastructure including the capacity for design, manufacture, and assembly, as well as installation and service provision has not grown along with the rapid increase of sub-standard solar products on the market (ERG, 2012). The main challenges identified by the private sector include the lack of clear policy and standardization procedures on solar equipment, limited foreign exchange availability and the involvement of several government actors in the various stages of the import process (ERG, 2017b). The limited availability of foreign currency requires importers to wait up to three months or longer to access the foreign exchange needed to purchase solar products (TAK IRDI, 2016).

According to Hilawe et al, 2017 Ethiopia enterprises are required by multilateral financial institutions to deposit 10% of the value of the products being imported they also charge interest rates of 15–20%. Similarly, commercial banks provide loan guarantees to solar enterprises to access a loan facility from the Development Bank of Ethiopia. While the Bank charges 12% interest, commercial banks add an additional 4% to secure the loan guarantee, increasing the total interest to 16%, which is directly accrued by the end user increasing costs further.

According to Lighting Africa (2018), to address the financial issue Lighting Africa in Ethiopian is working, in collaboration with the Government of Ethiopia in helping household and private sector enterprises and small businesses to access financing through the Market Development for Renewable Energy & Energy Efficient Products Credit Line. This financing facility was established in 2013 with US$20 million from the World Bank. This has since been doubled to US$40 million due to the great success of this initiative. The funding facility, which is administered by the Development Bank of Ethiopia (DBE), provides private sector companies with the foreign exchange working capital to import qualifying solar products that meet Lighting Global Quality Standards. In addition to this Lighting Africa program in Ethiopia is working to address another market bottlenecks though creating consumer awareness and education campaign.

2.1.3 Innovation Diffusion Theory (IDT)

The individual process of adoption and diffusion is an integrated part of the larger process of social change. Rogers, 2013 describes diffusion as “the process in which an innovation is communicated through certain channels over time among the members of a social system”. He further defines a social system as “a set of interrelated units that are engaged in joint problem solving to accomplish a common goal”. Units in a system can differ in their behavior by means of homophily and heterophily: homophily refers to the similarity between individuals, for example regarding education level, beliefs, and social status; whereas heterophily is when individuals differ on these attributes. One distinctive challenge is that individual adopters are often heterophily. According to Naomi (2014), adoption of a new idea, behavior, or product (i.e., "innovation") does not happen simultaneously in a social system; rather it is a process whereby some people are more apt to adopt the innovation than others. Also, a number of studies show that there are different characteristics between people who adopt an innovation early and people who adopt an innovation latter. When Promoting innovation to the target population it is important to understand the characteristics of the targeted population that will affect the rate of adoption of the innovation. This makes it difficult for an actor attempting to diffuse an innovation to choose only one single approach (Duan, 2010).

The main attributes that affect the adoption of an innovation are:

1. Relative Advantage – the degree to which the innovation is seen as being superior to the idea or product it replaces.

2. Compatibility – the degree to which how the innovation is seen as consistent which adopters existing values, past experiences, and needs.

3.Complexity- the extent of how difficult is the innovation to use and understand.

4.Triability- the extent to which one can experiment or tested the innovation before making a commitment to adopt.

5.Observability – the degree to which the innovation results are visible to others.

6. Perceived risk- the expected probability of economic or social loss resulting from innovation.

One of the attributes is compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 2013). A lack of compatibility in IT with individual needs may negatively affect the individual's IT use (McKenzie, 2001). Hoerup, 2001 describes that each innovation influences teachers' opinions, beliefs, values, and views about teaching. In order to increase the rate of adoption of innovation and decrease uncertainty innovation should be compatible with individual needs. Hence, this also includes naming with can be meaningful to the potential adopter as a part of compatibility. The other most obvious attribute that adopters seek in new technology is a relative advantage: "the degree to which an innovation is perceived as better than the idea it supersedes" (Greenhalgh et al., 2004). Emphasizes that potential users will likely not consider innovation if they do not see relative advantages, which are foremost measured in economic returns. Moreover, there are decisive social factors such as user satisfaction and prestige that influence an individual's perception of the relative advantage of innovations (Greenhalgh et al., 2004).

In addition, the research result by Caird et al, 2008 shows that the use and adoption of renewable energy systems by householders extends the categorization of adopters depending on their level of engagement with the technology and motivation to reduce energy use. The model they propose presents the consumer as an agent influenced by various sources such as the socio-economic context, consumer variables, communication sources, and product and system properties. Within the two models proposed by (Rogers, 2003) and (Caird et al, 2008), there are common factors that inform the decision-making process, namely the innovation attributes, and the categorization of adopters. The innovation diffusion theory can directly apply to the understanding of different characteristics exhibit by solar technology adopters and non-adopters in this study.

2.1.4 Theory of Reasoned Action

The Reasoned action theory was developed by Martin Fishbein and Icek Ajzen as an improvement over Information Integration Theory. Reasoned Action is explicitly concerned with behavior. The person's intention measures the relative strength of the aim to perform a behavior. Attitude consists of beliefs about the consequences of performing the behavior multiplied by his or her evaluation of these consequences (Fishbein & Ajzen, 1975). "the person's perception that most people who are important to him or her think he should or should not perform the behavior in question" (Fishbein & Ajzen, 1975). It can be defined as a person's volitional behavior is predicted by his attitude toward that behavior and how he thinks other people would view them if they performed the behavior (Naomi, 2014). A person’s attitude adds up with subjective norms, it will result in his behavioral intention. Fishbein and Ajzen state, however, that attitudes and norms are not weighted equally in predicting behavior. "Indeed, depending on the individual and the situation, these factors might be very different effects on behavioral intention; thus weight is associated with each of these factors in the predictive formula of the theory. For example, you might be the kind of person who cares little for what others think. If this is the case, the subjective norms would carry little weight in predicting your behavior" (Miller, 2005, p. 127).

This theory explains the attitude and subjective norms that determine people intention to adopt solar technology in this study. The theory states that both attitude and subjective norms are important determinants of people's intention to adopt and use technology in enterprises (Massey and Burkman, 2002). In addition, the intention to adopt technology is influenced by one's attitude. According to Venkatesh et al ,2000 states that individual behavior is influenced by his or her behavior's intention which is influenced by his or her attitude towards the behavior of subjective norm. The Reasoned Action theory can apply to the understanding of household attitude and behavior that determine the adoption of solar energy in this study.

2.1.5 Energy Ladder Hypothesis

The energy ladder hypothesis assumes that a household's energy choice depends crucially on the household's income level. The concept can thus be seen as a stylized extension of the economic theory of the consumer: as income rises, consumers not only demand a larger amount of the good but also change their consumption pattern in favor of higher quality goods (Hosier and Dowd, 1987). As income rises, households move first from using traditional fuels, such as wood, to transitional fuels, like kerosene, and then to modern fuels, such as electricity from the grid (Leach, 1992). According to (Farsi et al, 2007), modern fuels are generally perceived to be superior to traditional or transitional fuels in efficiency, comfort, and ease of use. The stark differences observed in energy use patterns between poor and rich countries as well as between households with different income levels within many (developing) countries motivated the energy ladder hypothesis, which has since served as the basis for many empirical applications in the literature (Heltberg2004; Gebreegziabher et al. 2011).

In addition, different research has confirmed that income is one of the main demand-side factors determining household fuel (energy choice). On the supply side, there is often a lack of access to markets for modern fuels and the required equipment may not be supplied. All these factors together may explain why so many poor households are prevented from climbing up the energy ladder (Irene, 2013). Energy ladder hypothesis indicates household income is one of the main determinants that affects household's adoption of solar energy.

2.2 Empirical Literature Review

2.2.1 Income level

One of the main determinates that influence the adoption of solar technology is household income. According to Caird et al, investigation on the adoption of energy efficiency and renewable energy technology confirmed that much of the documented results show that the barriers to the adoption of renewable technology are mostly financial. A number of studies also indicate that income plays a critical role in influencing household decisions to adopt new technology like solar energy. Walekhwa et al, 2009, also found that the probability of a household adopting renewable energy sources increases with increasing household income. In addition, the Warkaw and Dr. Chawla (2016), research confirm that the annual household income has a positive significant effect on the decision of adoption of renewable energy source positively. Hence, another research by Naomi (2014), found a significant relationship between the household level of income and the adoption of solar power for domestic use in the Kitengela area.

According to Jacobs (2006), using quantitative analysis for Kenyan solar home system(SHS) describes various aspects of Kenyan SHS market and presents analyses based on two cross-sectional surveys among rural Kenyan households which were conducted in 2000 and 2001. Jacobs finds that the benefits of solar electrification are captured, primarily by the rural middle class, that solar plays only a modest role in supporting productive activities and education, and that solar electrification is more related to general market forces than to poverty alleviation and sustainable development. Based on the 2000 survey, Jacobs further finds that most SHSs are owned by households in the first three wealth deciles. He characterizes these households as belonging to the rural middle class, with annual household incomes well above USD 2,000 (in current USD). In another study by Farsi et al, 2007 takes a slightly different approach and also find that income is one of the main factors that prevent households from using modern and cleaner fuels in an application for India based on a household expenditure survey.

The targeting of low-income communities in developing countries should be a key to businesses central mission to create sustainable energy, products, and innovations (Prahalad, 2012). Hence, Christensen, 2013 recommends to be successful in these communities, companies should activate, inform, and involve low-income populations.

Multiple scholars argue that innovations in developing countries are exposed to local barriers and conditions, especially in the areas of energy and business modeling. Ajzen (2011), states that in developing countries, these barriers can be low incomes, low education levels, and bureaucratic organizational structures that hinder the successful promotion of the innovation.

2.2.2 Household Ownership of Land and Cattle

In related to household income it can be express with household assets like household land size and cattle ownership in rural areas can also reflect the determination of household to adopt solar in addition to income. According to Warkaw and Dr. Chawla (2016), households' average farm size was 11.78 timad and 7.22 timad for alternative renewable energy source adopter and non-adopter households respectively. This difference is statistically significant at 5%. This implies that household who have larger farm size is better in adopting alternative renewable energy source for rural household's energy consumption. Therefore, households that have large land sizes are better in adopting alternative renewable energy sources for rural household's energy consumption. Additionally, the study result supported by Walekhwa et al, 2009 the probability of a household adopting renewable energy source increases with an increasing number of cattle owned. From the findings it can be concluded there is a direct relationship between household income, land size and the number of cattle owned with the determining household decision to adopt solar technology for their domestic use.

2.2.3 Access to Financial Institution

The primary obstacle to carrying out renewable energy projects in developing countries is the absence of low cost and long term funding. According to Isaac (2014), funding plays a major role in the formulation of renewable energy technologies policies. The renewable energy with a huge cost of importing parts put an extra burden on foreign exchange reserves of African economies, which are frequently little and approaching exhaustion, and need expensive funding strategies and huge subsidies (Karekezi and Kithyoma, 2002). The subsidies are unsustainable in the long run there should be favorable funding strategy provide by banks and other financial institution to support the private sector. In addition, Sampa 1994, explains the experience in many countries that the establishment and success of any renewable energy technology are dependent to a great extent, on the government existing policy. These policies are a significant factor in conditions of their power to create an enabling environment for renewable energy technology public exposure and mobilizing resources, in addition to supporting private sector investment.

According to Isaac (2014), to improve access to credit, banking institutions should seek alternatives to strict demands e.g. the collateral requirements. Since banking policies are not likely to vary in the near future, a possible action is to recommend potential end users to create self-help groups or cooperatives to be able to acquire loans through cooperative banks, the majority of which do not have strict collateral demands. Additionally, small credit or micro-finance institutions can provide financing for renewable energy technology investors and users at less costly and accessible terms. These institutions are important in making sure projects continue even when external support stops. Irene (2013), findings show that there was a positive relationship between individuals having a savings account, shares, ability to secure a loan and the use of solar energy. This means that individuals who had a savings account, had shared, were able to secure loans easily adopted the use of solar.

2.2.4 Level of Knowledge and Awareness

The adoption of solar energy heavily depends on the knowledge and awareness of solar technology. Knowledge and awareness about solar technology can be transfer from different information sources such as neighbor and friends /family relatives and local markets through government and non-government campaigns. A number of studies by different scholars confirm there is a direct relationship between the adoption of solar technology and awareness and knowledge about the technology. According to Naomi (2014), research on the Kitengela area in Kenya found a significant relationship between the adoption of solar power for domestic use and the level of knowledge and awareness about the technology. In other research done by Gichuhi (2016), he sought to find out the social influence on solar energy technology adoption. The result shows, that 38% of the respondents disagreed that their peers think that they should use solar energy in their household, other 34% agreed that their family was very much interested in using solar energy technology and the rest 39% disagreed that their friends thought that they should adopt the use of Solar technology.

According to Kaplan (1999), the finding showed that the adoption of renewable energy systems often requires extensive research and deliberation by the householder, and therefore, marketing activities that increase familiarity such as offering small-scale PV goods such as radios, calculators, and lamps are beneficial. Similarly, Omer (2009), strongly agrees that renewable energy sources are environmentally friendly must been courage, promoted, implemented, and demonstrated by a full-scale plan especially for use in remote rural areas. In addition, marketing concurs with other recommendations and formal or informal training about the socio-economic benefits of solar technology at the household level play a critical role in the adoption of the technology for household needs.

The development of greater awareness through customer education programs, marketing material, and information about processes involved, including disruption that may occur during installation or operation help the installation of the technology (Aggarwal 1998, Bolinger et al,2001). Specifically, householders need information such as descriptions of the technology, methods of operation, and their overall performance with regard to energy savings and environmental benefits (Lai 1991; Berger 2001). According to Warkaw and Dr. Chawla (2016), research on the determinants of adoption of renewable energy sources towards reducing deforestation on Ambo district data were collected from 452 household heads and the respondents were asked whether they have information/training about socio-economic benefits of solar energy at household level, more than half of respondents (69.5%) confirmed that they have information about the benefits of solar energy while 30.5% of them opined that they have no information so far. There finding identified the most bottleneck problem in the expansion of renewable energy sources in their study area, households were failed to adopt because they fail to understand their immediate use and inadequate information.

According to Irene 2013, founding shows that there is a positive relationship between the individuals who had installed solar systems in their household, those who had seen a solar lamp in use, who had seen solar power in use, those who were aware of solar technology providers and those who had received informal or formal training on solar systems against adaption and use of solar.

2.2.5 Distances from Market and Electric Grid

The determinates of household adoption to solar energy can also be affected by household access to information with is the combination of household location distances from the market, rural extension centers, electric grid. According to Legesse et al, (2015) regards to public services like agricultural extension center, health extension center, market, access to the main road and so on services, directly and indirectly, has a contribution for the adoption of alternative renewable energy sources such as biogas technology and solar power. Hence, another research by Warkaw and Dr. Chawla (2016), found the average distance from household's home to market services for renewable energy source adopter household was 3.55 kilometers while the mean distance traveled by access to renewable energy source non-adopter households was 6.83 kilometers. This difference is also highly statistically significant at 1%.

Another study by Naomi (2014), on the factors affecting the adoption solar power for domestic usage in Kajiado country finding shows that 60.1% of the household heads indicated that the vendor and the grid Electricity was less than 5 km from home, however less than half of them knew the cost of installing Electricity in their home or of using any other energy source apart from what they were used to. This indicates that increased distance of the alternative source of energy does not positively influence the adoption of solar technology.

This study result supported by Abate (2016), founding indicates that location of households is close to market better in adoption technology decision. However, Irene, (2013) the study result showed that there was a positive relationship between the distance from the vendors to the households' home and the cost of installing a solar unit against the use of solar energy. This means that the longer the distance is from the vendor's home, the higher the chances of adapting to the use of solar and the more the household heads knew of the cost of installing a solar unit. This implies the more the chances of them adapting to use of solar energy.

2.2.6 Household Educational Level

Rebane and Barham (2011), analyze the determinants of a solar home system(SHS) awareness and adoption in Nicaragua. They used survey data from 158 households in rural Nicaragua, 40 of which had adopted being male, being young and having a high-quality residence are all positive determinants of SHSs adoption. According to Isaac (2014), the household head characteristics that were considered in his study were gender, age, and level of education. Among these variables secondary and primary level education significantly influence the adoption of solar energy. This suggests that as household heads get more education they are likely to be exposed to more information such as the adoption of other sources of energy. In supporting this Irene, (2013) findings of the study showed that there was a positive relationship between the level of education of the household head and the adoption of solar. It implies that the more educated people tended to adopt the use of solar and the higher their education level the more they adapt to the use of solar energy.

According to Gichuh ,2016 study finds shows 65% of the respondents had certificate qualification, 25% of them had diplomas, 8% had degrees 1% of the respondents had post graduate diploma and 1% had masters. This Implies that majority of the respondents were knowledgeable. Hence, Majority of the more educated people tended to adopt the use of solar technology and the higher their education level the more the adopted to the use of solar energy. The results from different researchers confirm that education level of household head is one of the determine that affects household adoption of solar energy.

2.2.7 Household Demographic Characteristic

According to Warkaw and Dr. Chawla (2016), research founds demographic characteristics of average household age were 43.44 and 44.83 years old for adopter and non-adopter alternative renewable energy source household heads respectively and it is significant. A similar study by Walekhwa et al, (2009) illustrates that the probability of a household adopting renewable energy source increases with decreasing age of head of household. As a result, it can be concluded that younger age household head is better than older age household head in adopting alternative renewable energy source for rural household’s energy consumption in the Ambo district. With regards to the mean family size of alternative renewable energy sources, the adopter household was 7; the mean family size of non-adopter alternative renewable energy source household was 6. This difference is statistically not significant. In other study, by Isaac (2014), his results indicate that household size had a negative but significant influence on the adoption of solar energy. This implies that as family size increases there would be lower chances of adopting solar energy. This could be explained by the fact adoption of solar energy requires investment and as such households with large families may be spending most of their resources in the upkeep of the children other than investing in solar energy.

One of the determinate of adoption of solar energy is household head age in the study by Naomi (2014), found 50.6% of the household heads were aged between 18 years to 24 years. This shows that the largest population of the respondents was young as a result of which they were able to understand issues related to solar technology. Similarly, Gichuhi (2016), solar energy technology adoption at the household level the research found that the larger population was youths and as a result, they were able to understand issues related to solar technology.

CHAPTER THREE

Data and Methodology

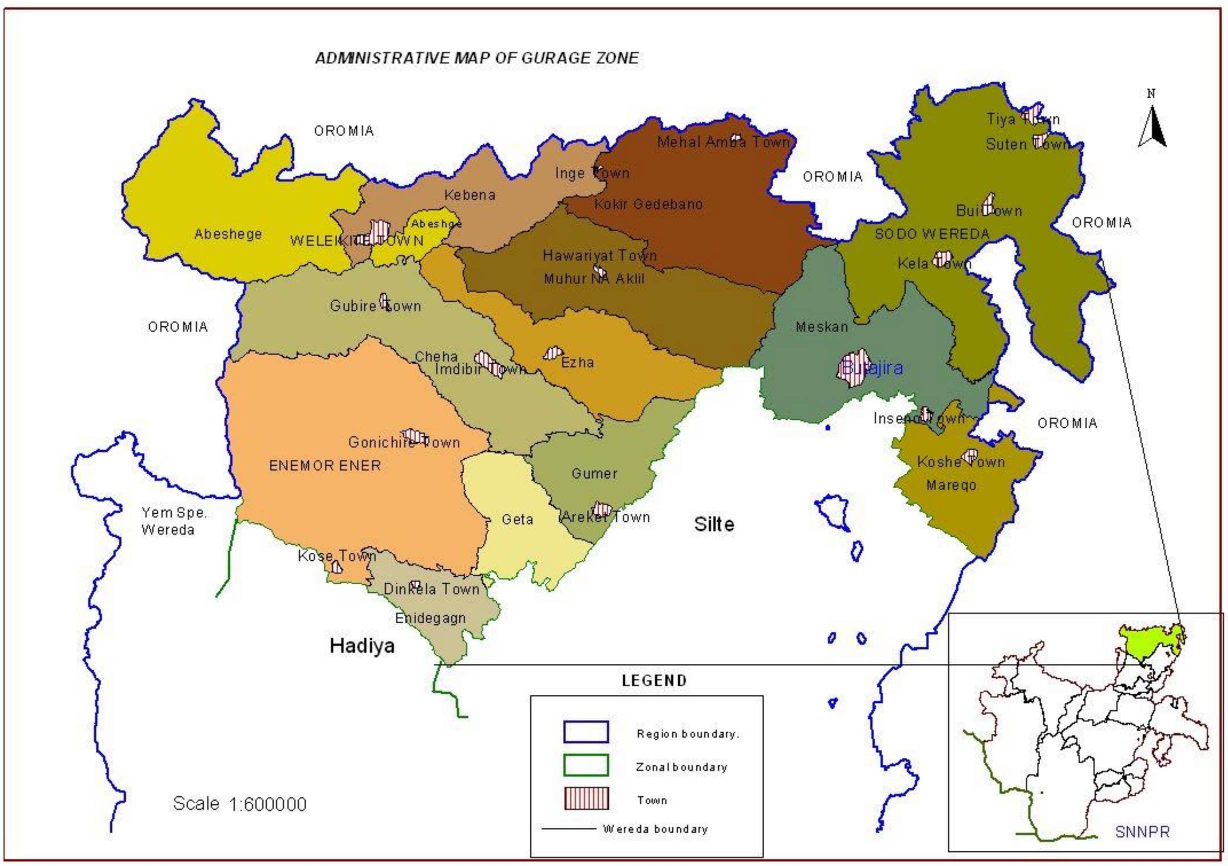
This chapter presents the research methodology employed in the study. It describes the study area, sample technique, and sample size. In addition, it indicates the data collection, sources, and analysis strategies and the econometric model employed in the research.

3.1 Description of the study area

Gurage is a zone in the Ethiopian Southern Nation, Nationalities and People's Region (SNNPR). The zone is the homeland of Gurage people. It is located 155 Km south west of Addis Ababa, the capital city of Ethiopia, and 259 Km far from Awasa, the regional capital. The Gurage zone is bordered on the southeast by Hadiya and Yem special woreda, on the west, north, and east by the Oromia Region and on the southeast by Slit'e. The altitude of the area ranges from 1000-3500 meters above sea level, characterized by 4.1% wurch (very high altitude), 27.5% dega (high altitude), 65.3% woina dega (medium altitude) and 3.1% kola (low altitude). The average annual temperature of the area is about 18°C and receives a mean annual rainfall of 800-1400 mm. Welikite is the administrative center of the zone and Butajira is the largest city in the zone and the former administrative center. Other towns in the zone include Endibir and Enseno. The Gurage zone is organized by 13 woredas 412 rural and 50 urban kebeles.

According to the Central Statistical Agency of Ethiopia (CSA) 1999, this zone has an estimated total population of 1,724,324, of whom 836,896(48.53%) are men and 887,428(51.47%) are women. With an area of 5,893.40 square kilometers, it has a population density of 292.6 per km. In the Gurage zone, 54.4% of the population is between 15-64 and 45.6% are composed of 65 age and above elder people and under 15 age of young children's. The six largest ethnic groups reported in Gurage zone were the Sebat Bet Gurage (45.02%), Silte'e (34.81%), Soddo Gurage (9.75%), Mareqo (2.21%), Amhara (2.16%), and Kebena (1.82%); all other ethnic groups made up (4.2%) of the population. Sebat Bet Gurage is spoken as a first language by (39.93%), Silt'e (35.04%), (10.06%) spoke Soddo Gurage, (3.93%) spoke Amharic, (2.16%) spoke Libido and (1.93%) spoke Kebena; the remaining 6.95% spoke all other primary languages. Gurage's are generally known for their hard-working culture and inventing ekob which marks a major contribution to the Ethiopian merchant society.

The Gurage zone is known for agricultural production such as teff, corn, berbere, chate and also for its livestock production. Ensent is their main staple crop, but other cash crops are grown, which include coffee and chat. Its people live a sedentary life based on agriculture, involving a complex system of crop rotation and transplanting. Animal husbandry is practiced, but mainly for milk supply and dung. The study focuses on two Gurage zone weredas Cheha and Ezha which found at a distance 42 and 30 km respectively from the zone. They have a rural household population of 30,255 and 23,782 respectively. The major towns in Ezha and Cheha are Agenna and Endibir respectively. The study on the determinates of household adoption of solar energy in the Gurage zone was conducted in two selected woredas.



3.2 Sampling Technique

The study is based on primary data collected from two woredas of the Gurage zone. A structured questionnaire is used to collect the required data. The study applies a stratified random sampling method in selecting interviewees. The method is chosen because the target population is divided into divisions, locations, wards, and villages (Krejcie et al, 1970). In this case, the Gurage zone is divided into 13 different woredas and the study randomly selected Cheha and Ezha woredas that have different population sizes. Cheha and Ezha woredas have 39 and 28 kebeles respectively. The study randomly selected two kebeles from Cheha woredas and the other two kebeles from Ezha woredas. And using simple random sampling procedures 216 households were randomly selected from the two kebeles in Cheha woredas and interviewed. Similarly, the remaining 169 respondents were randomly selected from the two kebeles in Ezha woredas.

3.3 Sample Size

The required sample size for collecting quantitative data was determined by using Cochran's (1977) formula. The sample size was made by assuming that 50% of the individuals included in the study have adopted solar energy technology, with a marginal error of 5% and 95% confidence interval. The formula to calculate sample size is shown as $n_o = \frac{z^2\ pq}{e^2}$

no= the desired sample size

Z= the standard deviation at the required confidences level

P= the estimated proportion of an attribute that is present in the population

q= 1-p

e= the margin of error

Thus, $n_o = \frac{1.96^2\ 0.5\times0.5}{0.05^2}$ = 385

Based on the stated formula, the sample size is determined to be 385 households.

3.4 Data Source

Data for this research were gathered from primary and secondary sources. The study based on primary data collected from Ezha and Cheha woreda in a Gurage zone. The data is obtained using questionnaires for sample respondents in both woredas. The use of questionnaires enables the respondents to remain anonymous and be honest in their responses (Cooper and Schindler, 2003). The questionnaire is divided into a different section that contains the main demographic and socio-economic variables that determine the adoption of solar energy in the Gurage zone. Regarding secondary data, were collected from the Gurage zone administerial office such as census, official documents, and records.

3.5 Data collection procedure and Quality Assurance

The data collection questionnaire is developed that goes in line with the objective the study wants to achieve. The questionnaire was primarily prepared in English and translated to Amharic and then back to English to check its consistency. In total, three data collectors(enumerators) who can speak both Amharic and Gurage language were used to facilitate the study are third year welkite university students who had previous experience in similar projects. Half-day training was given to the enumerators for two days on the purpose, procedures, and data collection tools to ensure the quality of the data.

The detailed socio-economic data of the target households were gathered using direct observation, and structured questionnaires were conducted with the respondents who are residents in Ezha and Cheha woredas in March 2019. The trained data collectors carry out the interviews in a specified time of data collection. Data completeness was checked after every interview. The questionnaire has been pre-tested in Ezha and Cheha woredas on 13% of the sample size to check and improve its clarity. The participant who was involved in the pretest is those who have adopted solar energy and who haven't adopted solar energy technology. The enumerators checked by asking the samples whether they had participated in the pre-test and by confirming this with the records. Hence, the data collection was carried out under the close supervision of the researcher.

3.6 Data Analysis

In this study, both descriptive statistics and econometric model is used for the analysis of data collected. Descriptive statistics were used to describe relevant aspects of variables and to provide detailed information about socioeconomic and demographic household characteristics. The study employs a Probit model to analyze the determinants of household adoption of solar energy in the Gurage zone. The socio-economic data obtained from the questionnaires was cleaned and organized using STATA. The collected data is presented in tables using different statistical techniques.

3.7 Model Specification

A probit model is a nonlinear regression model specifically designed for binary dependent variable (Stock and Watson, 2006). This study applied the probit model to observe the effect of socio-demographic variables on the probability of the adoption of solar energy.

The probit model can be defined as

$\boldsymbol{y_i^* = x_{i\beta} + \varepsilon_{i,}}$ --(1)

Where; β is a vector of parameters of the model, x_i is a vector of the explanatory variables and $\varepsilon_{i,}$ (the error term) and is assumed to have a random normal distribution with mean zero and common variance δ^2 (Green, 1997). y_i^* = unobservable or which is also named to be a latent variable, what we can observe is a dummy variable y_i, which is take the value y_i =1 if household adopt solar energy and y_i = 0 for those households who haven't adopt solar energy. It defined as;

y_i =1 if $y_i^* > 0$ ---(2)

y_i = 0 if $y_i^* \leq 0$ ---(3)

Where the ε_i are independent of all x_i

In this case, the respondents were asked whether they have adopted solar energy or not in their households. The binary outcome of yes and no response expressed in terms of the probit model. The solar energy technology adoption by a household and its determinants can then be specified as shown in equation 4.

The following is the probit model used in the study.

$$P(solarado = 1|X) = \Phi(\beta_o + \beta_1\ (sex)_i + \beta_2(age)_i + \beta_3\ (mar)_i + \beta_4(edu)_i + \beta_5(hsize)i + \beta_5(income)_i + \beta_6(remittance)_i + \beta_7(landsize)_i + \beta_8(owncattle)_i + \beta_9\ (mardis)_i \text{------------}(4)$$

Where $\Phi(.)$ Is the cumulative standard normal CDF.

3.8 Variable Specification

The determinate of household adoption of solar energy is affected by the demographic and socio-economic condition of a household. In this study gender of household, age, income, remittance, household size, land size, ownership of cattle and local market distances are the explanatory variables that affect the adoption of solar energy in the Gurage zone.

Table 1 :Variable Specification

Variable	Definition	Specification
Dependent Variable		
Solarado	Adoption of solar energy	A dummy variable: 1=yes adopt solar 0= No, those who haven't adopt solar
Explanatory variables		
Sex	Gender of household head	A dummy variable: 1= male; 0 = female
Age	Age of household head	Continuous variable: Age in years from birth
Mar	Marital status of the household head	A dummy variable: 1=married; 2= single, 3= divorced and 4= widowed
Edu	Education level of household head	A dummy variable: 0=no school enrollment , 1 = able to read and write , 2 = primary education, 3= secondary education
Hsize	Number of household member living under the same roof	In number
Income	Household annual income	In birr
remittance	Household head receive remittance from relatives	A dummy variable: 1= Yes; 0= no
Landsize	Total land size owned by households	In acres
owncattle	Household own cattle	A dummy variable: 1= yes; 0= no
Mardis	Local market distance	In kilometers

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

This Chapter presents the analysis and discussion of data obtained from the Cheha and Ezha woredas survey. In the descriptive analysis, the study analyzes and discusses the general characteristics of sample households including socio-economic and demographic characteristics that are expected to affect household adoption of solar energy in both woredas. In econometric analysis, probit model results are analyzed and discuss the factors that affect the adoption of solar energy technology.

4.1 Descriptive Analysis

4.1.1 Socio-Economic and Demographic Characteristics of Households

This section discusses the demographic characteristics of households such as sex, age, marital status, education level and household family size. The respondents were asked to indicate their gender in order to establish how the Demographic characteristics of household head affect the adoption of solar energy. The result indicates in Table 2 shows, 52% of household heads were male while the rest 48% of them were female-headed households. This implies that most houses are dominated by male household heads. This might be because most rural households in Ethiopian are known to be a male dominated in their characteristics.

The respondents were asked about their marital status. The responses of marital of the household indicate that the majority (74%) of household head were married, while 24%, 1% and 1% of them were widowed, divorced and single respectively. This implies that most of the household head in both woredas are married. The results are presented in Table 2.

The age composition of household heads the survey result in Table 2, illustrates that 28% of the household heads were age between 23-35 years, while 22%,28%, 22% of the respondent were age between 36-48 years, 49-60 years and above 61 years respectively. In short, the mean age of sampled household head was 80 years with a range of 23 to 80 years of age. This implies that the largest population was the middle and youth age as a result, they were able to understand issues related to related solar technology. In addition, the result indicates the majority percent of the population is middle age this explains there is youth migration from rural to urban for work with is a common culture among the Gurage ethnic group.

The distribution of the total sample respondents in terms of education level as describes in Table 2, has shown that 45% of the respondents have no school attainment,6% of them can read and write, 30 % had primary education and 19 % of them had secondary education. In the study, 55% of the respondents were knowledgeable with directly increase the rate of adoption of solar technology. This implies the level of education is a major factor affecting the adoption of solar technology.

The Table below shows the total number of households' members living under the same roof. It indicates 52%, 42% and 6% of households have 1-3, 4-7 and 8-10 family size respectively. The mean household size of the sample households was 4 with a maximum range of 10 and a minimum rate of 1. This study shows that unlikely to most rural Ethiopian the household size living under the same roof is lower in Gurage rural compared to other rural areas. This implies that there is a large number of household members' migration to the urban city looking for a work opportunity.

Table 2: Socio-Demographic Characteristics of Households

Demographic Variables	**Percentage**	**Standard Deviation**	**Mean**
Gender of Household Head		0.500275	1.480519
Male	52%		
Female	48%		
Marital Status		1.288015	1.755844
Married	74%		
Single	1%		
Divorced	1%		
Widowed	24%		
Age Group		15.00352	49.18701
23-35	28%		
36-48	22%		
49-60	28%		
61 years and above	22%		

Education Level		1.20976	1.238961
No School attainment	45%		
Able to Read and Write	6%		
Primary Education	30%		
Secondary Education	19%		
Household Size		2.064396	3.937662
1-3	52%		
4-7	42%		
8-10	6%		

4.1.2 Solar Technology Installation

The survey sampled respondents' household heads were asked if they had installed Solar energy technology in their household. Their responses highlighted in Table 3, indicates 54% of the respondents in both woredas had installed solar technology in their household, while 46% of the household had not installed solar technology in their home. The majority percent of the respondent had adopted solar technology. This implies that the Gurage zone has a higher adoption rate of solar energy technology in Cheha and Ezha woredas.

Table 3: Solar Technology Installation

	Percentage	Mean	Standard Deviation
Solar Technology Installation		0.5350649	0.499418
Yes	54%		
No	46%		

The respondent who had not installed solar technology in their households were further asked, about their energy choice for lighting purposes, 97% of the respondents use kerosene and the rest 3% still use firewood as a lighting source. These study results reveal that the majority of non-solar adopters have been using kerosene for lighting their homes which can lead to series health and environmental damage. Additionally, non-solar adopter was asked the reason they still haven’t installed solar technology in their household. As clearly shows in Table 4, 55% of the respondents states that they couldn’t afford to buy solar products, 30% of them have no awareness about solar technology; while 11% and 3% incurred lack of credit facility and market supply respectively to buy solar technology products. The result can further indicate the majority of households failed to adopt solar technology is because of the financial capacity and lack of awareness about the products. This reveals the fact most Ethiopian rural areas are affected by poverty and backwardness toward the adoption of new technology.

Table 4: Reason not to Adopt

	Percentage	Mean	Standard Deviation
The reason not to adopt		1.815642	00.9798997
Couldn’t Afford	55%		
Lack of Awareness about Solar Technology products	30%		
Lack of Credit facilities	11%		
Lack of Market Supply in the Region	3%		

4.1.3 Level of Knowledge and Awareness about Solar Energy

The study sought to look at the extent of knowledge and awareness of solar technology among sample households in Cheha and Ezha woredas. Particularly, the respondents were asked how they heard about or informed about solar energy technology products. As clearly shows in Table 5, 54% of the respondent in both woredas was informed by their neighbor, friends and family relatives, 27% of them heard about solar products from the local market and the remaining 15% of households have no idea about solar technology and 4% of the respondent had privies knowledge about solar technology products. This implies neighbors, friends, and family relatives are the major sources of information about solar energy in Gurage Zone residents.

Table 5: Sources of Information

	Percentage	Mean	Standard Deviation
Sources of information for Solar Energy		2.041558	1.193881
From neighbor, friends and family relatives	54%		
From the local market	27%		
Have no idea about solar technology	15%		
Privies knowledge about solar technology products	4%		

4.1.4 Cost of Installation

In line with the knowledge and awareness toward solar energy, respondents were asked if they knew how much it cost to install solar technology products in their household. As observed in Table 6, 62% of household heads knew the cost of installing solar technology in their homes. The remaining 38% of the household head did not know the cost required to install solar technology products in their household. They did know the cost of installing because of, lack of awareness and out of 62 % of the solar adopter, 28% of the household head did know the cost of installing because they were bought by family relatives living in the urban city.

Table 6: Cost of Installation Solar Technology

	Percentage	Mean	Standard Deviation
Cost of Installation		1.381818	0.4864645
Knew the Cost of Installation	62%		
Did not Know the Cost of Installation	38%		

4.1.5 Distance of Local Market and Grid Electricity

On the Local market distance, the respondent was asked how far the local market from their homes. As clearly shows in Table 7, 60% of the household head indicates that the local market and grid electricity was 7-9 km from home, 25% of respondents were 4-6 km from home, the rest 9 %, 6% are 10-12 and 13-15 km distance from home. This implies that most of the household was 7-9 km distance from the local market. This also means the majority of the household member in Cheha and Ezha woredas were far from grid electricity and had low chances of electricity connection.

Table 7: Local Market and Grid Electricity Distances

	Percentage	Mean	Standard Deviation
Distances in kilometers		7.623377	2.228128
4-6	25%		
7-9	60%		
10-12	9%		
13-15	6%		

4.1.6 Solar Adopter Households

On the use of Solar Energy, the study sought to know the number of solar bulbs and the average number of solar bulbs per day they use to light their homes by solar adopter households. In addition, the respondents were asked the average number of hours per day the household use solar bulbs for lighting purposes. Their responses are highlighted in Table 8.

Table 8: Solar Usage

Category		Percentage	Mean	Standard Deviation
Number of Solar Bulbs	1-2	22.3%	3.800971	1.405286
	3-4	54.4%		
	5-6	23.3%		
Average Number of Solar Bulbs used per day	1-2	66%	2.286408	1.068626
	3-4	31%		
	5-6	3%		

As Table 8 shows, 54.4% of the household have 3-4 numbers of solar bulbs, the reaming 23.3 %, 22.3% have 5-6 and 1-2 number of bulbs in their home respectively. This implies most of the households in Cheha and Ezha woredas buy solar energy products that have 3-4 solar bulbs. This justified the fact it is more compatible with household needs and affordable by most households. According to the respondent in both woredas, 66% of them use 1-2 numbers of solar bulbs per day on average, 31% use 3-4 solar bulbs per day on average and the rest 3% use 5-6% number of solar bulbs per day on average. The result indicates the majority of sample respondents use 1-2 solar bulbs per day in Cheha and Ezha woredas. This implies the majority of the rural community in both woredas night activities are limited with is common among most Ethiopia rural areas and they use solar bulbs primary for lighting purposes.

4.1.7 Recommendation of Solar Energy

In this section, the solar technology adopter respondents were asked if they would recommend the use of solar technology products to others. Their responses are highlighted in Table 9.

Table 9: Recommend Solar to Other

	Percentage	Mean	Standard Deviation
Recommend Solar to Others		1.11165	0.3157032
Would Recommend	89%		
Would not Recommend	11%		

As indicated in the above Table 9, 89% of solar technology adopter recommend others to use in their household and the remaining 11% of solar adopter would not recommend others to use it. The reason behind not recommending solar to other households is because they suffer from a frequent technical problem with solar products and low performance during the rainy season. This line with consumer knowledge on how to identify quality products is low.

4.1.8 Household Attitude Toward Solar Technology

The study sought to find a solar adopter household attitude in Ezha and Cheha woredas toward solar technology. As indicated in Table 10, 65% of the respondents strongly agree solar was fully compatible with their household needs, 62% of the respondents strongly agreed that solar technology was easy to use, 65% strongly agree that positive results of using solar technology are clearly visible. 66% of the household strongly agreed that it was more advantageous to use solar products than kerosene and firewood for lighting, 77% strongly disagree that technical support for solar technology was easily available and user friendly, 67% strongly agree that solar technology was cost effective to use. This implies that the majority household has a good attitude toward solar technology advantageous to use than kerosene and firewood but they are facing difficulty by lack of technical support in both woredas.

Table 10: Attitude toward Solar Technology

Household attitude toward solar technology	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The solar energy technology is fully compatible with my household needs	0.5%	7%	0%	27%	65%
Solar energy technology is easy to use	0%	2%	0%	36%	62%
The positive results of using Solar energy technology are clearly visible	0.5%	6%	0.5%	28%	65%

It is more advantageous to use solar energy technology than kerosene and firewood for lighting	1%	4%	0.5%	28%	66%
Technical support for Solar energy technology is easily available it is also user friendly and secure	77%	21%	0.5%	1%	0%
Use of Solar technology is cost effective	0.5%	5%	1%	27%	67%

4.1.9 Household Annual Income

Household income refers to the annual collective earning of the household. This income is earned through the sale of grains or vegetable products, animal and their dairy products, sale of good crafts, sale of local drinks, renting farmland, manual labor and others.

Table 11: Average Household Annual Income

Observation	385
Mean	25098.88
Standard Deviation	16095.19
Minimum	3000
Maximum	88000

Additionally, in line with household income, the respondent was asked about their total land size and ownership of cattle. It can be observed in Table 12.

Table12: Household Ownership of Land and Cattle

Ownership of Land and Cattle	Percentage	Mean	Standard Deviation
Total Land Size owned in Acres Meter		8981.818	5944.595
None	2%		
1500-10000	88%		
20000-40000	10%		
Ownership of Cattle		1.080519	0.2724498
Household own Cattle	92%		
Household don't own Cattle	8%		

4.1.10 Remittances Receive by the Household receive

The sample household respondent from Cheha and Ezha woredas were asked if they receive remittances from relatives living in another area. As Table 13 shows, 52% of household head receive remittance and 48% of the household head did not receive any remittance. This implies most of the households in both woredas receive remittance from their family relatives. This illustrates the fact most households in the Gurage zone receive remittance. This is because almost one member from the household had migrated to the urban city for work and the majority are involved in trade related work. In addition, the remittance received by a households' head 80% of them were from domestically and the remaining 20% receive from abroad. This implies the major remittance is sent from domestically within line show most of the migration is from rural areas to urban in the same country boundary.

Table 13: Remittances Receive by the Household

	Percentage	Mean	Standard Deviation
Households Receive Remittances		0.5168831	0.5003651
Receive Remittance	52%		
Does not Receive Remittance	48%		

4.1.11 Access to Credit Facility Institution

The Household in both Cheha and Ezha woredas were asked if they have access to credit facility institutions like micro finances to buy solar technology products. 84% of the household respondent did not have access to credit facility institution and 16% of the respondent have access to credit facility institutions in both woredas. This implies the majority of the household doesn't have access to credit facility institutions. Additionally, the mean amount of loans borrowed by a household that has access to credit is 5984 birr.

4.2 Econometric Results

In this section, the study presents the results of econometric analysis. In the econometric analysis, socio-economic and demographic variables are included to explain the dependent variable. As described in the methodology part, to examine factors that determine the adoption of solar energy by households in Cheha and Ezha woredas probit model were used in this study. The results of the probit regression are given in Table 14. As mentioned in the methodology section, 385 observations were used in the regression. Both the coefficients and the marginal effects for each variable are presented in Table 14. As the result shows sex, age, marital status and education level of the household head, household size, income, cattle ownership, and remittances significantly influence the adoption of solar energy in Cheha and Ezha woredas. Among the independent variables used in the analysis for the adoption of solar energy land size and local market, distance has no significant impact on the adoption of solar energy in both woredas. The Variance Inflation Factor(VIF) is also computed to test multicollinearity. The VIF result confirms that there is no multicollinearity across explanatory variables as indicated in Table A.1.In addition, the probit model correctly predict 99.22% of the values as indicated in Table 15.

Table 14: Result of Probit Regression

Variable	Probit Coefficients and Standard Errors	Marginal Effects and Standard Errors
Female	-5.812*** (0.945)	-0.227*** (0.043)
Age	-0.127*** (0.041)	-0.002** (0.001)
Single	-3.052*** (0.661)	-0.036*** (0.014)
Divorced	-3.903*** (0.705)	-0.049*** (0.011)
Widowed	-0.829 (0.712)	-0.012 (0.011)
Able to read and write	3.322*** (0.936)	0.068*** (0.023)
Primary education	1.819 (0.984)	0.034 (0.024)
Secondary education	3.281*** (1.069)	0.067** (0.029)
Household Size	-1.139*** (0.202)	-0.014*** (0.005)
Household Income	3.718*** (0.946)	0.047*** (0.009)
Remittance	3.102*** (0.766)	0.051*** (0.015)
No Cattle owner	-4.026*** (1.06)	-0.047** (0.018)
Local Market Distance	0.213 (0.128)	0.003 (0.002)
Land size	.00016 (.00011)	0.000 (0.000)

Wald chi2 (14) = 1169.89
Prob > chi2 = 0.0000
Pseudo R2 = 0.9683

NB: Robust standard errors in parenthesis
** Significant at 1%
*** Significant at 5%

As Indicated in Table 14, the sex of household head has a negative significant effect on the decision of adoption solar energy in both Ezha and Cheha woredas. It shows female headed household has 22 % less likely to adopt solar technology compare to male headed households. It is also statistically significant at 1%. This indicates female headed households in Cheha and Ezha woredas have low financial and social status in the community compare to male headed households. This line with gender inequity among women and men in rural Ethiopian.

Marital Status of the household head is also one of the determinates of household adoption of solar energy in Ezha and Cheha woredas. According to the result, single and divorced household heads have a negative significant effect on the decision of adoption of solar energy and they are both statistically significant at 1%. This implies that a single household head has 3.6 % of lower probability of adopting solar technology compare to married household heads in both woredas. Similarly, the divorced household head has 4.9 % less likely to the adoption of solar energy compared to the married household head. In addition to this, the widowed household head respondent has a negative sign. It shows that widowed household heads are 1.2% less likely to adopt solar energy compared to the married household head. However, the result is not statistically significant.

The age of household head has a negatively significant effect on the adoption of solar energy technology at 1% level of significance. When the age of household head increase by one year; the probability of adoption of solar energy will decrease by 0.2%. The result supported by Warkaw and Dr. Chawla (2016), research finding in Ambo shows that the probability of household adoption of renewable energy sources increases by 2% with a decreasing age of household head. And it is statically significant at 10%. A similar study by Walekhwa et al, (2009) illustrates that the probability of a household adopting renewable energy source increases with decreasing age of head of household. It can be concluded that the younger the household age is the better than older age household in adopting solar energy technology in both Ezha and Cheha Woredas.

As indicated in the result the additional year of age decreases the adoption of solar energy by 0.2% only. When comparing this result with the founding of Warkaw and Dr. Chawla, (2016) in Ambo in Oromia the additional year of age decrease the adoption of renewable energy source by 2%. Hence, comparing the two result it shows that it is more common among older household head to adopt solar energy in Gurage zone compare to Oromia region. The reason is there is high remittance receive by older age households in Gurage which encourages them to invest in solar energy. In addition, Gurage zone youth have a higher tendency compare to other Ethiopian regions to migrate to the urban city looking for work.

Household size has a negative effect on the adoption of solar energy in Cheha and Ezha woredas and a statistically significant level of 1%. The results indicate when household size increase by one person, the probability of household adoption of solar energy will decrease by 1.4%. This implies the adoption of solar energy technology products requires investment and household with large families spends most of their resources in the upkeep of the children other than investing in solar energy products. Similarity, research by Isaac (2014), results indicate that household size had a negative but significant influence on the adoption of solar energy. And implies that as family size increases there would be lower chances of adopting solar energy.

The education level of the respondent from Cheha and Ezha woredas have a positive effect on the adoption of solar energy technology products. The household head who can read and write are 6.8 % more likely to adopt solar technology as compare to household head that doesn’t have school enrollment. And It statically significant at 1%. The respondents with primary education have 3.4% more chance of adoption of solar energy than with no education. However, it is no statically significant. This is because the majority of the household have primary education in both woredas. In addition, respondents with secondary education have 6.7 % more chance to adopt solar energy than those respondents with no education and it is statically significant at 1%. This suggests that the more household head get more education they are likely to be exposed to more information such as the adoption of solar energy. In addition, Irene 2013, study finding also showed there was a positive relationship between the level of education of the household head and the adoption of solar. It implies that more of the educated people tended to adopt the use of solar and the higher their education level the more the adopted the use of solar energy.

The households' annual income is found to be one of the influential factors which determine households' adoption of solar energy in Cheha and Ezha woredas. It has a positive sign which means a household with more annual income is more likely to adopt solar technology. The variable is statistically significant at 1%. It shows if household annual income increase by one; the probability of adoption of solar energy will increase by 4.7%. With regard to cattle, ownership has a positive significant effect on the adoption of solar energy in both woredas at 1%. This implies that those household that does not have cattle are 4.7 % less likely to adopt solar energy compare to those household own cattle. Hence, cattle are an asset of households. In addition, household land size has no significant effect on the adoption of solar energy in Cheha and Ezha woredas. This indicates the fact Gurage zone has a high population density per km and lower land size.

In contra with Gurage zone, the result found by Warkaw and Dr. Chawla (2016), in Ambo Oromia region household those have larger farmland has a positive significant effect on the decision of adoption of renewable energy source positively at 1% level of significance. This implies that household's farm size of land is increased by one; the probability of adoption of renewable energy source will be increased by 13%. This implies Oromia region has a low population density and have a large farmland than Gurage Zone. With regards to livestock ownership, they state households' livestock ownership has a positive significant effect on the decision of adoption of renewable energy source positively at 1% level of significance. This implies that the household's number of livestock own is increased by one; the probability of adoption of renewable energy source will be increased by 14%. This indicates both Ambo distinct and Gurage zone livestock(cattle) ownership has a positive effect on the adoption of solar energy. But in Ambo the coefficient is higher than the Gurage zone which implies the Ambo Oromia region number of livestock higher than the Gurage zone.

Remittance sends from relatives have a positive significant effect on the adoption of solar energy in Cheha and Ezha woredas. As indicated in Table 14, the household head who receive remittance from relatives have 5% more chances of adopting solar energy compare to those household head that doesn't receive remittance from their relatives. And it is statically significant at 1%. This implies remittance has an enormous role in determining the adoption of solar energy in both woredas.

In addition, distances of the respondent from home to the local market has a positive sign. When the respondents' house distance from local market increase by one km the probability of adoption of solar increase by 0.3%. However, the local market distance is not a statistically significant variable.

The probit model correctly predict 99.22% of values.

Table 15: Model predict

```
. estat classification

Probit model for solarado
```

Classified	True D	True ~D	Total
+	204	1	205
-	2	178	180
Total	206	179	385

```
Classified + if predicted Pr(D) >= .5
True D defined as solarado != 0
```

Sensitivity	Pr(+| D)	99.03%
Specificity	Pr(-|~D)	99.44%
Positive predictive value	Pr(D| +)	99.51%
Negative predictive value	Pr(~D| -)	98.89%
False + rate for true ~D	Pr(+|~D)	0.56%
False - rate for true D	Pr(-| D)	0.97%
False + rate for classified +	Pr(~D| +)	0.49%
False - rate for classified -	Pr(D| -)	1.11%
Correctly classified		99.22%

CHAPTER FIVE

Conclusion and Policy Recommendation

5.1 Conclusion

For a country like Ethiopian where electric grid expansion is mostly limited to the urban side of the country, the vast majority of rural residents in a different part of Ethiopian rural areas have low electric grid connection and most of them have no chance of connecting to the grid in the near future. This is because of the high fracture cost incurred to provide electricity for the rural resident. Solar energy can be taken as an important solution to provide an off-grid for Ethiopian rural households in general. Hence, it is evident in the last decades' different parts of Ethiopian rural areas have been using solar energy in their households. Thus, the adoption of solar energy among rural households in a different part of the country is affected by different socio-economic and demographic factors. This study gives focus on the determinates of household adoption of solar energy in the Gurage zone specifically on Cheha and Ezha woredas.

The study sought to investigate the determinants of the adoption of solar energy in the Gurage zone. The study used cross-sectional data collected from 385 households in selected Cheha and Ezha woredas. The study analyzes the determinates of adoption of solar energy based on the households' characteristics and socio-economic factor. The household demographical characteristics included in the analyses are household gender, age, household size, and education level. Further, the socioeconomic factor included the annual income of the household, land size, ownership of cattle and local market distance. In addition, the study includes remittance received by the household head. To achieve the objective of the study, the probit regression model was used to analyses the determinate factor affecting the adoption of solar energy in the Gurage zone.

The probit model result revealed that the adoption of solar energy in the Gurage zone is influenced by household demographic characteristic and socioeconomic factors. More specifically, the adoption decision is positively affected by household annual income, remittance, ownership of cattle and education and all these variables are found to be significant. However, unlike most Ethiopian rural areas the land size owned by households found to be insignificant. This is because both Cheha and Ezha Gurage zone woredas households have found to have lower and almost equal land size. Similarly, Local market distance is insignificant in both woredas. The study result also found a household size, age, and gender of the household head to have a negative and significant effect on the adoption of solar energy in the Gurage zone. More specifically, the result of gender shows that female headed households are less likely to adopt solar energy and the increasing household head age and household size decrease the chances of adopting solar energy. In addition, local market.

5.2 Policy Recommendation

The study founding's are important to implicate polices recommendation for the effective promotion of solar energy technology products in the Gurage zone. Hence, this study draws the following policy implication to enhance solar energy adoption in a Gurage zone.

- As a result of the study show, being a women household head decrease the adoption of solar energy in both woredas. Therefore, government and nongovernment organization should give special focus on the woman empowerment to increase the adoption of solar energy by women household head. This can be achieved by providing credit facility which is easily accessible for women household head and increases their awareness about solar energy products using marketing strategies design especially for women which shows the benefits and application of solar energy.

- The Education level of the household head increases understanding of solar energy technology which increases the adoption of solar energy by households. Thus, the government should work on improving education quality in rural areas. And providing elders education programs to increase the number of households who can read and write.

- The study further found a household with a low annual income had low chances of adoption of solar energy. Thus, to increase the adoption of solar energy government and nongovernment should continue to work on poverty alleviation program in rural areas and facility credit institution near the community which provide loan to buy solar energy products for the household. In addition, the government should consider lower tax rate and subsidies solar energy products for the private sector so solar energy product can be affordable to the households.

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APPENDIX

Table A.1 multicollinearity by VIF

Variable	VIF	1/VIF
Income	5.73	0.174569
Edu	4.52	0.221179
Age	4.15	0.240888
landsize	3.02	0.331171
remittance	2.40	0.417168
sex	2.38	0.420334
mar	2.19	0.456363
hsize	1.56	0.643065
mardis	1.24	0.803324
owncattle	1.19	0.842252
Mean VIF	2.84	

Questionnaire

A Survey on the determinate of Household adoption of solar energy in Gurage zone

<u>Introduction:</u> This research questionnaire on the determinate of Household adoption of solar energy in Gurage zone is designed by a postgraduate economic student for master thesis (research) purpose. Please be precise on giving the answer as it's really helpful for analysis purpose. I want to inform you that all your response to these questions will be treated with strict confidentially and shall be used for the purpose of this research paper only.

Section One: Households General Information

1. Gender of Household head.

- ☐ Male
- ☐ Female

2. Household head age______________________.
3. Marital Status of Household head.

- ☐ Single
- ☐ Married
- ☐ Widowed
- ☐ Divorced

4. Education status of household head?

No school attainment	☐	Able to read and write	☐
Primary education1-6	☐	Primary education7-8	☐
Secondary education 9-10	☐	Secondary education 11-12	☐
Other specify	☐		

5.All member of household living under the same roof (Household size)?

Household Member	Number
Children age below 5	
Children attending school	
Adult Men	
Adult Women	
Total household size	

Section Two: Household Solar Energy Adoption

6. Is your house connected to the national electricity grid?

- ☐ Yes
- ☐ No

7. Do you have a solar system installed in your house?

- ☐ Yes;(please go to question 10)
- ☐ No

8. If your answer is No to question 7, what kind of energy source are you currently using for lighting in your home?

- ☐ Kerosene
- ☐ Fire wood
- ☐ Dry cell
- ☐ Other, specify ___________________________.

9. If your answer is No to question 7, why don't you have installed solar product still?

- ☐ Couldn't afforded it
- ☐ Lack of credit facility
- ☐ Lack of awareness about the products
- ☐ Lack of supply in the market
- ☐ I didn't find solar products useful
- ☐ Other, specify _______________________

10. How do you hear/have knowledge about solar energy technology products?

- ☐ From neighbor and friends'/family relatives
- ☐ Have privies knowledge about the products
- ☐ I heard about the product from local market
- ☐ Have no idea about solar technology products
- ☐ Other, specify____________________________

11. Do you know how much it would cost for the installation of a solar product in the house?

- ☐ Yes
- ☐ No;(please go to question 13)

12. If your answer for question 11 is yes, is solar product affordable?

- ☐ Yes
- ☐ No

If your answer is No, please explain briefly

____

13. How far is the local market from your home______________________________?

14. How far is the Grid electricity from your home_____________________________?

15. Do you have access to financial institution that facilities credit to buy solar technology products?

☐ Yes

☐ No

Section Three: Financial Sources

16. What is your household source of income throughout the year from the list below?

Sources of Income		Tick	Amount of income in birr
1	Sale of produced grains or vegetables/fruits(market sale)		
2	Sale of animals/ own produced animal products		
3	Sale of own produced or gathered goods/ crafts		
4	Casual labor/ temporary salary(daily wage)		
5	Petty trade/ small businesses(mini shops, local drinks)		
6	Employment/ regular salary		
7	Renting farm land to others		
8	Other means, Specific		

17. Does your household own a farm land?

☐ Yes
☐ No

18. What is the land size owned by the household? ____________________.

19. Does the household own cattle?

☐ Yes; how many_________________?
☐ No

20. Do you get income transfer from other household members who live in other areas (remittance from relatives)?

☐ Yes
☐ No;(please go to question 23)

21. If your answer to No. 20 is yes, from where do you get the remittance?

☐ Domestic
☐ Foreign

22. If your answer is yes, how much do you get per year__________________?

23. How much is your average annual household expenditure?

List of expenditure		Amount of expenditure in birr
1	Food and drink(salt, coffee)	
2	Clothe and shoe	
3	For house materials	
4	Transport	
5	For school materials(student uniform/exercise book)	
6	For energy(gas)	
7	Social event (edir)	
8	Other means, specify	

Section Four: For Solar Technology Adopter only

24. Would you recommend others to use solar technology for their home?

☐ Yes
☐ No

If No, why not? Please explain briefly

____

____.

25. Have you ever borrowed loan from financial institute to buy solar energy products?

☐ Yes

☐ No;(places go to 27)

26.If yes, name the source of the financial institute that gives you the credit and the amount you borrowed?

Source of credit___________________________and amount borrowed___________.

27. What is the alternative energy source other than solar energy you used as substitution for lighting in your home?

☐ Kerosene
☐ Firewood
☐ Dry cell
☐ I used only solar, no substitutes
☐ other

28. Which of the following electronic device does your house solar technology support?

- ☐ Solar radio; how many____________
- ☐ Mobile phone charging; how many___________
- ☐ Solar lamp; how many_____________
- ☐ Other; specify __________________

29. On average how many of the solar lamp is used to light your home per day_____________?

30.On the average, how many hours per day do you use solar lamp to light your home_____________________?

31. What kind of electronic device does the household owned?

- ☐ Mobile phone; how many____________
- ☐ Radio; how many ______________
- ☐ TV; how many ________________
- ☐ We don't have any electric devices

32. Please indicate the degree to which you agree or disagree with the following statements. Use a scale of 1-5 where; [1] is strongly disagree; [2] disagree; [3] neutral; [4] agree; and [5] strongly agree.

Household altitude to ward solar technology	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
The solar energy technology is fully compatible with my household needs					
The Solar energy technology is easy to use					
The positive results of using Solar energy technology are clearly visible					
It is more advantageous to use solar energy technology than kerosene and fire wood for lighting					
Technical support for Solar energy					

technology is easily available it is also user friendly and secure					
Use of Solar technology is cost effective					

THANK YOU!!!