IMPACT OF RURAL ELECTRIFICATION ON HOUSEHOLD'S WELFARE; IN CASE OF GURAGE ZONE, SNNPRS

M.Sc. THESIS

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DEDICATION

I would like to dedicate this thesis to all of my family members for their unreserved love, support, consistent encouragement and prayer.

DECLARATION

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this thesis. Any scholarly matter that is included in the thesis has been given recognition through citation. The thesis is submitted in partial fulfillment of the requirements for master's degree at the Wolkite University. The thesis will be deposited in the Wolkite University Library and is made available to borrowers under the rules of the Library. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate. Brief quotations from this thesis may be made without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from or reproduction of this thesis in whole or in part may be granted by the Head of the Department when in his or in her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the Thesis.

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ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
BoA	Bureau of Agriculture
CFW	Conceptual Frame Work
CSA	Central Statistics Agency
DFID	Department for International Development
EELPA	Ethiopian Electric light and Power Authority
EEPCO	Ethiopian Electric Power, Corporation
FGD	Focused Group Discussion
GTP	Growth and Transformation Plan
GERD	Great Ethiopian Renaissance Dam
GZAD	Guraghe Zone Agricultural Office
GZDoFED	Guraghe Zone Departement of Finance and Economic Development
LDC	Least Developing Countries Report
MOFED	Ministry of Finance and Economic Development
PPS	Probability Proportional to Size
PSM	Propensity Score Matching Method
SNNPR	South Nation Nationality and People Region
SSA	Sub -Saharan Africa
WAO	Woreda Agricultural Office
WB	World Bank

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ABSTRACT

The main goal of this study was to impact of rural electrification on household's welfare; in case of Gurage zone, SNNPRS. Towards this end, a multi stage sampling technique was used to collect data from a total of 228 randomly selected sample households, of which 125 households were electrified and 103 households were non-electrified. This study used both primary and secondary data collected through interview schedule and review of various documents respectively. Descriptive statistics as well as econometrics methods of data analysis was employed. The result from the binary logit model indicated that education level, community access to good road, connection with national line, income of the households were found to be positively and significantly determining grid household's electrification. Moreover, the propensity score matching model, based on the radius caliper (0.1) matching technique was used to analyze the impact of rural electrification on household's consumption expenditure and income. Accordingly, the average treatment effect on treated (ATT) estimation result revealed that rural electrification had significantly increased the per capita food consumption expenditure, per capita total expenditure and total annual income of the households. Thus, constructing rural roads, expansion of the capacity of the electric power and tackling electric power outage ad facilitate either formal or informal education access there by to electrify rural farm households were recommended to the government bodies to sustain the significant outcome of rural electrification.

Key words: *Impact, Propensity score matching model, Income*

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Access to electrification can potentially affect economic development through a number of channels but the most evident link is through improved productivity at the individual and household levels. Electricity is an enabler for poverty reduction, social progress, equity, enhanced resilience, economic growth, environmental sustainability and access to basic human needs such as (water, food, shelter, healthcare, education and access to information (Diery & Busari, 2009). The main direct benefit of electricity is clean lighting source but it can also positively contribute to farm and non-farm productivity through the improved production process and reduced cost of production (Chakravorty, 2016).

Rural electrification is a potent driving force for industrial growth and overall economic development of rural areas (World Bank 2016).Bringing electricity to rural areas started in United States of America (USA) in 1920s and by1965, all the rural areas in USA had electricity (Katie,2010). Despite widely recognized importance, electricity is not available everywhere and many people still depending on alternative sources of energy such as wood, charcoal and kerosene (Pellegrin&Tasciotti, 2012). Lacking reliable access to electricity is considered a limit on people's opportunities and quality of life. However, literature indicates that rural electrification is a global phenomenon; there are still many people in the world who do not have access to electricity. In total, nearly 1.1 billion out of the total population of 6.5 billion global and 590 million of the energy poor population in Sub Saharan Africa alone do not have access to electricity (IEA, WEO 2018).

Electric access as one of the infrastructures is a crucial factor in determining the civilization, economic, political, and social transformation of any society (IEA, 2017). Improved household energy technologies for the very poor can prevent health problem globally, these time burdens, like the health effects from indoor air pollution exposure, disproportionately fall on a certain demographic section of society based on age and gender (Adair-Rohani et al. 2016).

The birth of modern electricity in Ethiopia dates back to the late 1890‟s when King Menelik II of Ethiopia acquired the first generator to light his palace and only two years after his victory over Italy. The diplomatic relations between Ethiopia and Germany developed very well during the era of Menelik and he received the generator as a gift from the German government in light of expressing their good relationship (HyPower, 2006). As Dawit, 2010 cite. David Wallechinskyetal, 1977, nearly three decades later, in connection with the coronation ceremony of King Haileselassie in 1930, the supply of electricity were extended to light the streets of Addis Ababa. Since then, the Ethiopian electric energy sector has undergone through several development activities and restructuring.

The first hydroelectric power in Ethiopia, Aba Samuel hydroelectric power which is located on the Akaki River was constructed in 1936. Upon completion it had an installed capacity of 3.3 MW and it started production in 1941. After an additional turbine was installed to the plant in 1953, the plant's capacity reached 6 Megawatt. Nonetheless, the plant stopped working in 1970 for its turbines failed. Operation of this oldest hydropower plant was handed back to state power utility Ethiopia Electric Power in mid-December, 2017 following the completion of a two-year Chinese-led rehabilitation with a capacity of 6.6MW(Ministry of Finance and Economic Cooperation,2017).

In 2005, the Government of Ethiopia launched the ambitious 'Universal Electricity Access Program' (UEAP) with the specific objective to provide grid-based electrification to rural towns and villages. While UEAP constitutes one of the most significant grid expansion programs in Africa; thus far, the focus has been on connecting the town and villages, but not as much on household connections. Between 2005 and 2015, electricity grid was spread to about 6,000 towns and villages from the initial 667, grid coverage reached 60 percent of the towns in the country; however, the household electrification rate remains quite low atabout15 percent, with over 80 million people left without access to electricity (Barnes, 2016).

Access to electricity can make real difference to the livelihood of people (Barnes &Samad,2009).Althoughelectricityalonewillnotreducepoverty,thelackofaccessto this modern energy is a severe constraint to development. Improving access to electricity is thus essential for poverty reduction and its ultimate eradication. To reduce the level of poverty one should enhance income generating means and bring change in quality of life of people. The ultimate objective of

electrification should thus be provision of electricity to a large number of rural town and village dwellers on sustainable basis, and to support income generating activities.

The rural area is suffering from the lack of access to electricity with the rate being 32% coverage, compared to the urban area with92% connection to electricity. In Ethiopia, 55.2% of population is living without access to electricity in 2019 (IEA, 2021). To curb this problem a government of Ethiopia gave strategic priorities in the energy sector and number of grand projects Such as Koysha and Great Ethiopian Renaissance Dam (GERD) are under construction to increase the country's energy production.

Rural electrification is one of the bases for development. It enhances the quality of life, particularly, for rural household; it gives extended chores to be accomplished. The impact of electrification is as diverse as going from darkness to light (Akpandjas, 2017). According to South Nation Nationality and Peoples Regional State annual report (2022), Gurage Zone is one of the 11 zones and 8 special woredas of SNNPRS State with 16 districts, and 8 City Administrations. There are also 411 rural localities (Kebeles) in the zone, out of which only 183 villages are connected with grid electricity so far (GZAO, 2022). Therefore, this research was aimed at analyzing the impact of rural electrification on household's welfare; in case of Gurage zone, SNNPRS.

1.2 Statement of the Problem

Rural electrification generates substantial and encouraging changes in the welfare of the rural communities. The considerable benefit of rural electrification is as crucial requirement for the improvement of the quality of life in rural areas and the transformation of the economy (Khandkeretal.2013). In recent years, there has been a growing interest in understanding the role of rural electrification (RE) programs in improving welfare and poverty reduction. Providing access to electricity remains one of the critical binding constraints in spurring rural development (UNDP, 2015). However, nearly 1.3 billion individuals around the world lack access to electricity. Of these, over 770 million reside in sub-Saharan Africa (IEA, 2019).

Like other developing countries in Sub-Saharan Africa, Ethiopia has been striving to expand its currently limited basic public service deliveries and infrastructures nationwide, including, hospitals, schools, roads, irrigation facilities, electricity, clean water and sanitation. Among them, rural electrification has been ranked as a priority for government development given its welfare-improving and poverty-reducing role. During the past decade, there has also been substantial development assistance to extend coverage of electricity grids in rural Ethiopia from both multilateral donors, such as the World Bank (WB) and the African Development Bank. The assistance is also in line with the United Nations' Sustainable Energy for all, which was launched in 2011 to make sustainable energy for all a reality by 2030 (Auroshis Rout et al., 2021).

The international energy agency projects that achieving universal electrification will cost about $49 billion birr per year between 2019 and 2030.Report from Pathway to Prosperity Ethiopia Case Study (2021)show that, the Ethiopian Government dispersed over $10 billion for public investment over the past decade and now Ethiopia has the second-largest electricity capacity in Africa. However, generation capacity of electricity ranks around 143rd globally and over half the population is without electricity energy. Electric energy is the driver of activity in every economy and its importance cannot be overemphasized. It enhances quality of life at the household level and stimulates the economy at a broader level. The immediate benefit of electrification comes through improved lighting, which promotes extended hours of study and in turn contributes to better educational achievements.

Lighting can also benefit many other household activities, such as sewing by women, social gatherings after dark, and many others. Moreover, Electronic devices such as radios and television also improve the access to information by rural households and can provide entertainment to family members. According to World Bank (2014), in Sub-Saharan Africa, the average household spends around 2 hours per day collecting firewood (Kammila et al., 2014). Globally, these time burdens, like the health effects from indoor air pollution exposure, disproportionately fall on a certain demographic section of society based on age and gender (Adair-Rohani et al., 2016).

Electrification is a service which can pave way for progress and growth on issues such as poverty alleviation, gender equity and public health. However, the empirical evidence on the welfare gains from rural electrification is mixed. Some studies have found positive impacts on income, consumption; education (Khandkar et al., 2012; 2013). Mam (2018) also found that, investment in household electrification contributes to social and economic development and improves quality of life. Moreover, Studies conducted in Asia had also found positive effects of impact of rural electrification on household welfare (Khandker, et al., 2014; Van de Walle, et al. , 2015; Braham , 2013). In contrast, other studies failed to observe such impacts (Bensch et al., 2011; Peters and Sievert, 2016). Lee, Miguel (2020) also founds that rural electrification to be welfare reducing with negligible benefits and large costs, while Dinkelman (2011) found only some positive effects in South Africa. From Given evidence, the welfare gain from rural electrification is positive in Asia and less positive effect in Africa as compared to Asia.

Therefore, it is tremendously important to understand whether rural electrification benefit justifies such high investment cost. In this context, findings of the study add to existing body of evidence and provide important information to policymakers on impacts of rural electrification on household's welfare in context of Ethiopia particularly in study area, where there is little evidence that shows whether there is any welfare impact. In addition, this paper further contributes to the broader literature on infrastructure and economic development in issue of development economics. Furthermore, the study also collected household and village-level data in rural parts of Ethiopia (Gurage Zone) using a carefully structured and non-structured household interview. Therefore, this study tried conduct to fill a knowledge gap in literature.

1.3 General Objective

The General objective of the study is to analyze the impact of rural electrification on rural household's welfare in Gurage Zone, SNNPR.

1.3.1 Specific Objectives

1. To analyze the determinants of rural electrification in Gurage Zone;
2. To analyze the impact of rural electrification on rural household's consumption expenditure in study area.

1.4 Research Questions

The following fundamental questions are raised as basis for the study:

1. What are the determinants of rural electrification in Gurage zone?
2. What is the impact of rural electrification on rural household's consumption expenditure?

1.5 Significance of the Study

The study assessed information from voice of concerned body and other related literatures in response of impacts of electricity in rural household's welfare. Thus, findings of the study can be utilized in various ways. Firstly, it provides baseline information to the implementers of rural electrification projects as well as other players and stakeholders in the electricity and energy industry. Secondly, the zone and regional governments will use the results of the study so as to make policy decisions relating to improvement of rural electricity. Thirdly, as impacts of electricity in rural households welfare in the study area is less researched before, the results of the study provides base line information for further research. Moreover, it may help to development practitioners and other stakeholders that may involve in rural development particularly in the study area.

1.6 Scope of the Study

This study was conducted to assess impacts of rural electrification in household's welfare on Gurage Zone, SNNPR, and Ethiopia. To estimate the socio economic impact role of electrification in rural household's welfare, the study adapted to one-dimensional welfare based on cross-sectional data collection from with and without electricity sample household.

1.7 Limitation of the Study

The study was undertaken in Gurage zone in South Nation Nationality and Regional State, Ethiopia, with the aim of assessing socio economic impacts of electricity on rural household welfare. Hence, generalization of some facts and findings of the study were limited to the specific area that was undertaking the study. A large sample size that was made up of different Zones from within and outside South Nation Nationality and people Regional State had allowed for generalizations of the findings. Nevertheless, the study research missed such opportunity due to financial and time constraints.

1.8 Organization of the Thesis

This study is organized in to five chapters. Chapter one constituted the introduction, which focuses mainly on the background, statement of the problem, objectives, research questions, significance and scope of the study. Chapter two deals with reviews of different literatures about definition of terms, theoretical, empirical evidence for rural electrification and the conceptual frame work of the study. Chapter three is designed to provide some clue about the study area, the methodology and model specification used in this study. Chapter four presents the results of the empirical analysis and discussion of the findings. Chapter five presents conclusion and recommendation

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CHAPTER TWO

LITERATURE REVIEW

2 Theoretical Literature Reviews

Definition and Basic Concepts

Electrification: - is the process of powering by electricity and is usually associated with changing over from another power source. The broad meaning of the term, such as in the history of technology and economic history, usually applies to a region or national economy. Electrification is the build out of the electrical generating and distribution systems and is in progress in rural areas in some developing countries. This included the change over from line shaft and belt drive using steam engines and water power to electric motors.

The electrification of particular sectors of the economy is called by terms such as factory electrification, household electrification, rural electrification or railway electrification. From development view point, the term "electrification" is defined as a process of connecting a house, village (town) or an area with a supply of electricity. It is the process of providing electricity to the households and villages located remotely or in isolated areas of a country (IEA, 2010).
Rural Electrification is the process of bringing electrical power to rural and remote areas and powering by electricity to support the economic, social, environmental and political development of either a region or most rural and remote areas. The concept of rural electrification can also be defined as the supply of electricity to the rural area to bring about important social and economic benefits (URT, 2004).

Welfare is the provision of a minimal level of wellbeing and social support for all citizens, sometimes welfare is referred to as public aid. The concept of welfare and utility are related but not identical: welfare is derived from either a direct consumption of goods or characteristics of goods while utility is derived from only consumption (Grootaert, 1982). Atkinson (1998) cited Sen.'s view of "welfare theory" it is beyond individual utilities weather it is treated as pleasure or fulfillment". As cited by Grootaert (1982) Muellbaure (1980) outlined that welfare is determined by consumption of goods and services at household level, household composition and access to public services; and leisure time at individual level. Welfare study identifies the group who are getting better or worse-off and the dimension(s) in which they

mainly do so in society.

Social welfare is also refers to having access to what is needed for a good life. Further, the scope of the concept seems almost all embracing. Some would argue that welfare primarily includes the covering for food, shelter, health care; others would include needs for education, culture, work, leisure, solidarity, mobility, recognition, democratic participation and the like. (Andersen 1988).

2.1 Overview of Rural Electrification

Electrical energy is one of the prime inputs for social and economic development globally and remains partly a fundamental prerequisite to economic development (Ahlborg et al., 2011). Accelerating the introduction of basic, clean energy services is seen as a key strategy for promoting sustainable development in rural areas. Still, many people worldwide lack access to modern energy, such as electricity, and Africa lags behind other developing regions of the world. Most developing countries underpin the need for RE policies in intensifying RE programs, especially in Sub-Saharan Africa where over 585 million people lack access to electricity (IEA, 2011).

Electricity access is increasingly at the forefront of governments 'preoccupations, especially in the poorest countries. As a consequence, a lot of rural electrification programs and national electrification agencies have been created in these countries to monitor more accurately the needs and the status of rural development and electrification. Nonetheless, success stories of rural electricity have been reported world over. For instance, China implemented the RE program and currently has only 0.6% population without connectivity, China adopted a six phase framework aimed at developing locally managed electrical programs, and combination of central grid extension and local grids (Zhang et al.2011). Conversely, Costa Rica and Brazil expanded RE increasing its adoption to almost 100% (Barnes, 2007 and Niez, 2010).

Sub Saharan Africa has experienced low rural electrification rates. Despite significantly low rates of RE accessibility in Africa, some countries like Ghana with urban and rural accessibility at 99% and 49% respectively (Kemausuor et al., 2012). In South Africa, technology development through prepaid metering and blanket electrification, played an essential role in reducing the real cost per connection (Bekker et al., 2008). Evidently, successful RE programmers have been realized under intense political support, participation of special institutions and local committees. However, despite these efforts, many parts of the country have remained unconnected to

electricity. REA is a single autonomous authority with a clear mandate to accelerate the pace of electrification in rural areas (REA, 2013).

The government‘s intentions are that all Kenyans have access to electricity by the year 2030 as envisaged in the country‘s long term blueprint for development, the Vision 2030. Electrical energy for household use remains an important avenue of alleviating rural poverty especially in Developing Countries (Abdullah et al., 2012). There is continued emphasis on increasing rural electricity accessibility to rural households globally whose adoption at household level is quite low in the SSA. However, increased accessibility to RE does not translate into automatic adoption by rural households (Christensen et al., 2012). Additionally, accessibility to a grid connection does not guarantee use of electricity among all end users (Winkler, 2011).

Ethiopia has a proactive program to reduce CO2 emissions and affirming the development of renewable energy. National Planning Commission of Ethiopia (2021) in the ten years perspective developmental current national plan also called Ethiopia 2030: The Pathway to Prosperity (2021–2030), the energy sector is included as one of the strategic areas to build climate resilient green economy by 2030. The focus areas of energy in the current national 10 years perspective developmental plan include equity in access to electricity services, energy access and quality, alternative sources of energy, reliability of electricity infrastructure, investment, and income in the energy.

2.2 Impact on electricity

Electricity may not solely be responsible and able to create all the conditions for economic growth, but energy services like lighting, cooking, cooling, heating, etc. are obviously essential for basic human and economic activity (IEA, 2013). In theory, access to electricity can improve socio-economic conditions in developing countries because of its influence on key components of poverty: health, education, income and environment (Kanagawa and Nakata, 2008). Electricity is seen as a pre-requisite for productive activities because there is a strong correlation between rural poverty and access to electricity (Chaurey, Ranganathan and Mohanty, 2004).

Electrification can lead to improvements in household economic indicators through adoption of appliances that increase productivity, enabling development of household enterprises, reducing the time needed for household chores (including firewood collection), increasing the time available to engage in income generating activities. Productive use of energy in rural areas is expected to result in increased rural productivity, greater economic growth, and a rise in rural employment, which would not only raise incomes but also reduce the migration of the rural poor to urban areas (Cabraal et al., 2005). With respect to agricultural production, electricity use result to modernized agriculture providing motive power for agriculture-based industries and power farm machinery (Cabraal et al., 2005).

Electricity provides significant indirect social benefits such as greater equity and improved quality of life. Women in households with electricity were much more aware about gender equality issues than women in households without electricity (Barkat, 2003). Electrification programs should therefore be combined with a strong development focus and target productive sectors (Christensen et al., 2012).

Rural development is referred to as development that benefits rural populations; where development is understood as the sustained improvement of the population‘s standards of living or welfare (Anríquez *et al.,* 2007).Access to reliable electricity has long been recognized as a driver of social and economic development. A growing body of literature shows that low access to and poor quality of electricity affects households’ living standards and social welfare (Samad and Zhang 2016).

Household access to electricity facilitates timely cooking of food, provides a comfortable living temperature, lighting, and enables the use of communication appliances, which all contribute to the individual and family quality of life (Mvondo, 2010). Once households are connected to electricity, the first and most immediate benefit is more lighting. This enables children to spend more time studying in the evening, gives adults more time and flexibility for completing household chores, and allows home-based income-generating activities to continue later into the evening More study time for children can lead to higher school enrollment and grade attainment (Khandker, Barnes and Samad, 2013).

In addition, electric lighting reduces households' dependence on alternative lighting sources, most notably kerosene, thereby lowering smoke and indoor air pollution and the probability of various respiratory diseases. After electrification, households acquire such things as radios, television sets, fans, air conditioners, space heaters, and refrigerators increasing exposure to knowledge and information and improving comfort, food storage, and hygiene. Given the substantial benefits of electricity, access to modern energy has been identified as key to fulfilling the United Nations Millennium Development Goals (UNDP 2005). Access to electricity also enhances quality of life at the household level and stimulates economy at a broader level (Khandker et al., 2009). Electricity is a critical tool for use at micro level (household). Energy services are a crucial input to the primary challenge of providing basic needs among households. For instance, household access to electricity facilitates timely cooking of food, provides a comfortable living temperature, lighting, and enables the use of communication appliances, which all contribute to the individual and family quality of life (Mvondo, 2010). Numerous uses of electricity by households that are seen as consumptive (e.g., home lighting or television) in fact help achieve political freedom, opportunities to receive basic education, opportunities to receive health care, and freedom to participate in the labor market (Cabraal, et al.,2005).

2.3 Analytical and Methodological Framework

2.3.1 Analysis of Welfare

Analysis of welfare uses microeconomic techniques to evaluate welfare at the aggregate level. A typical methodology begins with the derivation of a social welfare function, which can then be used to rank economically feasible allocations of resources in terms of the social order or preference (Arrow, Kenneth J, 1951). Such functions typically include measures of economic efficiency and equity, though more recent attempts to quantify social welfare have included a broader range of measures including economic freedom.Welfare from the general meaning, welfare refers to the various conditions making people's lives happy, which includes obtained protection and care for the individual's body and various factors affecting the free development of an individual's intelligence and spirit (Zhao, Guo, Zhang, & Li, 2014).

From the general meaning, welfare refers to the various conditions making people's lives happy, this includes obtained protection and care for the individual's body and various factors affecting the free development of an individual's intelligence and spirit (Zhao, Guo, Zhang, & Li, 2014). However, the meaning of social welfare is beyond the individual scope, which requires one to consider the way to live a better life from the social aspect (Yew-Kwang Ng, 2003).

The issue related to social welfare involves two main points (1) what the society should do to help people live a happy life and (2) what kind of regime and policy the society should undertake to guarantee people's happiness. Therefore, the social welfare of electricity service refers to the welfare brought by the implementation of electricity service led by the government and implemented by electric power enterprises in an economy-acceptable and quality-guaranteed way. The welfare benefits from rural electrification invariably result from the use of some type of appliance or machine. Thus, it is necessary to trace some of the pathways of electricity and its eventual social and economic impacts. For example, when households are connected to electricity, the first and most immediate benefit is more lighting. This enables children to spend more time studying in the evening, gives adults more time and flexibility for completing household chores, and allows home-based income-generating activities (such as shops) to continue later into the evening can children lead to higher school enrollment and grade attainment (Khandkeret.al 2014).

In addition, electric lighting reduces households' dependence on alternative lighting sources, most notably kerosene, thereby lowering smoke and indoor air pollution and the probability of various respiratory diseases. After electrification, households acquire such things as radios, television sets, fans, air conditioners, space heaters, and refrigerators—increasing exposure to knowledge and information and improving comfort, food storage, and hygiene.

Given the substantial benefits of electricity, access to modern energy has been identified as key to fulfilling the United Nations Millennium Development Goals (UNDP 2005). The adoption of grid electricity first means having access to a reliable and inexpensive electricity supply. Consumers soon begin buying a variety of electric appliances, including light bulbs, radios, television sets, space coolers/heaters, cooking devices, and other small machines.

The next step is that these appliances produce results, such as more light, which allows more study or home production, more access to information and entertainment, more comfort, better food preservation, more efficient cooking, and finally more motive power for productive uses (IEG2008). At times, households use small cooking devices, such as hotplates or electric coils, for heating water. In the case of rural Ethiopia, people sometimes cook with the electric injeramitad (hot plate for cooking traditional flatbread). In addition, in some instances, electric lighting and small grinders allow people to prepare food more efficiently, thus freeing up their time for other activities (World Bank 2004).

The use of such appliances, in turn, can create intermediate outputs, such as extended study time, longer hours of operation for home businesses, better business knowledge, better health, and more efficient business operation. These intermediate outputs can lead to final development outcomes, such as improved education, health, and income. In the case of education, for example, children's increased study time due to electric lighting results in better performance at school; in the long run, this leads to higher educational attainment and ultimately higher income.

2.3.2 Measurement of Welfare

What is the measurement of welfare in a nation? In contrast to the notion of 'wealth' in classical economics, welfare has been difficult to reduce to a single economic unit such as gross domestic product (GDP). This complexity, and the lack of agreement upon what counts as welfare and what does not, has resulted in an absence of standardized units or scales that could be used for cross-country comparisons. In the 1970s, a new approach to measuring welfare was pioneered by the Social Indicators Movement

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A new generation of social scientists began questioning GDP and Gross National Product (GNP) as valid measures of welfare, at least when used as exclusive indicators (Cobb and Rixford 1998). Instead, the Indicators Movement started defining various self-reported measures of 'subjective' well-being and quality of life, which actually relied on scales that could easily be administered in surveys, such as Hadley Cantril's Self-anchoring striving scale (Cantril 1965).

The Easterlin paradox would become a recurring question in the emerging field of happiness studies, and it sparked a scholarly debate on the relationship between economic growth and subjective well-being. Easterlin argued that economic growth only increased happiness up to ascertain level. People living in rich countries were in fact happier compared to people living in poor countries; however, within a single rich country, further economic growth (measured as GNP) did not seem to cause increased happiness. Instead, Easterlin concluded that 'higher income was not systematically accompanied by greater happiness' (Easterlin 1974).

Easterlin's paradox is not the only critique of purely economic measures of welfare at this time in history. However, Scitovsky (1976), viewed of a rational consumer in neoclassical economics and showed how American society created hard-working, increasingly consuming, but quite unhappy citizens that did not experience any real improvements in the general standards of welfare. However, in the 1960s the crisis in welfare economics had already begun, as manifested by the 1961 United Nations' interim guide to define 'levels of living', as a set of indicators for assessing aspects of welfare beyond economical measurement, for example, education, health, nutrition, freedoms and housing (United Nations 1961). This indicator approach broke abruptly with the welfare economics tradition since it downplayed economic measurements as merely being one of several. Instead, it brought forth a set of 'objective' indicators of actual living conditions, combined with indicators that were more difficult to compare between nations, for example, 'human freedoms', which were regarded as varying between cultures. The indicator approach and the quest for alternative measures of welfare had gained momentum in many countries.

In welfare analysis the central issue is determining plausible welfare indicator for use. However, getting credible welfare indictor is not as such easy since the living standard concept is inherently multidimensional (Deaton, 2002). According to Grootaert (1982) welfare can be can be summarized in to three such as true index of welfare, full total income and full expenditure. (1).True index of welfare: the index is derived from household consumption and employment behavior al model with the idea that association of welfare associated with preference such as goods, leisure, household composition, access to public service, decision to have children.

Even if this method of measuring welfare is well recognized in its direct measure it has critics such as: it is not applicable in areas where labor market is failed or absent, it falls to capture voluntary non-participation. Thus, the identification and measurement problem lead to unreliable and inconsistent measure of welfare. Full income concept: in this approach welfare is measured by the total income the household generate from any source of income plus the monetary value of leisure activities and non-paid home activities (Adeniyi, O. A., 2014). Measure of welfare by consumption: welfare is considered as the function of consumption of goods and services with the assumption preference is revealed by purchase of goods and services. Although, different indicators are used for welfare analysis, consumption is taken as a proxy for living standard indicator (Moratti, and Natali, 2012).

2.3.3 Models of Impact Evaluation

Impact evaluation assessment is simply evaluating how outcomes of interest are changed as a result of particular intervention such as project, program or policy (Khandker, 2010). Moreover, any intervention has a policy quest to determine the effectiveness of the intervention to enrich the pertinent goal. Thus, impact evaluation may qualitative, quantitative or both.

Qualitative impact evaluation is simply the assessment of the impact regarding on the identification of the way to implement, operate the intervention not the outcome of beneficiaries due to intervention. Hence, it can't indicate what if in the absence of the intervention (Gertler et al., 2011). Unlike qualitative impact evaluation, quantitative impact evaluation indicates what happen in the absence of the intervention and evaluate the outcome against the counterfactual outcome (Gertler et al., 2011).

Quantitative impact evaluation may be two types ex post and ex ant. An ex-post evaluation examines the actual impact/ outcomes after program based on actual data either after or both before and after program implementation across participants and non-participants (Khandker et al., 2010). While an ex-ante evaluation predicts the possible benefits or pitfalls of an intervention using data before intervention through simulation or economic models at the given individual behavior and markets (Gertler et al., 2011).

Impact evaluations are technical exercises that rely on econometric and statistical models. There are three main kinds of impact evaluation designs. These are experimental, quasi experimental and non-experimental with which are respectively associated with control groups, comparison groups, and non-participants. Impact Evaluation (IE) rigorously measures the impact that a project has on beneficiaries. It typically does this by comparing outcomes between beneficiaries and a control group (AIEI, 2010*)*. In Experimental or Randomized Control Design method selection into the treatment and control groups is random within some well-defined set of people. In this case there should be no difference (in expectation) between the two groups besides the fact that the treatment group had access to the program.

In Non-experimental or Quasi-Experimental Design methods it can be used to carry out an evaluation when it is not possible to construct treatment and comparison groups through experimental design.

Propensity score matching methods require that a separate propensity score specification be estimated for each treatment, group-comparison, and group combination. Furthermore, a researcher should always examine the sensitivity of the estimated treatment effect to small changes in the propensity score specification; this is a useful diagnostic on the quality of the comparison group (Baker, 2000). In the estimation of average treatment effect using propensity score matching method there are about five steps that is to be followed.

Propensity Score Matching (PSM) is used to estimate what would have happened to someone under the counterfactual through estimating participant's outcome in the absence of electrification using the observed outcome for a similar non-participant (Lance et al., 2014). The ultimate goal of matching is match participants with non-participants based on the probability of electrification in the treatment through observed characteristics (Khandker et al., 2010). The underling concept in PSM is that if treated and control gr oups are matched, both have same probability of being participant (Baker, 2000). Once a matched sample has been designed, the treatment effect is estimated by comparing outcomes of treated and controlled group in the matched sample.

Propensity score matching has advantages and disadvantages. Advantages propensity methods over the other method are: first, it reduces dimensionality of matching (Gilli and Rampichini, 2011). Second, it is possible to do in the absence of baseline or panel data (Khandker et al., 2010). Third, it avoids an ethical problem which is denying of potential beneficiaries as a result of random assignment (Baker, 2000) . Fourth, data generation is less costly as compared to experimental al., 2011).

The regression discontinuity design (RDD) is also an impact evaluation method that can be used for programs that have a continuous eligibility index with a clearly defined cut-off score to determine who is eligible and who is not. Because the RDD method estimates the impact of the program around the cut-off score, or locally, the estimate cannot necessarily be generalized to units whose scores are further away from the cut-off score, this is, where eligible and ineligible individuals may not be as similar. The fact that the RDD method will not be able to compute an average treatment effect for all program participants can be seen as both a strength and a limitation of the method, depending on the evaluation question of interest.

2.4 Review of Empirical Literature

Electricity infrastructure as consumption and an intermediate good is linked to welfare in income and expenditure. Literatures regarding the impact of rural electrification indicate two lines of evidence. Khandker, Barnes, and Samad (2013) studied a World Bank rural electrification program in Vietnam implemented in six regions between 2000 and 2005.Using a two-period household panel data set with an electrification intervention. This shows that, children in households connected to the electricity grid tend to stay in school longer. Access to the electricity grid also increased the enrolment rate by approximately 8% for boys and 9%for girls and years of school completed by 0.16 for boys and 0.07 for girls. It also increased household incomeby28% and consumption by22.7%.

Tanguy Bernard (2012) reviewed trends in rural electrification the in Sub-Saharan Africa. In particular, the study shows that motivations for rural electrification programs have evolved significantly over the years, following changes in development paradigms. Findings of the study show, however, that knowledge of the impact of this has only marginally improved :low

connection rates and weak productive utilization boys' completed years of schooling by 0.23 and girls' completed years of schooling by 0.16.

Van de Walle et al. (2015) examined long-run effects at both regional and household levels for the Indian grid roll-out program. They used data sets from 1982 and 1999 on study population in 15 states in which the connection status increased substantially in between these two surveys. Kumar and Rauniyar (2011) established that, access to electricity has significantly increased years in schooling for additional 0.75 additional years and increased study time at home for the children by 9.366 minutes/day in Bhutan. Scott (2015) revealed that only 35% of primary schools in Africa have access to electricity which then hampers the children to have good.

Rud (2012) investigated the effect of electricity provision on industrialization using a 20-year-panel data (from1965-1984) of Indian states, of which many had receive access to the electricity network in the course of the observed period. He used ground water availability as a predictor for network expansion (since water pumps played an important role in the green revolution) and hence as a source of exogenous variation. The findings show that an increase in one standard deviation in the measure of electrification is associated with an increase of around 14% in manufacturing output for a state the mean of the distribution. Thus the study found that electricity provision increased manufacturing output by approximately 14%. Studies revealed a lack of effect of rural electrification (Sievert, 2016, Peters and Sievert, (2016). and Lenz et al. (2017). Given evidence of positive effects found in Asia and less positive effect in Africa as compared to Asia, this study is intended to examine whether there is any positive effect in Ethiopia particularly in study area.

2.5 Overview of Ethiopia Energy Policy

Ethiopia has invested substantial resources in expanding generation capacity and grid net- work. As a result, installed generation capacity has quadrupled within a decade from around 1,100 MW in 2009 to 4,512 MW in 2020 out which 90 percent is generated from hydropower, and the country is the third highest available generating capacity in Sub-Saharan Africa (SSA). Ethiopia is also advancing efforts to diversify its energy mix with wind, solar, and geothermal sources to complement the large hydropower base and to mitigate vulnerability to fluctuations in rainfall. Given its massive clean energy reserves, Ethiopia aims at becoming a power hub in East Africa and a cornerstone of the regional power market and of the East African Power Pool (EAPP).

The country, Ethiopia, has a considerable renewable energy endowment, with an abundant hydropowerpotential,solarandgeothermal,aswellfossilfuels.However, it has a potential of renewable energy and up to 45,000 MW from hydropower, 10,000 MW from wind, 5000 MW from geothermal and an average of 5.26 kWh per square meter per day from solar energy (Asress, 2013). In terms of hydropower potential, Ethiopia has a considerable renewable energy endowment, with an abundant hydropower potential. Despite the huge potential to exploit, very small portion has been developed owing to lack of financial resources amongst other factors (EEPCo, 2021).

Ethiopia is gifted with significant renewable energy resources, with huge potential of hydro, solar, wind, bio and geothermal power. It is one of the few countries in sub- Saharan Africa, if not the world, which generates more than 90% of its electricity from renewable resources. The existing total electricity generation capacity installed in Ethiopia is about 4244.67 MW, of which hydropower takes the largest share (Mengistu, M.G, 2015).The estimated exploitable potential for hydropower is 45 GW, wind is 10 GW, geothermal is 5 GW, and solar irradiation ranges from 4.5 kWh/m2/day to 7.5 kWh/m2/day, Genale Dawa III power plant, 324 MW of wind power, 7.5 MW of Geothermal, 317 MW of biomass and others (Ashebir, 2020).

The National Energy Policy of 1994 was implemented with the goal of addressing the problem of energy supply and its utilization (EEA, 2005). This policy prioritized to enhance hydrological energy resource development for the power sector energy efficiency, and transition to modern energy services for the household sector. According to 2010 World Bank data, the majority of the Ethiopian population about 83.2% are lives in rural areas, where modern energy services are rarely available and largely rely on traditional biomass energy sources, such as wood, cow dung and agricultural residues; for cooking and heating (Tessama , 2013).

The Ethiopian Electric Power Corporation (EEPCO), founded in 1956, is the state-owned utility in charge of electric power generation, transmission, distribution, sales service in the country and maintenance of the national grid. The company has been undergoing various continued transformations, such as via Customers' Management System (CMS), decentralization of Accounting and Billing system from once highly centralized down to the regional distribution offices, districts, and customer service centers ,and Prepayment (Metering) System, in an effort to realize its long term strategic vision of becoming a center of excellence in providing quality electric service to everyone's doorstep and being competitive in energy export.

Ethiopia has, for the first time in its history, opened up its electricity generation and distribution sector to private investors. The decision follows the ratification of a new proclamation by Ethiopia's House of People's Representatives this year (2018).

Nowadays Ethiopia total installed capacity of electric generation is about 4.5 GW mainly generated by hydro (90%) and followed by wind energy 7.6%. According to Ethiopia country report only about 45% of the country population has access to electricity. From this, urban population has 97% access to electricity, while in rural areas electricity access remains extremely low at about 31% (Ashebir, 2020).

Ethiopian ministry of water, irrigation and energy prepare a draft of national energy policy in 2013, to give emphasis in the development and utilization of all renewable energy sources. The key goal in the updated national energy policy is to ensure the availability, accessibility, affordability, safety and reliability of energy services to support accelerated and sustainable social and economic development and transformation of the country. The Energy policy seeks to meet the following broad objectives:-

- ✓ Improve the security and reliability of energy supply and be a regional hub for renewable energy.
- ✓ Increase access to affordable modern energy.
- ✓ Promote efficient, cleaner, and appropriate energy technologies and conservation measure.
- ✓ Strengthen energy sector governance and build strong energy institution.
- ✓ Ensure environmental and social safety and sustainability of energy supply and utilization.
- ✓ Strengthen energy sector financing (ibd)

Ethiopia has a proactive program to reduce CO2 emissions and affirming the development of renewable energy. Since Ethiopia's energy consumption is mainly based on traditional energy sources, the government has involved a remarkable initiative under different policies related to energy production, deployment, and electrification for the last two decades. Since Ethiopia's energy consumption is mainly based on traditional energy sources, the government has involved a remarkable initiative under different policies related to energy production, deployment, and electrification for the last two decades. Major emphasis was dedicated to hydropower, solar and wind energy resources. The GTP-1 (2010–2014) and GTP-II (2015–2020), each represents includes energy policies. The main objectives of energy policy involve ensuring a reliable supply of energy, encouraging a remarkable shift from the traditional energy source to a modern energy source, and give priority to the development and dissemination of indigenous energy resources. In the GTP-II plan, the energy policy includes the generation of energy from different renewable source.

As The National Electrification Program (NEP), that sets a target of universal electrification by 2025, presents an integrated approach of grid and off-grid solutions. The majority of the Ethiopian population about 83.2% is lives in rural areas, where modern energy services are rarely available and largely rely on traditional biomass energy sources, such as wood, cow dung and agricultural residues; for cooking and heating (WB, 2010).

According to World Bank report, it is expected that a rapid growth of renewable energy power plants installations will be carried out and about 500 MW of biomass capacity is also expected to be brought in the power mix by 2025. The country has initiated to construct a number of large hydroelectric projects which includes 2,160 MW Gilgel Gibe IV (Koysha) hydropower project and also the massive 6,500 MW Great Ethiopian Renaissance Dam (GERD) being built on the Abbay (Blue Nile) River, which will be the largest dam in Africa and the sixth largest in the world upon completion (Ashebir , 2020).

Despite persistent challenges, Ethiopia is undertaking great effort towards the development of renewable energy technologies including the development of hydropower, wind, solar and geothermal energy. The country has exploited only 5% of its full hydropower potential, and other sources are not fully developed. Hence, over 65 million people still do not have access to electricity(Girum et al., 2021). The country is hoping to complete the grand Ethiopian renaissance dam in the coming few years which will be utilized mainly for electricity generation. The first filling of the dam (4.9 billion cubic meters of water) has completed in July 2020 and the second phase of filling of the dam in July 2021, indicating significant development of hydropower energy sources and the third in 2022.

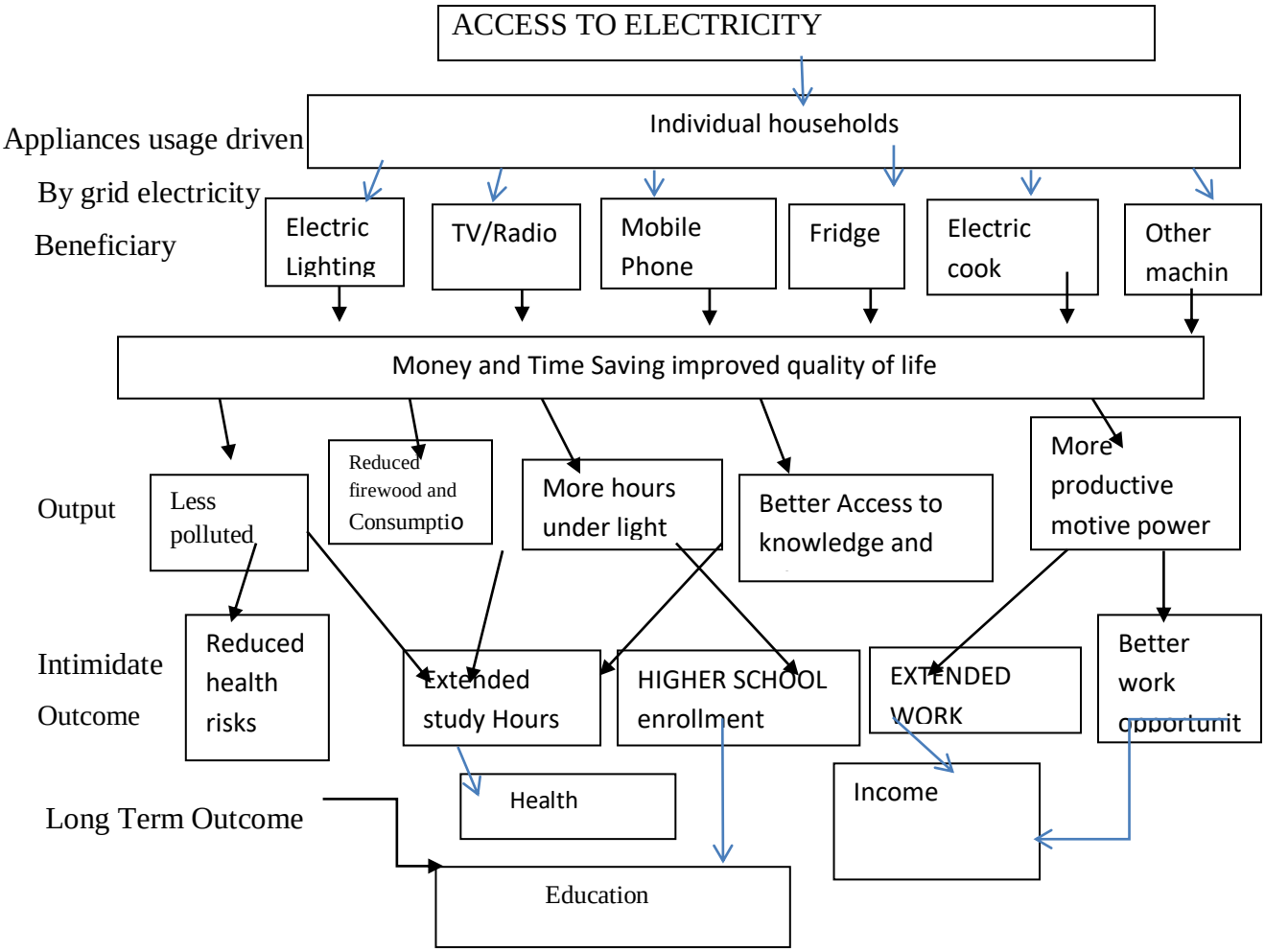
2.6 Conceptual Framework

For this study, the independent variable is rural electrification while the dependent variables household welfare, including income and consumption, education and health. Households ,who are connected to the electricity grid, would purchase appliances, such as electric lamps, radios, televisions, refrigerators, fans, electric cooking and electric machines, that produce outputs, such as improved lighting, access to knowledge and information, better food preservation, greater comfort, more efficient cooking and more productive motive power(Khandker et al., 2013). There are various pathways by which rural electrification affects household's welfare. Firstly, rural electrification can also affect consumption directly through the reduction in spending on traditional lighting as well as the increase in spending on connection fees and tariffs. Secondly, Electrification leads to education improvements primarily through increasing the time available for children to go to school, through substitution in time spent on household chores with that spent on studying.

This is attributed to the increase in the quality and quantity of household lighting. These outcomes can also be achieved through community-level effects of electrification, e.g. schools getting access to electricity will also lead to access of resources such as internet and computer labs. Community level effects also capture the increases in household-level education expenditure (Lipscomb et al. 2013).

Thirdly, With regards to health impacts, electrification primarily leads to health improvements through its negative impacts on kerosene and biomass fuel (example: firewood) use and the subsequent reduction in indoor air pollution. Barron & Torero (2015) electrification leads to fewer respiratory infections in children under six years of age. This age effect comes from reduction in kerosene use and associated particulate matter concentrations in electrified households (Samad et al. 2013).

Fourthly, Electrification can also impact employment, labor supply, income and other productive uses of energy (Bonan et al. 2017) and households engaging in both agricultural and non-agricultural activities are induced to invest in electric machines, which permits them to attain productive motive power, thus improving the efficiency of their business activities, which results in a surge in productivity and thereby an increase in income and consumption (Lenz et al., 2017). Figure 1 shows the conceptual framework for this study with independent and dependent variables including the factors to be assessed to test for the impacts that the dependent variable has on independent variable.



Adopted from Peters and Sievert (2016).

Figure 1: Access of Electricity and its outcome in rural household

CHAPTER THREE

RESEARCH METHODOLOGY

In this chapter the description of the study area, research design, sampling techniques and sample size, types and sources of data, methods of data collection, description of the variables and their expected signs were presented.

2.7 Description of the Study Area

Gurage zone is one of the zones and special woredas of Southern Nations, Nationalities and Peoples regional state (SNNPRG). It is located on 1000-3700 meter above sea level. Its weather condition is favorable to different kinds of agricultural activity. Agro-ecology of Gurage zone is mostly record is 32^0c and 7 ^{0}c respectively (Gurage Zone Finance and Economics department, 2021). In Gurage zone divided into four groups these are 4.1% Wurich, 27.5% Dega, and 65.3%Weyna dega, 3.1% kola. It is located in the western part of central Ethiopia. It is bordered on the south east by Hadiya on the west, north and east by State of Oromia, Yem on south west and on the southeast by Silte Zone. Its land area is estimated as 5893.4 hectare. The zone is divided in to 16 Districts and 8 city administrations. The distribution of rainfall and temperature mainly follows this pattern. The annual average rainfall ranges from 800 MM/annum -1,400 MM/annum. There is 449 kebeles, out of which 38 are urban and 411are rural kebeles. In total of the rural woreda 183 kebeles are electrified (GZAO, 2022). According to Gurage Zone Finance and Economics department (2021) the current estimated population data is 1,888,924 and of which 917,149 are male and 971,775 are female. Among 1,596,656 households are 768,336 males and 828,320 are females (GZDOFED, 2021).



Figure 1:-: Map of Gurage zone

2.8 Research Design

Research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure (Kothari and Garg 2014). The design which gives the smallest experimental error is considered the best design in many investigations (Kothari and Garg, 2014). A survey is an attempt to collect data from members of a population in order to determine the current status of that population with respect to one or more variables. Survey research is therefore a self-report study which requires the collection of quantifiable information from a sample (Mugenda and Mugenda, 2003). The cross sectional survey design involves making observations of a population or sample of the study at one point in time (Babbie, 2010). With respect to the objectives and the nature of research questions, the study employed a cross-sectional survey design which is commonly used in social science studies since it allows collection of in-depth data on different groups of respondents at one point in time.

2.9 Sampling Techniques

Sampling technique is the process of selecting respondents that constitute a sample (Kothari &Garg, 2014). The study utilized multi-stage sampling techniques. In the first stage, simple random sampling technique was used to select the study area. Therefore, Gumer, Cheha, Abeshge and Edezaworeda were selected as representative of sixteen woredas of Gurage Zone. In second stage, random sampling procedure is also used to select two kebeles, electrified and non -electrified kebele from each worda to make a total number of eight. Out of them, Zizencho, Gerarena-yeferema, Darecha-Zegebaboto and Lay-gerabakebeles are electrified and Esenena Adangezo, Buchach, Wera- Debane and Fenta kebeleies are non-electrified. Finally, at kebele level the population was stratified into those with electricity and those without. From each stratum households with and households without national grid electricity services was sampled based on probability proportional to the size (PPS).

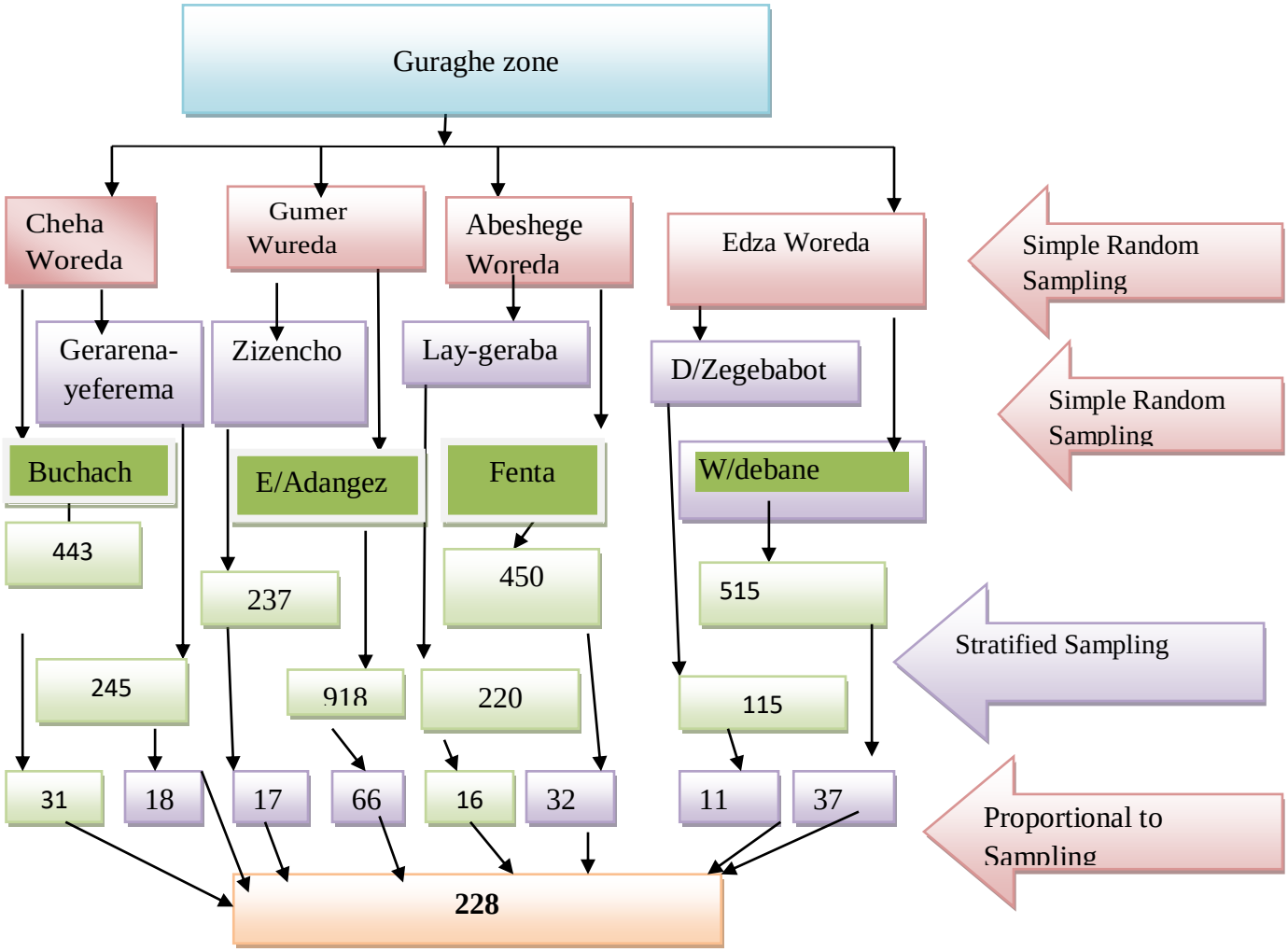


Figure 2:- Sampling Techniques

2.10 Sampling Design

The sample design is a plan for obtaining a sample from a given population. It refers to determining the number of respondents to be included in the sample and the sampling technique or the process of taking a sample from a population.

2.10.1 Sampling Frame

Sekaran and Bougie (2011) defines sampling frame as a physical representation of all the elements in the universe/population from which the sample is drawn. According to Sarndal, Swensson, and Wretman (2013), the list of items in the population constitutes the sampling frame. Sampling frame and the population differ in that the population in general and the frame is specific. The sampling frame of this study is constitute of 3183 electrified households registered in Zizencho, Gerarena-yeferema, Darecha-Zegebaboto and Lay-geraba) and4 non-electrified kebeles in Esenena Adangezo, Buchach, Wera- Debane and Fenta kebeleies in Gurage Zone.

2.10.2 Sample Size Determination

To determine the sample size, information about the total household heads of 4 electrified kebeles (Zizencho, Gerarena-Yeferema,Darecha-Zegebaboto and Lay-geraba) and 4 non electrified kebeles (Esenena Adangezo,Buchach,wera debane and fenta) are taken from each selected woreda (WAO,2022) . Based on this, the total numbers of household heads for selected kebeles of woredas are 3183 (WAO, 2021). From this statistical data, clear that the study has no enough resources in terms of time and finance to survey all electrified and non-electrified households. It is for this reason that some few selected segments of the study population which included households were subjected to study that constitute a subset of the population, sample of this study. According to WAO and WEUO (2022), the total number of household heads in selected villages with electricity is 857 and without electricity are 2326 households. The number of sampled with electricity and non-electricity households include in the study was determined by using the formula developed by (Kothari, 2004).

$$n = \frac{Z^2 * p * q * N}{e^2 (N-1) + Z^2 * p * q}$$

Where: n=Sample Size, Z = Z value (1.96 as per table of area under normal curve for the given confidence level of 95%,*e*= margin of error is the plus-or-minus figure usually, expressed as decimal (±.05); the estimate should be within 5% of true value. The researcher wants to be 95 per cent confident that the percentage has been estimated to be within ±5% of the true value.

As we have not been given the *p* value being the proportion of defectives in the universe, let us assume it to be *p* =0 .8 taken on the previous study on household survey analysis.

p = sample proportion, success for each households to be included in the sample (*P*=0.8);

q = 1 – *p*, non-electrified households to be included in the sample (*1-P*=0.2)

N=Population (3183 household size is taken from WAO and WEUO 2022 four Woreda 8 kebele estimate). The desired margin of error (also called confidence) is set equal to 5%. The error in sampling is calculated to check whether the sample taken is representative. This margin of error ensures representativeness from the selected population (it is important to decide how many questionnaires need to be completed to be representative of the overall population using or not RE), because the general accepted margin of error for representative samples is 10% or less (Hosking and Preez, 2003);

Where, n-the sample size,

N-the population size,

e- The acceptable sampling error where,

n= $1.96^2$0.8*0.2*3183/ $(0.05)^2$(3183-1) +1.96^2*0.8*0.2

=228 sample household was selected

* 95% confidence level and 0.5 are assumed should be within 5% of true value. The researcher wants to be 95 percent confident that the percentage has been estimated to be within ±5% of the true value. We get 228 sample households of which 125 were Non-electrified whereas 103 of them were electrified.

Table 1 Sample Size of the 8 rural kebeles of selected Woredas in Gurage zone

Name of Woreda	Selected Name of Kebele	No. households	Sample Size	Status of the kebele
	ZEZENCH	237	24	Electrified
GUMER	ESENENA-ADANGEZO	918	56	Non-electrified
	GERARENA- YEFEREME	245	20	Electrified
CHEHA	BUCHACH	443	25	Non-electrified
	DARECH-ZEGEBABOTO	155	31	Electrified
EDEZA	WERA-DEBANE	515	24	Non-electrified
	LAY-GERABA	220	28	Electrified
ABESHEGE	FENTA	450	20	Non-electrified
	Total	3183	228	

Source: Own computation result based on survey data, 2023

2.11 Sources of Data

Data collection is the process of gathering and measuring information on targeted variables in an established systematic fashion that enables one to answer relevant questions and evaluate outcomes (Sekara and Bougie, 2010). The study depends on the data obtain from primary and secondary sources. Both qualitative and quantitative data were collected from primary and secondary sources. Primary data was collected from electrified /beneficiaries and non-electrified /non-beneficiary households in the study area. In the formal sample survey structured and semi-structured questionnaire was pre-tested to endorse new information before the formal survey was carried out. Then the questionnaires were administered to collect pertinent data. Enumeration was done by recruiting four experienced enumerators for the study site.

2.12 Tools of Data Collection

Data collection is the process of gathering and measuring information on targeted variables in an established systematic fashion that enables one to answer relevant questions and evaluate outcomes (Sekara and Bougie, 2010). It is well known that instruments of data collection are basic component for a research to achieve its intended objective. Therefore, in this study the

tools for data collection have been: questionnaire, focus group discussions and key informants interview. Each of the instruments is discussed below.

2.12.1 Questionnaire

Questionnaire has the ability to seek information from several respondents within short period of time Johnson & Christensen (2008). Questionnaires contain a combination of structured and unstructured question. A questionnaire was used for collecting data from 228 selected rural with and without electrified households about their demographic and socioeconomic characteristics and its impact on household's welfare in study area. The survey questionnaire were originally prepared in English language and then for the sake of easy understanding by the enumerators and respondents it has been translated in into Amharic in order to make the questions clear, avoiding ambiguity as well as to make it easily understood by the respondents. The first draft of questionnaire has been pretested on a few pilot respondents to evaluate the accuracy of the questionnaire such as missing of data and inconsistency of data, to understand respondents' concepts on questions and their ways of surveying procedures, to evaluate the nature of respondents and to estimate the time required for filling a single questionnaire by using convent sampling. Finally, the actual data collected process from sample population could be conducted after every correction or comments made on information obtain from pre-test results. The data collection process was managed by the researcher and other enumerators who were trained by the researcher on how to collect the data.

2.12.2 Focus Group Discussions

A Focus Group Discussions has been held in a permissive environment in order to extract opinions and share ideas and perceptions through group interaction. Each members of focus group discussion were selected purposively in study area by the help of kebele extension agents and kebele administrator ("lekemenber"). A structured discussion with four focus groups could be conducted in the study area, in which each group members have been comprised of seven members. They were household heads that have a better knowledge about the impacts of electricity on household's welfare. Discussion was held in Kebele office, farmer training center, at the village and in the school compound where households were chosen. The information was

collected based on checklists. During the discussion the researcher served as a mediator by forwarding questions and then leaving the stage open for discussion. During the discussion information was gathered by voice recorder. It would be serves as part of data triangulation to ensure reliability and validity and investigate additional facts that would be not be addressed by the other survey methods.

2.12.3 Key Informant Interview

One of the methods used for collecting information were key informant interview. It is important to gather information that may not be available through other techniques, because they give an opportunity to listen respondents in person (Creswell, 2009). Therefore, semi-structured interview was prepared for purposively selected key informants from woreda government institutions such as Administrative Office, kebele administrative office staffs Woreda Electric Utility office, and District offices. Face to face key informant interview method was preferred due to its flexibility and ability to provide new ideas on impacts of electrification on rural households welfare.

2.13 Data processing and Analysis

Data processing included coding and classification of the collected data, cleaning the raw data and organizing data according to emerging themes. Coding was carried out before data was entered into STATA Software for analysis. Information on what each code means was listed in a codebook that accompanied the data set. Data entered was subjected to data view option to display in order to cross check the accuracy of data entered. This exercise led immediately to checking of errors and omissions, cleaning of errors and controlling data quality. The qualitative data that collected using the open ended questionnaire and interview guide was taken in form of notes and used to compliment the quantitative data thematically.

2.14 Methods of data Analysis

In this study descriptive as well as econometric method of data analysis was used. Descriptive statistics such as mean, percentage, and standard error, standard deviation, minimum and maximum were used whereas econometrics model such as binary logit model for the determinants of rural electrification and Propensity score matching (PSM) model for the impact analysis were employed to analyze the necessary data collected from the sample households in the study area. Moreover, to analyze the data in the econometrics model statistical software package Stata version 15.0 was used.

2.14.1 Descriptive Statistics

In this study socio economic, institutional and demographic characteristics of the households in the study area were explained by using descriptive statistics. The descriptive statistical tools like mean, percentage, standard error, standard deviation, minimum and maximum were used for the analysis after the data has been collected, edited, coded and labeled. The chi-square ($\chi 2$) and t-test statistics were used to test statistical significance of both the dummy and continuous variables respectively.

2.15 Econometric Model specification and estimation procedure

2.15.1 Binary Logit Model

For estimating binary choice models three types of models have been proposed such as the linear probability model, logit and probit models represented by linear probability function, logistic distribution and normal distribution function respectively (Gujarat, 1995). According to Hosmer and Lemeshow (1989), the major point that distinguishes these functions from the linear regression model is that the outcome variable in these functions is dichotomous. Moreover, probit model which is associated with the cumulative normal probability function and the logit model which assumes cumulative logistic probability distribution are very close to each other except at the tails. Thus, we are not likely to get very different results using the logit or the probit model.

According to Maddala (1983), the choice between the logit and probit models revolves around practical concerns such as the availability and flexibility of computer programs, personal preference, experience and other facilities because the substantive results are generally indistinguishable. Therefore, given the similarity between the two models, in this study the researcher employed the binary logit model to analyze factors determining rural electrification because binary logit model is appropriate when the decision maker chooses between two alternatives (which takes the value of 1 if the households is electrified and 0 if not.

Therefore, the specification of binary logit model based on Gujarit (1995) as follows:

$$P_i = E(Y = 1|X_i) = \frac{1}{1+e^{-(\beta 0+\beta iXi)}} \quad \text{……………………………………………………(1)}$$

This can further be written as:

$$P_i = \frac{1}{1+e^{-Zi}} \quad \text{……………………………………………………………………… (2)}$$

The probability that a given household is electrified expressed in equation 2 but the probability of the household not electrified is given by:

$$1 - Pi = \frac{1}{1+e^{Zi}} \quad \text{……………………………………………………………………… 3)}$$

Thus we can write this as:

$$\frac{Pi}{1-Pi} = \frac{1+e^{Zi}}{1+e^{-zi}} = e^{Zi} \text{……………………………………………………………………… (4)}$$

Then (Pi/1-Pi) is the odds ratio of the probability that a household electrified to the probability that the household do not electrified.

Finally, taking the natural log of equation (6):

$Li = ln(\frac{Pi}{1-Pi})$, Zi $=\beta_{0+}\ \beta_1\ X_1+\beta_2X_2+\ldots..+\beta_n\ X_n$ Where, Pi indicates either the probability of electrification which ranges from 0 to 1. Zi is a function of explanatory variables (Xi) which is also expressed as: $Zi = \beta_0+\beta_1X_1+\beta_2X_2+\ldots. +\beta nXn$ where, β_0 is an intercept, β_1, β2……... βn are slopes of the equation in the model Li = is log of the odds ratio, which is not only linear in Xi but also linear in the parameters. Xi = is vector of explanatory variables which includes demographic, socioeconomic and institutional factors affecting rural household's electrification in the study area. If the disturbance term (Ui) is introduced, the binary logit model for electrification becomes: $Zi = \beta 0+ \beta_1\ X\ 1+\beta_2X_2+\ldots. +\beta n\ X\ n + Ui$.

2.15.2 Propensity score matching Model (PSM Model)

According to Khandker *et al.,* (2010), impact evaluation is the act of studying whether the changes in well-being are indeed due to the intervention and not to other factors. Evaluating the impacts of improved technology is not straight forward because they are designed and implemented in a complex and ever-changing environment (Stern *et al*., 2012). In addition to this, there may be a hidden bias that results from unobserved heterogeneity in the electrification, which can in turn influence the outcome of rural electrification (Smith and Todd, 2005). Thus, to solve this problem PSM model was used in this study to analyze the impact of rural electrification on household's consumption expenditure and income in the study area. Propensity Score Matching (PSM) was preferred among others because of absence of baseline survey data, the beneficiaries may be self-selected and the availability of field data which is often based on crosses sectional survey. Therefore, in this study PSM model was employed because PSM is the appropriate method when such kind of problem arises.

There are a set of steps to be followed in the process of conducting propensity score matching. According to Caliendo and Kopeinig, (2008), the researcher must make decision regarding the choice of covariates, models for creating propensity scores, matching distances and algorithms, the estimation of treatment effects, and diagnosing the quality of matches (Caliendo & Kopeinig, 2008). Thus, the steps to be followed in estimating PSM were discussed as follows:

A) Selecting the covariates

The first step in estimating propensity score is to select the variables (covariates) to be used in the model. The propensity score allows the researcher to balance the intervention and comparison group, conditional upon the multivariate distribution of the covariates (Stuart and Rubin, 2008a). The inclusion or exclusion of key covariates affects the accuracy of inferences a researcher can make about the effects of an intervention (Brookhart *et al*., 2006; Steiner *et al*., 2010). According to Stuart (2010), the key covariates include variables which are related to self-selection into the intervention and to the outcome of interest. Thus, using a large set of covariates is recommended, even if some of the covariates are only related to self-selection and other covariates, and not necessarily to the outcome of interest (Stuart & Rubin, 2008).

B) Select Model for Creating Propensity Scores

There are different ways of calculating propensity scores to create a multivariate composite of the covariates (Rosenbaum & Rubin, 1983; Stuart, 2010; Stuart & Rubin, 2008a). But logistic regression is the most frequently used method of creating propensity scores which is available in most statistical programs (Austin, 2011; Stuart, 2010). Logistic regression creates propensity scores by simply computing the probability that the person received the intervention given the set of covariates included in the model. The impact of household's electrification on given out come (Y) or income and expenditure can be specified as:

$T_i = Y_i (D_i = 1) - Y_i (D_i = 0)$ ..... (1)

Where T*i* is treatment effect (effect due to electrification), Y*i* is the outcome on household *i*, D*i* is whether household *i* has got the treatment or not. Nonetheless, since $Y_i(D_i=1)$ and $Y_i(D_i=0)$ cannot be observed for the same household simultaneously, estimating individual treatment effect *Ti* is impossible and one has to shift to estimating the average treatment effects of the population than the individual one.

The most commonly used average treatment effect estimation is the average treatment effect on the treated (TATT) which is specified as:

$T_{ATT} = E(T_i \mid D=1) = E([Y_i \mid D=1] - E[Y_i \mid D_i=0]$ ……..……..…….……(2)

Equation (2) would have been valid if electrification be random $E([Y_i \mid D=1] = E[Y_i \mid D_i=0]$. Since the counterfactual mean for those being treated, $E[Y_i \mid D=1]$ is not observed, there is a need to choose a proper substitute for it to estimate ATT. Though it might be thought that using the mean outcome of the untreated individuals, $E[Y(0)| D=0]$ as a substitute to the counterfactual mean for those being treated, $E[Y(0)|D=1]$ is possible, it is not a good idea especially in non-experimental studies. This is because it is likely that components which determine the treatment decision also determine the outcome variable of interest. Therefore, the outcomes of individuals from treatment and comparison group would differ even in the absence of treatment leading to a self-selection bias.

But, by rearranging and subtracting $E[Y_i \mid D =0]$ from both sides of equation 2, ATT can be specified as: $E[Y_i \mid D=1]- E[Y_i \mid D=0]= T_{ATT +} E[Y_i \mid D=1] - E[Y_i \mid D=0]$----------(3)

In equation 3, both terms in the left hand side are observables and ATT can be identified if there is no self-selection bias. That is, if and only if $E[Y_i \mid D=1]–E[Y_i \mid D=0]=0$. However, this

condition can be ensured only in a randomized experiment (i.e. When there is no self-selection bias). Therefore, some identified assumptions must be introduced for non-experimental studies to solve the selection problem. Basically there are two strong assumptions to solve the selection problem. These are: Conditional independence assumption and common support condition.

Assumption1: Conditional Independence Assumption (CIA):

The CIA is given as: $Y_1 Y_0 \perp D / X, \forall X$,---------- (4)

Where, $\perp$ indicates conditional independence and X- stands for set of observable characteristics Y_0 – beneficiaries and $Y1$ –not-beneficiaries. Given a set of observable covariates (X*)* which are not affected by treatment (in our case, electrification), potential outcome (expenditure and income) is independent of treatment assignment (independent of how the households were selected).

The implication of CIA assumption is that the selection is solely based on observable characteristics (X*)* and variables that influence treatment assignment and potential outcome (expenditure and income) are simultaneously observed (Bryson *et al*., 2002; Caliendo and Kopeinig, 2005). Hence, after adjusting for observable differences, the mean of the potential outcome is similar for $D = 1$ and $D = 0$. Therefore, $E(Y0 / D = 1, X) = E(Y0 / D = 0, X)$

Assumption 2: Assumption of Common support

Imposing a common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group (Bryson *et al*., 2002). According to Ravallion (2008), treatment units will therefore have to be similar to non-treatment units in terms of observed characteristics unaffected by electrification; thus, some non-treatment units may have to be dropped to ensure comparability. Based on the above two assumptions, the PSM estimator of ATT can be written as:

$T_{ATT} = E[Y_1 - Y_0 / D = 0, P(x)] = E[Y_1 / D = 1, P(x)] - E(Y_0 / D = 0, P(x)]$ -------- (5) Where P(x) is the propensity score computed on the covariates X. Equation (5) shows that the PSM estimator is the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants. In general, the common support region is the area within the minimum and maximum propensity scores of beneficiary and non-beneficiary groups, respectively and it is done by cutting off those observations whose propensity scores are smaller than the minimum and greater than the maximum of beneficiary and non-beneficiary groups, respectively.

$$0 < P(Di= 1|Xi) < 1 \text{----------} (6)$$

C) Select a Matching Algorithm and Create Matches

After computing the propensity scores a common approach is to create balanced intervention and comparison groups by using one to one or one to many matching. According to (Caliendo & Kopeinig, 2005), there are various approaches for creating a comparison group, however the most common matching algorithms are nearest neighbor (NN) matching, radius caliper matching and kernel matching and they have been discussed below.

I. Nearest Neighbor (NN) Matching: Nearest neighbor matching is one of the common and frequently used type of matching algorithms in PSM. In nearest neighbor matching the treatment group is matched to the control groups with the closest propensity scores. The individual from the non-electrified group is chosen as a matching partner for electrified with the least caliper distance in terms of propensity scores (Caliendo and Kopeinig, 2005). Thus, a reasonable distance should be taken to minimize the bias. Matching can be done with or without replacement. However, in matching without replacement the comparison groups can be used only once as match. Hence, different nearest matching with the least caliper distance shall be used to estimate the average treatment effect on the treated.

II. Radius caliper matching: The use of nearest neighbor matching may create poor matches when the closest match is far away. Dehejia and Wahba (2002), suggest a variant of caliper matching which is called radius caliper matching. In Radius caliper matching, the main principle is not only to use the nearest neighbor with in each caliper, but all of the comparison members with in the caliper. Moreover, the radius caliper matching avoids poor matches by specifying a caliper or maximum propensity score distance by which a match can be made. It also uses many comparison cases as they are available within the caliper, but not the poor matches.

III. Kernel matching: According to Becker and Ichino (2002), in a kernel matching the treated units are matched with a weighted average of all control whose weights are inversely proportional to the distance between the propensity scores of treated and control. Moreover, it is a non-parametric matching estimator which compares the outcome of each treated groups to a weighted average of the outcomes of all the untreated groups, with the highest weight being placed on those with propensity scores closest to the treated individuals. Although, it has its own drawbacks the kernel matching results in lower variances which is achieved because of using more information. However, it disadvantage is that some of the observations used may be poor

matches which leads to importance of imposing common support region (Caliendo and Kopeinig, 2005).

D) Assessing the Matching Quality

Once the matches are created, it is important to assess the quality of the matches in order to ensure the comparison group has a distribution of propensity scores similar to the intervention group. Matching quality has been checked if the matching procedure is able to balance the distribution of the relevant variables in electrified and non-electrified (Smith and Todd, 2005). The idea behind balancing tests is to check whether the propensity score is adequately balanced. In other words, a balancing test seeks to examine if at each value of the propensity score, a given characteristic has the same distribution for the treatment and comparison groups (Caliendo and Kopeinig, 2008). According to Shahidur *et al.*,(2010), for propensity score matching to work, the treatment and comparison groups must be balanced in that similar propensity scores are based on similar observed X, Standard bias, t-test, joint significance, balance test and pseudo-$R^2$are the mechanism used to test the matching quality. The basic idea of all approaches is to compare the situation before and after matching and check if there are any differences after conditioning on the propensity score. The distributions of the treated group and the comparator must be similar, which is what balance implies. Mathematically:

$$\ddot{P}(\mathrm{X}\,|\mathrm{D}=1) = \ddot{P}(\mathrm{X}\,|\mathrm{D}=0) \qquad (7)$$

E) Estimating the Average Treatment Effect

The comparison of outcome variable should be made only after creating matches between groups and evaluating quality of balance among electrified and non-electrified. The inclusion of outcome variables after all matches have been made is critical for following propensity score matching best practices (Stuart and Rubin, 2008a). After a quality sub sample of non-electrified is created as a comparison group, the analyses become straightforward. Once a comparison group is created using propensity score matching techniques, the effect of the intervention can be estimated.

F) Sensitivity Analysis

The other thing to be considered in propensity score matching model is that all matching estimators are not exactly robust against hidden biases due to selection bias and unobservable characteristics. According to Rosenbaum (2002), the estimation of treatment effects with matching estimators is based on the selection on observables characteristics. However, a hidden

bias might arise if there are unobserved variables which affect assignment into treatment and the outcome variables simultaneously. Since matching estimators are not robust against hidden biases, it is important to test the robustness of results to departures from the identifying assumption by using bounding approach.

This problem of hidden bias is circumvented by the following bounding approach. Within the logit model to estimate propensity score, the probability of electrification needs to be complemented by a vector U containing all unobservable variables and their effects on the probability of electrification captured by γ:

$$P(X)=Pr(Z=1|X)=F(X_{\beta}+U\gamma)=e^{X_{\beta}+U^{\gamma}} \text{ ----------(8)}$$

Rearranging the odds ratio of two individuals (m and n) who are identical in observable characteristics, the resulting relative odds electrification is given by:

$$\frac{P(Xm)}{(1-P(Xm))} * \frac{(1-P(Xn))}{P(Xn)} = \frac{e^{Xm_{\beta}+Um\gamma}}{e^{Xn_{\beta}+Un^{\gamma}}} = e^{[\gamma(Um-Un)]} \text{ ----------(9)}$$

Sensitivity analysis now examines how strong the influence of γ on the electrification process needs to be, in order to attenuate the impact of electrification on potential outcomes (Rosenbaum, 2002). Let assumed that the unobservable variable is a binary variable taking values zero or one. The following bounds on the odds ratio of the electrification probability of both individuals are applied:

$$\frac{\mathbf{1}}{\boldsymbol{e}^{\gamma}} \leq \frac{P(Xm)}{(1-P(Xm))} \frac{(1-P(Xn))}{P(Xn)} \leq \boldsymbol{e}^{\boldsymbol{\gamma}} \text{ ----------(10)}$$

If e^{γ}=1 both individuals have the same probability of electrification, they are identical in X

If e^{γ}=2, one of the matched individuals may be twice as likely to electrified as the other agent (Rosenbaum, 2002). If e^{γ} is close to one and changes the inference about the treatment effect, the impact of electrification on potential outcomes is said to be sensitive to hidden bias. In contrast, insensitive treatment effects would be obtained if a large value of e^{γ} does not alter the inference about treatment effects (Aakvik, 2001). Therefore, the question arises at which critical impact level of the unobservable variables alters inference about the treatment effect of electrification was be undermined, as indicated by the loss of significance (Diprete and Gangl, 2004).

2.16 Description of variables and working hypothesis

2.16.1 Dependent Variables

For this particular study the researcher has identified dependent and independent variables;

Rural households access to electrification

The dependent variable in the logit model was the household's electrification which is binary dependent variable taking the value of 1 if the household is electrified and 0 if the household is not electrified. In this model the researcher has incorporated the socio-economic, institutional and demographic factors affecting the household's electrification

2.16.2 Outcome variables

In this study the following variables were used as impact indicators including households total consumption expenditure and total annual income.

Total per-capita consumption expenditure: The consumption expenditure is obtained by dividing real household food and non-food consumption expenditure by adult equivalent family size (FDRE, 2010/11). Khander et al. (2014) showed rural electrification has a positive relationship with total consumption expenditure. Therefore, rural electrification was hypothesized to influence the per capita total consumption expenditure positively.

Total annual income: Total annual income of the household is continuous variable that a household earned from different sources in the last twelve months was measured in Ethiopian Birr. Rural electrification was expected to influence total annual income of the households significantly and positively. Study conducted Chakravorty *et. al.*, (2014) estimated the impact of electricity quality on household income found positive relationship between rural electrification and annual income.

2.16.3 Choice and definition of independent variables

In establishing the model and choice of explanatory variables the researcher should be guided by economic theory, knowledge of previous research and information about institutional settings (Smith and Todd 2005; Sianesi 2004). Thus, based on the review of different literatures the following potential explanatory variables were identified which were expected to have influence on the dependent variable. Therefore, the demographic, socioeconomic and institutional variables found most commonly affecting rural electrification were defined and hypothesized along with their expected signs as follows:

Income level (AICME): One of the main determinates that influence the rural electrification is household income. Walekhwa et al, 2009, found that the probability of a household being beneficiary of rural electricity increases with increasing household income. In addition, the Warkaw and Dr. Chawla (2016), research confirms that the annual household income has a positive and significant effect on the rural electrification positively. Therefore, in this study income of household's head was expected to affect the household's electrification positively.

Age of the household head (AGHH): Age is a categorical variable measured in years. Age of the household head was one of the factor which constrains rural electrification in the study area. In this study age of household's head was expected to affect the household's electrification positively.

Marital status (MRTSS): Marital status of the households was the other explanatory variable which was treated as dummy taking value of 1 if the household head is married and 0 otherwise. Marital status I this study was expected to influence rural electrification positively.

Sex of the household head (SXHH): Sex of the household head in this study was considered as a dummy variable which takes the value of 1 if the household head is male and 0 otherwise. Male headed households are expected to have higher income because of the better labor inputs and farm experience when compared to their female counterparts. Male headed households are more likely to be electrified than their female counterparts. Thus, sex of the household head was expected to affect the rural electrification positively.

Education level of the household head (EDUHH): This is a categorical variable measured in years of formal schooling completed by the household head. Education level of the household head was expected to affect the rural electrification positively.

Community access to good roads (CARD): This was another dummy variable which was affected to influence rural electrification. Communities with good road access are more likely to be electrified than their counterparts. Therefore, positive relationship was expected for this variable.

Family size (FMLYSZ): This is a continuous variable measured in numbers of members per adult equivalent in the household. The family size was expressed in adult equivalent by using the conversion factor adjusted for age group and sex (Storck *et al*., 1991). Households having a large number of family members are more likely to be electrified than their counterparts. Thus, this variable was expected to affect the rural electrification positively.

Household occupation (OCPHH): Households occupation was another dummy variable which was expected to effluence rural electrification. In this study area, the households were owners of multiple type of occupation such as trading, farming, professionals, and artisans. It was assumed that diversification of occupation is more likely to encourage rural electrification in the study area. Thus, this variable was expected to affect the rural electrification positively.

Connection to the national grid line (CNGL): This was another dummy variable which takes the value of 1 if the household head was connected ad 0 otherwise. It was expected to influence rural electrification positively in the study area.

Adoption of solar energy (ADPSE): This was dummy variable which takes value of 1 if the household had installed solar energy and 0 otherwise. Households who had installed solar energy technology in their household are less likely to be electrified when compared to their counterparts. Thus, it was expected to affect rural electrification negatively.

Table 2 Summary of explanatory variables and their expected sign

Name of the explanatory Variables with their short forms	Type of the variable	Expected sign
Age of the household head (AGHH)	categorical	Positive
Sex of the household head (SXHH)	Dummy	Positive
Educational level (EDCHH)	categorical	Positive
Family size (FMLYSZ)	Continuous	Positive
Household occupation (OCPHH)	categorical	Positive
Connection to the national grid line (CNGL)	dummy	Positive
Adoption of solar energy (ADPSE)	dummy	Negative
Community access to good roads (CARD)	dummy	Positive
Income level (AICME)	Continuous	Positive
Marital status (MRTSS)	Dummy	Positive

Source: Own computation based on literature, 2023

2.16.4Diagnostic tests of the model

Before running econometrics model, all the hypothesized explanatory variables were checked for the existence of multicollinearity, hetroskedasticity and model specification test. An important assumption for the multiple regression models is that there should be no perfect multicollinerty among independent variables. The problem of multicollinearity arises when at least one of the independent variables is a linear combination of the others. According to Wooldridge (2003), multicollinearity results in inflated standard errors, opposite sign of the estimated regression coefficients which are different from the hypothesized direction and smaller t-ratios that might lead to wrong conclusions. Therefore, the presences of problem of multicollinearity among the variables were tested by using variance inflation factor (VIF). Gujarati (2004), indicated that as the rule of thumb if the mean VIF exceeds 10 that variable is highly collinear. On the other hand, hetroskedasticity tends to occur when the variance of the unobservable changes across different segments of the population with the explanatory variables (Wooldridge, 2003). Thus, in this

study Breusch-Pagan hetroskedasticity test was used to detect the presence of hetroskedasticity problem for errors. Finally, the link test was used to verify whether the model was correctly specified or not. In this regard, the model was said to be appropriate if no relevant variables were excluded from the model or irrelevant variables were included in the model.

2.17 Ethical Consideration

Before starting the data collection, the researcher explained the respondents about the purpose of the study which was conducted in the study area. Thus, the researcher clearly introduced the purpose of the study as a requirement for the partial fulfillment of master's degree program and the respondents were kindly requested for their willingness to fill the questionnaires on a voluntary basis were refusal or abstaining from participating was permitted. Moreover, the researcher has also assured the respondent's confidentiality of the information given since the findings of the study will be used for the intended purpose only. Therefore, all the filled information was put in strict confidentiality.

CHAPTER FOUR

3 RESULTS AND DISCUSSIONS

This chapter of the thesis was structured in to three sub sections. In the first sub section the descriptive statistics results of the households demographic, socioeconomic and institutional characteristic's and descriptive statistics results for the outcome indicators using mean, percentages and frequencies were presented and discussed. In the second sub section the econometrics model result of the determinants of rural electrification was discussed. Finally, in the third sub section the impact of rural electrification on expenditure and income using propensity score matching model was presented and discussed.

3.1 Results of descriptive statistics

A combination of different descriptive statistics tests was performed on the household data based on the observable characteristics. The descriptive statistical tools such as mean, frequencies and percentages, standard deviations, minimum and maximum were used for the descriptive analysis for the entire sample as well as the electrified ad non-electrified households. Accordingly, descriptive statistics was done for both categorical and continuous variables including household's sex, age, educational status, family size, occupation, adoption of solar energy, access to national grid line. Finally, t-test and chi-square tests ($\chi 2$) were used to test the significance of the mean values of the continuous and categorical variables for both electrified ad non-electrified households respectively.

3.1.1 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 electrification. Electrification has contributed to the positive development on women's socio-economic status. Electricity has left a profound impact on women's mobility, decision- making, and freedom in using income and savings, better utilization of credit, knowledge about gender inequality issues. Women are the most work loaded member of the household, and a family headed by female household has a great opportunity to be easily acquainted with appliances that contribute in changing

the quality of life of the family as a whole positively. However, the result indicates in Table 3 shows, 65.78% of household heads were male while the rest 34.21% 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 Ethiopia are known to be a male dominated in their characteristics**.** Male-headed household are more likely to get connected to electricity as compared to the female headed households (Nishimwe *et al.* 2014).

As survey results indicated that, out of the total male headed households the majority about 76% were electrified whereas 53.33% of them were non-electrified. However, from the total female headed households about 24% were electrified whereas the remaining 46.66 were not electrified. Moreover, the chi-square test result revealed there were statistically insignificant differences between electrified and non-electrified respondents.

On the other hand, the respondents were also asked about their marital status. The responses of marital status of the household indicate that the majority (70.17%) of household head were married) of which about 72% were electrified whereas the rest of 67.96% were not electrified. However, the result from the descriptive statistics revealed that about 29.82% of the households were single of which 28% of them were electrified. This implies the majority of the respondents were married and electrified when compared to the counterparts. Moreover, the chi-square test result revealed there were statistically significant differences between electrified and non-electrified respondents at 5% level of significance.

The distribution of the total sample respondents in terms of education level as describes in Table 3, has shown that 28.22% of the respondents have no school attainment, 35.1% of them can read and write, 25% had primary education and 15.78% of them had secondary education. In the study, majority of the respondents were knowledgeable in influencing the electrification process. This implies the level of education is a major factor affecting the electrification. In addition, about 33.6% electrified households were attended at least primary school. Moreover, the chi-square test result revealed there were statistically significant differences between electrified and non-electrified respondents at 5% level of significance.

The age composition of household heads the survey result in Table 3, illustrates that 78.14% of the household heads were age between 23-35 years, while 15.35%, 15.35%, 21.05% of the respondent were age between 36-48 years, 49-60 years and above 61 years respectively.

This implies that the largest population was the middle and youth age as a result, they were able to understand issues related to rural electrification. 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. Moreover, the chi-square test result revealed there were statistically significant differences between electrified and non-electrified respondents at less tha1% percent level of significance.

The distribution of the total sample respondents in terms of occupation as describes in Table 3, has shown that 36.4% of the respondents were traders, 50.43% of them farmers, 11.84% artisans. From the total electrified respondents the majority (54.4%) of them were traders followed by farmers for which this figure was 32 percent. However, regarding connections to national grid lies about 49.56% of the respondents were connected to grid electric line of which 78.4 percent had access to electricity. However, the remaining, 50.43percent of the respondents had no connection to grid electric lie of which 85.43 percent of them had no access to electricity. Moreover, the chi-square test result revealed there were statistically significant differences between electrified and non-electrified respondents at 5% percent level of significance. The other important variable of this study was community access to good road. The result from descriptive statists revealed that, about 67.54percet of the population had access to good road of which about 54.4% were electrified ad the remaining 45.6 percent of them were o electrified. However, this figure was about 83.49 for o electrified respondents. Moreover, the chi-square test result revealed there were statistically significant differences between electrified and non-electrified respondents at less tha1% percent level of significance.

Table 3 Socio-Demographic Characteristics of Households

Variables		Category						χ^2
		Electrified		Non-electrified		Total		
		Frequency	%	Frequency	%	Frequency	%	
MRTSS	Married	90	72	70	67.96	160	70.17	5.68**
	Single	35	28	33	32.03	68	29.82	
SXHH	Male	95	76	55	53.33	150	65.78	0.836
	Female	30	24	48	46.66	78	34.21	
AGHH	23-35	78	62.4	33	32.03	111	78.14	4.284***
	36-48	20	16	15	14.56	35	15.35	
	49-60	15	13.6	20	19.41	35	15.35	
	61 years and above	13	10.4	35	33.98	48	21.05	
EDCHH	No School attainment	28	22.4	52	50.4	80	28.22	5.29**
	Able to Read and Write	35	28	23	22.33	58	35.1	
	Primary Education	42	33.6	15	14.56	57	25	
	Secondary Education	23	18.4	13	12.62	36	15.78	
OCPHH	Trading	68	54.4	18	17.47	83	36.4	4.35
	Farming	40	32	75	72.81	115	50.43	
	Artisans	17	13.6	10	9.708	27	11.84	
CNGL	Yes	98	78.4	15	14.56	113	49.56	15.6**
	No	27	21.6	88	85.43	115	50.43	
ADPSE	Yes	52	41.6	85	82.52	137	52.37	0.378
	No	73	58.4	18	17.47	91	39.91	
CARD	Yes	68	54.4	17	16.5	85	37.28	10.16***
	No	57	45.6	86	83.49	143	62.71	

*** and ** Shows significant at 1% and 5% significance level respectively

Source: Own computation result based on survey data, 2023

3.1.2 Descriptive statistics results for continuous variables

Family size (FMLYSZ): Family size measured in adult equivalent was another continuous variable which plays a vital role in rural electrification. The family size was expressed in adult equivalent by using the conversion factor adjusted for age group and sex (Storck *et al*., 1991). According to the descriptive statistics result, the mean family size in adult equivalent for the total sample size was about 6.2 with minimum and maximum family size of 2.35 and 11.2 respectively (Table 4). The average family size for electrified households was 6.5 with minimum and maximum family size of 2.5 and 10.8 measured in adult equivalent respectively. However, the mean family size measured in adult equivalent for non-electrified was 5.96 with minimum and maximum family size of 2.35 and 11.2 respectively. This shows that there was significant difference in mean family size between the two groups. The result from the t-test statistics also shows that there was statistically significant difference in family size for electrified and non-electrified at 1% significance level.

The profile of households shows that, the mean family size in the study area was 5.7 persons which was higher than the mean of Ethiopia (5.1) and Guraghe zone (5.2) respectively (CSA and WB, 2013; GZDFED, 2014). Large family size with limited economic activities and income sources lead to an increase in the number of dependent groups which lead to adverse living conditions and might be burden on natural resource bases.

Total annual income (AICME): 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. Based on the result from the descriptive statistics in table 4, on average the mean annual income for the whole observations was birr 24390.34 with minimum and maximum total annual income of birr 3560 and 65220 respectively. However, the mean annual income for electrified households was birr 28819.81 with minimum and maximum income of birr 6800 and 65220 respectively. On the other hand, the average total annual income for non-electrified in the study area was birr 20779.35 with the minimum and maximum income of birr 3560 and 47000 respectively. The result from descriptive statistics revealed that there was significant variation in the mean annual income between electrified and non-electrified.

Moreover, the result from the t-test shows that the difference between the two groups was found to be statistically significant in terms of total annual income at 1% significance level (Table 4).

Table 4 Summary of descriptive statistics result for continuous variables

Variables	Category						T-value
	Electrified		Non-electrified		Total		
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	
Family size	6.5	1.83	5.96	1.83	6.20	1.85	2.66***
Total income	28819.81	13550.56	20779.3	9011.699	24390.3	11951.21	3.46***

*****,** represents statistically significant at 1% significance level

Source: Own computation result based on survey data, 2023

3.1.3 Descriptive statistics results for outcome variables

The overall survey result indicated that the mean per capita food consumption expenditure and per capita total consumption expenditure including the per capita non-food consumption expenditure in Ethiopian Birr for the whole sample size was birr 3607.7 and 5952.2 respectively. However, the average per capita non-food expenditure for the whole observation was birr 2344.4 which was relatively lower than the per capita food consumption expenditure in the study area. According to the result from descriptive statistics, the average per capita food, non-food and total consumption expenditure for electrified was birr 4575.1, 2543.2 and 7118.4 respectively. However, for non-electrified households in the study area the average per capita food, non-food and total consumption expenditure was birr 2819.1, 2182.3 and 5001.5 respectively. The result from t-test revealed that there was statistically significant difference between the two groups in terms of per capita food consumption expenditure, per capita non-food consumption expenditure and per capita total expenditure at 1% significance level.

Table 5 Summary of mean comparison for outcome indicators

Outcome indicators	Electrified	Non-electrified	Total	T-value
	Mean	Mean	Mean	
Total annual income	28819.81	20779.35	24390.	6.48***
Per capita food consumption expenditure	4575.1	2819.1	3607.7	8.1***
Per capita total consumption expenditure	7118.4	5001.5	5952.2	7.36***

***, shows significant at 1% significance level

Source: Own computation result based on survey data, 2023

3.2 Econometric Model Result

3.2.1 Factors Determining rural electrification

Binary logistic regression model was used to estimate factors determining the rural household's electrification the study area. In estimating the model, the dependent variable used in this study was the household's electrification access which takes the value of 1 if the household electrified and 0, otherwise. Moreover, prior to the model estimation the explanatory variables were tested for the existence of the problem of multcolinearity, heteroscedasticity and model specification using VIF, hettest and link test respectively. Accordingly, the variance inflation factor shows that there was no serious problem of multicollinearity between the explanatory variables since the mean VIF was 1.28 which is by far lower than 10 (appendix 1). Thus, all of the explanatory variables were used in the model estimation. To detect the problem of heteroscedasticity the Breusch-Pagan/Weisberg test of heteroscedasticity was used and the result indicates that there was no problem of heteroscedasticity since the value chi2(1) = 0.09 and Prob > chi2 = 0.7701(appendix 2).

Therefore, the variables included in the model were hypothesized to affect rural electrification in the study area. Finally, the link test was used to test the model specification or estimation. The result from the link test revealed significant _hat (p-value =0.029) and insignificant _hatsq (p-value= 0.62) (appendix 1). Thus, based on the link test the model specification was found to be appropriate and there was no relevant explanatory variable excluded from the model or irrelevant variable added to the model. The binary logistic regression model result in table 5, shows that out

of ten explanatory variables used in the model four variables were found to be significantly determining the rural electrification at various significance level. The variables which were found to have significant influence include education level, community access to good road, connection with national grid line and income of the households. The significant variables affect the dependent variable either positively or negatively. Moreover, the model estimate indicates that the overall model is significant at 1% (Prob>chi2 = 0.0000) as shown by the likelihood ratio test.

Education level of the household (EDCHH): As it was indicated education level of the household head had positive and significant influence on the electrification at 5% significance level. The odds ratio of logistic regression result in table 5 indicates that keeping other variables constant, an increase in the household's level of education by one year in terms of years of schooling leads to an increase in the probability of rural electrification by factor of 1.086. In other words, educated farmers are 1.086 times more likely to electrify than their counterparts. Building on this evidence, some recent studies using advanced statistical techniques have established the causality between electrification and educational outcomes by controlling for the possibility that those with higher levels of education are more likely to adopt electricity (Khandker, Barnes, and Samad 2012).

Connection to the national grid line (CNGL): Connection to the national grid line has a positive impact on rural electrification the odd ratio shows that households connected to the national grid lie were 5.266 times more likely to electrify than their counterparts. The positive coefficient for this variable implies that the probability of electrification increases with an access to national grid lie. The result of this study was also in line with the findings of (Alam and Bhatachryya , 2017).

Community access to good roads (CARD): Community access to good roads positively impacts rural electrification suggesting that community access to good road networks significantly increases household probability of being electrified. Moreover, the variable was found to be influencing the household's probability of being electrified at 5% level of significance. All factors remaining constant, households having an access to good roads were 1.125 times more likely to be electrified in the study area (Table 6). In other words, households having an access to good road the probability of being electrified by factor of 1.125.

Income level (AICME): Based on the result from the model, income of the household influenced rural electrification positively and significantly at 10% significance level. The positive coefficient for this variable implies that the probability of being electrified increases with an increase in the annual income of farm households. The result from the odds ratio in table 5 indicates that, a unit increase in the annual income of farm households leads to an increase in the probability of being electrified by factor of 1.231, all factors remaining constant

Table 6 The binary logistic regression model result for determinants of rural electrification

Variables	Coefficients	Odds ratio	Robust Std. Err.	P-values
EDCHH	0.08	1.086	0.04	0.026**
AGHH	0.27	1.322	0.36	0.307
FMLYSZ	-1.12	0.323	0.19	0.055
CNGL	1.66	5.266	2.07	0.000***
OCPHH	0.58	1.786	0.52	0.46
ADPSE	0.39	1.483	0.17	0.212
CARD	0.11	1.125	0.07	0.036**
AICME	0.20	1.231	0.34	0.061*
MRTSS	0.902	2.466	0.75	0.361
SXHH	-0.43	0.644	0.19	0.149
_cons	-2.53	0.079	0.07	0.012**
Number of observation = 228		Wald chi2(12) = 51.75		
Log pseudo likelihood = -196.74093		Prob > chi2 = 0.0000		
		Pseudo R^2 = 0.1438		

***, **, * shows significance at 1%, 5% and 10% level respectively

Source: Own computation result based on survey data, 2023

3.3 The Impact of rural electrification on households income and expenditure

The propensity score matching (PSM) model was used to examine the impact of rural electrification on household's consumption expenditure and income in the study area. The PSM model was chosen among others because of the absence of base line survey data. The main aim of estimating the impact of rural electrification on household's consumption expenditure and income was to measure the mean difference in the outcome variables between electrified and non-electrified households in the study area. Moreover, the estimation of PSM model involves different steps. The first step involves estimating the propensity scores using the binary logit model, the second step deals with selecting the matching algorithms to electrified and non-electrified households, the third, the fourth and the fifth steps emphasizes on covariates balance test, estimating the average treatment effect on treated, sensitivity analysis and interpreting the results respectively (Stuart, 2010). Thus, in this sub section each step was discussed in detail one by one based on the results from PSM model.

3.3.1 Estimating the propensity scores

In order to estimate the propensity scores the binary logistic regression model was used since the dependent variable in this case is binary taking the value of 1 if the household is electrified or 0, otherwise. Moreover, as it was stated in Stuart (2010), the binary logit model was most commonly employed in propensity score estimation among others. The result from the propensity score estimation model revealed that the Pseudo R^2 was fairly low (0.1438). This low value of Pseudo R^2 indicates that, there are no systematic variations in the distributions of covariates between electrified and non-electrified households (Rosenbaum and Rubin, 1985). Once the propensity scores were estimated the next task was determining the region of common support or overlap.

3.3.2 Imposing the region of common support or overlap

According to Bryson *et al*., (2002), imposing a common support condition ensures that any combinations of characteristics observed in the treatment group can also be observed in the comparison group. Prior to selecting the matching algorithms, first the common support region should be imposed because sufficient overlap is required between the estimated propensity scores of the treated and control groups to ensure that the results are not biased, next observations whose predicted probabilities fall outside the range of the common support region should be dropped because the average treatment effect is estimated for observations whose predicted probabilities fall in the common support region. As it was indicated in table 6 the estimated propensity scores for electrified and non-electrified households were used to construct the common support region.

Accordingly, the estimated propensity score for treatment groups lies in the interval of 0.0797915 and 0.9558155 with mean propensity score value of 0.5494018. However, the estimated propensity scores for control groups (non-electrified) lies in the interval of 0.0295977 and 0.8946087 with the mean propensity score value of 0.3673355. Thus, the common support region or overlap was determined by taking the minimum of the maximum and the maximum of the minimum propensity scores from the electrified and non-electrified households groups. Accordingly, based on the result the common support region assumption was satisfied in the range of [0.0797915, 0.8946087]**.** This indicates that households whose estimated propensity scores falls below the minimum (0.0797915) and above the maximum (0.8946087) were excluded from the observations used to estimate the treatment effect on the treated and not considered for the matching purpose. As a result, out of the total sample size only eleven (3.29%) households were dropped out because of the overlap condition. As it was suggested in Bryson *et al*., (2002), the estimated treatment effect on treated for the rest of the households can be considered as representative, because of the proportion of the lost sample households were fairly small (3.29%).

Table 7 Distribution of estimated propensity score for the households

Variables		Obs	Mean	St.Dev.	Min	Max
Propensity score	Electrified	125	0.5494018	0.2060961	**0.0797915**	0.9558155
	Non-electrified	103	0.3673355	0.1812983	0.0295977	**0.8946087**
	Total households	228	0.4491018	0.2128252	0.0295977	0.9558155

Source: Own computation result based on the survey data, 2023

As it was indicated in figure 2 the common support graph shows the region of intersection for the propensity scores as well as it presents frequency distributions of propensity scores for both electrified and non-electrified households. Accordingly, the upper part of the graph shows the distributions of the estimated propensity score for the treated whereas the bottom part of the graph represents the propensity score distributions for control groups (non-electrified). The densities of the propensity scores are on the y-axis and a visual inspection of the density distributions of the estimated propensity score for the two groups in the figure shows that the common support condition is satisfied. This implies that the treatment groups are similar to the control groups in terms of observed characteristics unaffected by the electrification (Ravallion, 2008). Moreover, from the common support graph one can understand that the common support region was satisfied since there is substantial region of overlap. Thus, no common support problem exists between the treated and control groups.

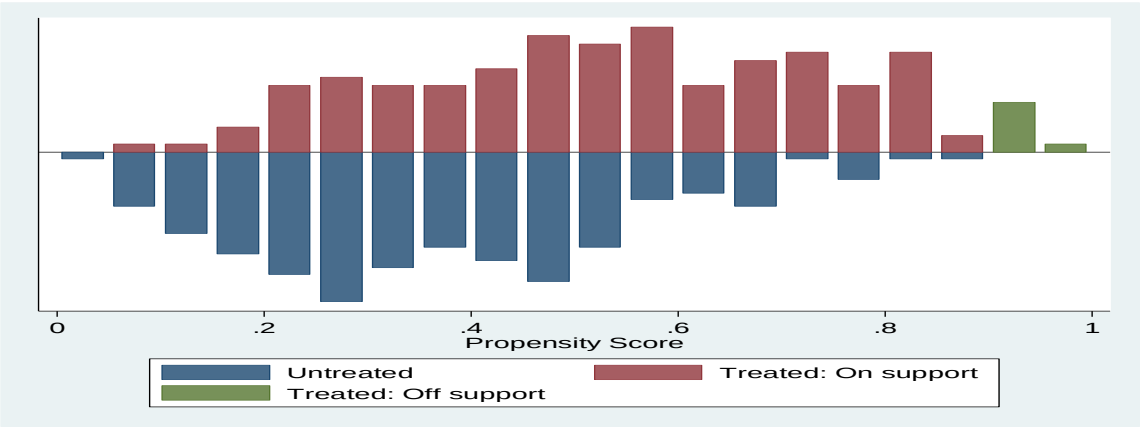


Figure 3 ;- Propensity score distribution and common support for both electrified and non-electrified households

Note: *Treated on support indicates electrified households who found a suitable match, whereas treated off support indicates households electrified but did not find a suitable match and Untreated indicates households not electrified.*

Source: Own Computation result based on survey data, 2023

3.3.3 Selecting a Matching Algorithm

There are a number of matching algorithms used to match the treatment and comparison groups, but the most commonly used matching algorithms includes the nearest neighbor, kernel and radius caliper matching. Sianesi (2004); Deheja and Wahba, (2002), proposed different criteria's to select the matching algorithms such as Pseudo R^2, matched sample size with p-values of the likelihood ratio test of the joint insignificance of all the variables, number of balanced covariates and the mean bias to be considered in selecting the matching algorithms. Accordingly, a matching algorithm which balances all the explanatory variables that result in insignificant mean differences between the treatment and comparison groups, bearing low Pseudo R^2 and resulting in large matched sample size was preferred as the best matching algorithm. Thus, by taking different selection criteria under consideration radius caliper matching with band width of 0.1 was selected as the best estimator since it results in largest number of balanced covariates (10), low Pseudo-R^2 (0.005) and large number of matched sample size (217)

Table 8 :-Performance of a matching algorithm based on various criteria of selection

Matching Algorithms		Number of balanced covariates	Matched sample size	Pseudo-R^2
Nearest Neighbor	1 Neighbor	9	217	0.032
	2 Neighbor	10	217	0.008
	3 Neighbor	10	217	0.007
	4 Neighbor	10	217	0.009
	5 Neighbor	10	217	0.010
Radius Caliper	0.01	10	210	0.01
	0.1	10	217	0.005
	0.25	10	217	0.023
	0.5	9	217	0.092
Kernel Matching	0.01	10	210	0.014
	0.1	9	217	0.005
	0.25	10	217	0.013
	0.5	9	217	0.058

Source: Own computation result based on survey data, 2023

4.3.3 The Covariates Balance Test

In order to ensure the absence of systematic differences between the treatment and control groups a fairly low pseudo-R^2 was suggested (Sianesi, 2004). Accordingly, the pseudo-R^2 which was 0.144 before matching was dropped to 0.005 after matching and it is fairly low. The implication for this a very minimum or low pseudo-R^2 after matching is that, there should be no systematic differences between electrified and non-electrified after matching. Therefore, low pseudo-R^2, the insignificant p-values of the likelihood ratio test, higher percentage reduction in mean bias, low standardized mean bias and the insignificant chi-square after matching showed that the radius caliper matching method with a band width of 0.1 is effective in balancing the distribution of the covariates between the electrified and non-electrified.

Table 9 :-Indicators of quality of balanced covariates using the radius caliper matching method with band width of 0.1

All Sample	PsR^2	LR chi2	p>chi2	Mean Bias Reductions
Unmatched	0.144	66.16	0.000	22.3
Matched	0.005	1.98	0.999	3.2

Source: Own computation result based on survey data, 2023

3.4 Estimating the average treatment effect on the treated (ATT)

3.4.1 The estimation of the ATT on household's consumption expenditure

According to the ATT estimation result the mean per capita food consumption expenditure and the per capita total consumption expenditure including the non-food consumption expenditure for electrified households was birr 1674.27 and 2062.74 respectively. Thus, the results of the mean impact indicate that electrification significantly increases per capita food consumption expenditure and per capita total consumption expenditure.

Table 10 :- The ATT estimation result of impact of rural electrification on households consumption expenditure

Outcome variables	Mean outcome variable		ATT	Std. Err. (Bootstrapped)	P-value
	Treated	Control			
Per-capita food expenditure	4622.3	2948.02	1674.27	2012.62	0.000***
Per-capita total expenditure	7182.7	5120.01	2062.74	2523.82	0.000***

*** indicates significance at 1% level of significance

Source: Own computation result based on survey data, 2023

3.4.2 The estimation of the ATT on household's income

As it was indicated in table 11, Total average annual consumption income of households with electricity is ETB 8796.49 higher than households without electricity and the difference is positive and significant (p=0.00). The result of this study is similar to the result of the studies of impact of rural electrification by Bernard (2012), Peters, et al.(2011), Bensch, et al (2011), Peters and Sievert (2016) and Lenz, et al (2017) where all show less positive effect of rural electrification in Africa as compared to Asia or Latin America.

Table 11 :- The ATT estimation result of impact of rural electrification on household's income

Outcome Variable	Mean outcome variable		ATT	Std.Err. (Bootstrapped)	P-value
	Treated	Control			
Annual Income	28619.66	19823.17	8796.49	12267.75	0.000***

*** indicates significance at 1% level of significance

Note: ATT stands for average treatment effect on the treated

Source: Own computation result based on survey data, 2023

3.5 Sensitivity Analysis Result

The other thing to be considered in propensity score matching is that all matching estimators not exactly robust against hidden biases due to selection bias and unobservable characteristics, hence a sensitivity analysis has to be performed. Thus the robustness of significant outcome variables should be tested. Sensitivity analysis test would be checked to test the problem of unobservable bias in non-experimental data analysis. For insignificant effects on outcome variables sensitivity analysis test is not meaningfully to be performed (Rosenbaum, 2002). There should be no hidden bias and the matching estimators are robust, if the unobservable variables which simultaneously affect rural electrification and the outcome variables were included in the estimation of the propensity scores.

As it was suggested by Rosenbaum (2002), the bounding approach was used to test the sensitivity analysis. Accordingly, the sensitivity analysis was estimated for only significant and lower bound outcome variables like per capita food consumption expenditure, per capita total consumption expenditure and total annual income. The Rosenbaum bound estimation was conducted between the gamma values of 1 up to 3 by summing 0.5 to 1 and continuing up to 3, in order to check whether the ATT is sensitive to hidden bias or not. Then the sensitivity analysis was performed at gamma (critical values of) 1, 1.5, 2, 2.5 and 3.

The result in table 12 shows that, the radius caliper based critical values of gamma with a band width of 0.1 in the first, second, third, fourth and fifth column at critical values e^{γ}=1, 1.5, 2, 2.5, 3 respectively under the assumption of conditional independency of free of hidden bias for all outcome variables shows significant and positive impact of rural electrification in the outcome variables. For instance, in the first column for each outcome indicators under the conditional independency assumption of the free of hidden bias at critical values of e^{γ}=1 indicates that rural electrification resulted in a significant increase in per capita food consumption expenditure, per capita total consumption expenditure and total annual income at 1% significance level. Moreover, the sensitivity analysis test result shows that the impact of rural electrification is not changing for all outcome variables and it was found to be statistically significant at 1%.

Table 12 :- The sensitivity analysis test result of ATT on outcome variables

Outcome variables	Upper bound significance level at various critical values using radius caliper matching with band width of 0.1				
	e^{γ} =1	e^{γ} =1.5	e^{γ} =2	e^{γ} =2.5	e^{γ} =3
Per capita food expenditure	0	0	1.1e-13	2.7e-11	1.1e-09
Per capita total expenditure	0	0	1.1e-13	2.7e-11	1.1e-09
Annual income	0	0	1.1e-13	2.7e-11	1.1e-09

Note: Gamma ($\mathbf{e}^{\gamma}$) indicates log odds of differential assignment due to unobserved factors

Source: Own computation result based on survey data, 2023

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. SUMMARY AND CONCLUSION

This study analyzed the impact of rural electrification on household's welfare in case of Gurage zone, SNNPRS. In addition to this, it has also tried to analyze the factors affecting rural electrification in the study area. A multistage sampling technique was used to collect data from 228 randomly selected sample households of which 125 were electrified, whereas the remaining 103 were non-electrified. The study used binary logistic regression model to analyze factors determining rural electrification in the study area. Moreover, among the quasi-experimental approaches, a propensity score matching model was used to analyze the impact of rural electrification on rural household's consumption expenditure and income in the study area. Along with the econometric models, a descriptive statistical analysis has been used to analyze data obtained from the sample households in the study area.

The result from the binary logistic regression model for the determinants of rural electrification revealed that, out of the ten explanatory variables four of them were found significantly determining rural electrification in the study area. Out of the significant variables education level of the household head, community access to good road, connection to the national grid line and income level were found to be positively and significantly determining rural electrification. This implies that, households who have better educational status in term of years of schooling, access to good road, having an access to connection to the national grid line and income level were found to be more likely to be electrified than their counterparts.

The estimation result of the average treatment effect on treated showed that there was significant mean difference between electrified and non-electrified in terms of expenditure and income. The radius caliper based estimation result of the impact of rural electrification on outcome indicators revealed that, the mean difference in per capita food consumption expenditure and the per capita total consumption expenditure including the non-food consumption expenditure between the two groups was found to be positive and statistically significant at less than 1% significance level. According to the ATT estimation result, the per capita food consumption and per capita total

expenditure was higher for electrified than non-electrified which was birr 1674.27 and birr 2062.74 respectively.

Similarly, the result from the ATT estimation revealed positive and significant mean differences between electrified and non-electrified in terms of total annual income. The result showed that, the average total annual income for electrified was birr 8796.49 which was higher when compared to non-electrified and was found to be statistically significant at 1% significance level.

5.2. RECOMMENDATIONS

Depending on the findings of the study the following recommendations are made. The study findings revealed that rural electrification has positively and significantly contributed to consumption expenditure and income in the study area. Thus, the concerned governmental and non-governmental organization should emphasize on the expansion of the capacity of the electric power and should focus on ways of tackling electric power outage.

Based on the study findings, community access to good road was found to be positively and significantly determining rural electrification in the study area. Thus, the concerned government bodies should work exhaustively in constructing rural roads there by to electrify rural farm households.

The study result has also revealed that, connection with national grid line was found to be positively and significantly determining the rural electrification. Thus, the local or regional government should design to electrify area which has connection with national grid line.

On the other hand, education was found significantly determining rural electrification positively. This implies that educated households are more likely to be award about the mult-purpose importance of electrification. Thus, the local government should facilitate either formal or informal education access such as adult education for rural farm households.

Based on the study result, the total annual income of households was found to influence rural electrification positively and significantly. Thus, either government or non-government organizations should provide support for households which enable them to generate income.

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APPENDICES

Appendix-1: Variance inflation factor (VIF) test result

Variables	VIF	1/VIF
Education	2.00	0.501213
Income	1.94	0.515926
Marital status	1.10	0.905798
Connection with grid line	1.05	0.952416
Family Size	1.04	0.957190
Occupation	1.94	0.501213
Sex of the respondents	1.03	0.966247
Adoption of solar energy	1.02	0.501213
Age	1.03	0.973130
Access to good road	1.02	0.980284
Mean VIF	1.28	

Source: Own computation result based on survey data, 2023

Appendix-2: Breusch-Pagan / Cook-Weisberg test for heteroskedasticity test result

Ho: Constant variance

Variables: fitted values of electrification

chi2(1)	= 0.09
Prob > chi2	= 0.7701

Source: Own computation result based on survey data, 2023

Appendix-3: The model specification test result (Link test)

Electrification	Coef.	Std. Err.	t	P>|t|
_hat	.8227721	.3756684	2.19	0.029
_hatsq	.1881811	.3787904	0.50	0.620
_cons	.0333122	.088912	0.37	0.708

Source: Own computation based on survey data, 2023

Appendix-4: Conversion factor used to estimate Adult Equivalent

Age	Male	Female
<10	0.6	0.6
10-13	0.9	0.8
14-16	1	0.75
17-50	1	0.75
>50	1	0.75

Source: Storck, et al., 1991

Appendix-5: Conversion factor to tropical livestock unit

Animal Category	Tropical livestock unit (TLU)
Ox	1.10
Cow	1.00
Heifer	0.50
Bull	0.60
Calves	0.20
Sheep	0.01
Goat	0.09
Donkey	0.50
Horse	0.80
Mule	0.70
Poultry	0.001

Source: Storck, et al., 1991

QUESTIONNAIRE

Introduction

This questionnaire is prepared by a Development Economics Post Graduate student in Wolkite University College of Business and Economics, Department of Economics for the Requirements of the Degree of Masters of Developmental economics. The aim of this questionnaire is to collect data about Impact of Electricity on Rural Household's Welfare in Case of Gurage Zone .The information you provide is important for successfully accomplishing the research. For this sake, I really confirm you that all the data will be used for academic purpose and will be analyzed anonymously and because of your provision, you will never be exposed to any harm.

Thank you

Instructions to enumerators:

Please make sure that the interviewee has fully understood the objectives of the interview and the information s/he gives will be confidential. It is absolutely necessary to win the confidence of the interviewee by creating climate of friendship and trust and asking her/him convenient time and place to get reliable information. Make brief introduction to each respondent about the purpose of this study and attempt all items and questions. Please put a tick mark **(√),Yes or No** for multiple choice question and write answers for open ended question in the space provided .Tell them the data that they will provide will be kept confidential and will not be disclosed to any third party and should not write their name.

PART ONE

Section One A. Socio-economic Characteristics of households

	Questions	Possible response
1	Sex of the households	1. Male 2. Female
2	Age of the respondent in completed years	1. 25-34years 2. 35-44 yrs 3. 45 – 54yrs 4.55-64 5. 65 and above
3	Marital status	1. Single, 2. Married, 3. Single parent, 4. widowed, 5. separated 6. Other (specify)_____
4	Family Size of household	Specify the number_____
5	Education	1. Did not attained formal education 2. 1-4 3. 5 -8 4. 9-12 5. certificate and above
6	Main occupation of the household head	1. Employed 2. Self –employed 3. Daily laborer 4. Unemployed/pensioner 5.Other (Specify)
7	Main type of dwelling unit walling material	1. Bricks. 2.Stone 3. Earth/Mud 4. Wooden 5. Iron sheet 6.Cement blocks

		7. Others Specify…
8	What is your occupation?	1. Farmer 2. Business 3. Employee 4. Others (specify)_____
9	Does the community has access to good roads	1. Yes 2. No
10	Does the household has a grid electricity connection	1. Yes 2. No

	PART TWO	
11	Do you have your own farm land	1.Yes 2 No
12	If yes to question 9, the size of the land is:	1. < 0.5hectar 2. 0.5-1.5hectar 3. 15.01-2hectar 4. 2.01 hectare and above
13	Do you keep any livestock?	1. Yes 2. No
14	If yes, types of livestock production that you participated in	Tick (√)
	Cattle	
	Sheep	
	Horse	
	Donkey	
	Mule	
	Goat	
	Others	

15	Does Agricultural activity alone is enough to be food secured?	1.Yes 2.No
16	If no for question 13, when have you started to engage in non-farm activity?	Specify in Months_____
17	On what type of non -farm activities do you engaged in?	Tick the sign (√) to the corresponding activity that you engaged in.
A	Small trading business	
B	Casual labor	
C	Salary/wage employed	
D	Others, specify----------	
16	Do you have got any transfer payment before	1.Yes 2.No
18	Dose household has access to credit	1. OMFI 2. Bank 3. Edir 4. Other_____
19	In which type of transfer payment do you benefited?	1.Remittances 2.Pension/grant 3.Social security benefits 4.No source of income
20	What types of related energy source do the households use	
A	Does household uses firewood and kerosene and charcoal?	1. Yes 2. No
B	Does household uses firewood and charcoal only?	1. Yes 2. No

C	Does household uses, kerosene and charcoal only?	1. Yes 2.No
D	Dose household uses firewood only?	1. Yes 2.No
E	Does households use kerosene only	1. Yes 2. No
F	Household does not use all sources?	1. Yes 2.No
21	How many hours per evening does your household usually use candles for lighting?	1. Specify in minute._____
22	*How much do you cost for this purpose?*	1. Specify birr_____
23	Does connection to the grid electricity benefits the household?	1.Yes 2.No

24	When did you Connected to National Electricity grid, and when started using electricity			1.Specify in months_____
25	Which household electric appliances do you own/and No. of times used/Benefits			
	Appliance	(1=No;2=Yes)	Daily, Weekly. Monthly. Yearly Frequency Codes A	Benefits of services
a	Radio set			
b	TV/DVD set			
c	Refrigerator			
d	Washing machine			

e	Electric iron			
f	Mobile phones			
g	Cooking/ heating /cooling devices			
h	Electric water pump			
i	Computers/printers			
j	Motorized agricultural machinery			
k	Lighting devices (bulbs, lamp shades)			
l	Others (Specify)……..			
26 DO you engage in income generating activities using grid electricity services?			1. Yes 2. No	
	If yes, please provide the following information			
27.	Income generating activities undertaken using grid electricity		Average amount (birr) obtained per month	
a				
b				
c				
d				
e				

f		
	How much do you cost monthly, specify in birr_____	
28	How much do you cost for utilization of electricity	1. Specify in birr_____

Social aspect of rural electricity

29	Top Evening Activities of Men and Women without and with Electricity (Yes/No)				
		Men		women	
	Household activity	Without electricity	with electricity	Without electricity	with electricity
a	Family discussion				
b	Tend cattle				
c	Radio listening				
d	Sleep early				
e	Domestic work				
f	Watch TV				
g	Help children study				
	Top Evening Activities of Boys and Girls without and with Electrification (Yes/ No)				
30	Household activity	Men (households)		Women (households)	
		With electricity	without electricity	With electricity	Without electricity

a	Family discussion				
b	Tend cattle				
c	Radio listening				
d	Sleep early				
e	Domestic work				
f	Watch TV				
g	Own duty				
		Household Without electricity		Household with electricity	
31	Has electricity improves children's education?	1. Yes 2. no		1. Yes 2. No	
32	Where children's do their homework	Tick the sign (√) to the corresponding activity that they engaged in			
		Household With electricity		Household Without electricity	
a	Home				
b	school				
c	Outdoors				
d	Neighbor				
e	No answer/no				

	children			
33	Children's study time			
a	Hours per night	1.Specify in minutes----------		1. Specify in minutes_____
34	Does lighting is adequate in your household	1. Yes 2. No		
		(agree,)	disagree	No opinion
35	The usage of kerosene for lighting is without any problem. (with and without electricity)			
36	Dose electricity helps for better lighting (for electrified)			
37	Does electricity reduce candle consumption			
38	Does electricity bring better indoor air quality			
39	Does electricity bring better health			

Semi structured interview Guides for key informant interviews

(Woreda electric district Official)

Introduction

This questionnaire is prepared by a Development Economics Post Graduate student in Wolkite University College of Business and Economics, Department of Economics for the Requirements of the Degree of Masters of Developmental economics. The aim of this questionnaire is to collect data about Impact of Electricity on Rural Household's Welfare in Case of Gurage Zone .The information you provide is important for successfully accomplishing the research. For this sake, I really confirm you that all the data will be used for academic purpose and will be analyzed anonymously and because of your provision, you will never be exposed to any harm.

Name of the organization_____ Date_____

Respondent's current position---------- Age----------

Sex---------- Level of education_____

1. For how long have you been working here?
2. How many rural households are access to electricity in the woreda in general and study kebele in particular?
3. How do you perceive households involvement in electricity?
4. What is the household demand for grid electricity services in the woreda specifically especially selected Keble's compared to supply?
5. Would you say that policies have contributed access to grid electricity services in this district?

4. What income generating activities are being done due to the presence of grid electricity services?

5. What is the contribution of grid electricity services to household income?

6. What should government do to improve grid electricity services?

7. What are the challenges facing households in utilization of grid electricity for household income generation?

8. Suggest what type of measures should be taken by the government and other stakeholders to improve rural electricity diversification.

Guideline for Focused Group Discussion

Date……

Kebele…….

Village……. number_____

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Thank you for your co-operation

2. Socio –demography of the respondent

	Sex	Age	Level of Education
Respondent 1			
Respondent 2			
Respondent 3			
Respondent 4			
Respondent 5			
Respondent 6			
Respondent 7			

1. For how long have you been using grid electricity services? …….(In years)
2. What is your average cost per month for using grid electricity services? …….birr
3. What are the main uses of electricity?
4. Do you engage in income generating activities using grid electricity services?
5. Are you perceived any opportunities your kebele that help households to improve their income? What are they?
6. Where did you charging your mobile phone (for non-electrified)?
7. Does the accessibility of electricity encourage you to buy television?
8. If yes, what type of income generating activities undertaken using grid electricity and Average amount (birr) obtained per month?
9. Does electric access improve household's welfare?
10. Briefly discuss the challenges you faced while using electricity?
11. What is your suggestion for the future regarding electricity in your village?

Thank you for your co-operation

Guideline for Key Informant Interviews

Date……

Woreda…….

number_____

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Checklist for Key Informant Interviews

(Woreda Administrative office, Woreda Agriculture Officer a, Woreda Water and Mineral and woreda Finance and Economy Development Office)

Name of the respondent……. Position held…….

Education level…… Age of the respondent……

1. How do you perceive households involvement in Electricity?
2. Which types of electrical energy is dominantly utilized in the woreda?
2. What are the reasons or motives (pull or push factors) for households to participate to this type of energy source?
3. How do you perceive the contribution of electricity for rural household's welfare?
4. What should government do to improve grid electricity services?

5. What are the total population of livestock and density of the woreda and selected kebele for Agricultural office)?
6. Does access to Electricity reduced the amount of travel time for purchasing kerosene and churching Mobil phone?
7. Does electric access improve household's welfare?
8. Does electricity helps for a better health?
9. What are the challenges facing households in utilization of grid electricity for household income generation?
10. Suggest what type of measures should be taken by the government and other stakeholders to improve rural electricity diversification.

Thank you for your co-operation