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Title of the project: Electricity access and Rural Household Productivity: Evidence from Tanzania

A dissertation submitted to the African Center of Excellence in Energy for sustainable development (ACE-ESD)

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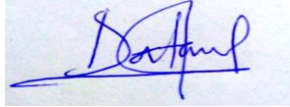
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October, 2021
Kigali-Rwanda

DECLARATION

I hereby declare that this research project is my own original idea and has not been presented for another degree in University of Rwanda or elsewhere. All sources of materials that will be used for the dissertation work will fully be acknowledged.

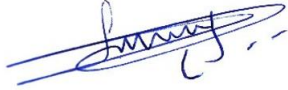Signed: Date: 1st November, 2021

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APPROVAL

This thesis has been submitted with the approval of my supervisor whose signature is appended against their respective names below:

Signed: **Date: 31 October, 2021**

Dr. Aimable Nsabimana

DEDICATION

I dedicate this piece of work to my parents, relatives and friends who have been with me on this journey of education. And lastly also to my wife Hellen Lavina.

ACKNOWLEDGEMENT

I take this opportunity to acknowledge my beloved family members for their undying support or provisions towards the completion of this dissertation, secondly, my friends who have helped me diligently on this struggle. And lastly to my supervisor, Dr. Aimable Nsabimana thanks for the direction and contributing to this noble cause. May the Good Lord reward you abundantly!

May the Good Lord bless you all!

ABSTRACT

Access to electricity is essential for soci-economic change or transformation of sub-Saharan Africa (SSA) economies and plays crucial role in enhancing the economic capacities of communities to achieve faster and more sustainable development progress and ensure equitable provision of electricity to both the urban and rural areas in Africa. Evidences show that sub-Saharan countries have embarked recently on electrification and rural electrification programs to provide and provide and improve on the access to electricity to enhance the household productivity, employment opportunities and improve the way of life in Africa. This investigates the effect of electricity access on the rural household productivity in Tanzania using the household and individual information from the LSMS-ISA of Tanzania national data survey panel. The study shows that electricity access increases the labor productivity and the wage of hired workers on the farm for the rural household. We also observe a decrease in the farm output of the household with access to electricity this implies the household uses electricity not for agricultural activities. The results also indicate that electricity accessibility significantly increases level of crop produce such as rice, maize and beans on the farm for the rural household with electricity. The results further show that electricity access significantly reduces the days spent on the farm by members of the household and associated with increase in total days spent on the farm by hired labor of households with access to electricity.

Key words: Electricity access, Rural household Productivity, Tanzania.

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LIST OF ACRONYMS

SSA	Sub-Saharan Africa
LSMS-ISA	Living Standard Measurement Study-Integrated Surveys Agriculture
EA	East Africa
IEA	International Energy Agency
GOT	Government of Tanzania
TWh	Terawatt per Hour
MW	Megawatt
UK	United Kingdom
DG	Distributed Generation
ATE	Average Treatment Effect
OLS	Ordinary Least Squares
NBS	National Bureau of Statistics
NPS	National Panel Surveys
REA	Rural Energy Agency
REF	Rural Energy Fund
REB	Rural Energy Board
UNDP	United Nations Development Programme
TANESCO	Tanzania Electric Supply Company Limited

CHAPTER ONE

INTRODUCTION

1.1. Background to the study

In Africa especially the Sub-Sahara regions most of the countries have embarked on electrification and rural electrification program in order to improve on the access to electricity and with all this programs and policies there is still uneven distribution of electricity among countries in terms of rural and urban areas. Electricity profoundly influences people's ways of lives and is fundamental for social development and economic growth especially in rural areas. Over the years, electricity has greatly helped in transforming societies and supported human development. Electricity contributes to attainment of the best basic human needs for example nutrition, warmth, education & light (Saing 2018). Furthermore, there is sufficient evidence that access to reliable, effective, cheap, and safe electricity sources can directly impact on productivity, health, and earnings, and can improve gender equity, attainment of education, and access to other infrastructure services(Bridge, Adhikari, and Fontenla 2016).

Electricity access enhances the social economic development and the social way of life among household members of a society in a nation (Alam et al. 2018). Notwithstanding the importance of access to electricity it has also improve the people's livelihood in the rural area settings in the society. There are many people in the world still with no or limited electricity access and other forms or sources of modern energies in the world. Currently in the world of 6.5 billion people there are 1.6 billion people without electricity access and most of the population in the world around 2.5 billion rely on biomass as their source of energy (OECD, 2006). It is mostly the poor population that lack the affordability and accessibility to electricity and the modern energies and this limitation and no electricity and other sources of energies has contributed to the poor being or people remained poor since they cannot afford it. There are some body of policy makers who believes that providing access to electricity and modern energies for the poor population especially in the rural areas improves on their way of life by creating income generating opportunities as seen from their quotes: *"Accessibility to affordable modern energy sources or services is important in the alleviation of poverty and this improves on the agriculture productivity, employment opportunities, economic activities, income generation and the way of life of the people especially the women and children*

according to the world summit on the sustainable development in the year 2002.'' (United Nations 2002)

According to the energy challenge for achieving the millennium development goals of 2005 modern energy inputs like fuels and electricity play a very essential role in the development of a society through the creation of job opportunities, generation of economic activities, trade, development of transport facilities, enterprise and increase in agriculture outputs (UN-Energy 2005).

The international energy agency IEA (2015) reported that 1.2 billion people living in the world has no access to electricity and from this population in the world 526 million i.e. 43 per cent resides in South Asia and South East part of Asia. This make up of 237 million people live in India, 50 million resides in Pakistan, 60 million live in Bangladesh, 39 million live in Myanmar and the other 49 million resides in Indonesia. But 634 million i.e. 53 per cent of the 1.2 billion of the population with no electricity access live in the sub-Sahara Africa region. This makes up almost half of the south Asia population 44 per cent that resides in the rural areas and have no electricity access and 13 per cent population in the rural areas of sub-Sahara Africa have electricity access. With all this South Asia succeeded in some extend to connect substantial part of their population to the national grid through the continuous government efforts and electricity sector investments but apparently in the sub-Sahara regions failed in achieving their set targets. Evidently this may not overemphasis to infer but the recent global North-south digital and economic difference attributed to difference in electricity access.

As of 2019, East Africa (EA) - here defined as the macro-region that includes Uganda, Kenya, Burundi Malawi, Rwanda, Mozambique and Tanzania - hosts 2.9 per cent world's population (The World Bank, 2019), but only caters for 0.14 per cent of global gross consumption of electricity (CIA, 2017). While regional share of the population with no electricity access has reduced from 90 per cent in 2000 to 64 per cent in 2017 (IEA, 2018), the number of people with no electricity really increased by about 8 million but the rapid population growth has outnumbered the electrification projects and government efforts put in place to provide electricity to the people. 141 million people are without access in the region, and high rural-urban inequality prevails in all countries. The regional final electricity consumption stood at 35 TWh in 2016 (CIA, 2017). In high income countries like Italy in the same year has consumed 310 Twh electricity although their population is 20 per cent less compared to the east Africa's population. Provision and electricity accessibility has been discovered as the major challenge in Tanzania especially in the rural areas with only 24.5 per cent have electricity according to April 2020 report from the Rural Energy Agency (Lake, 2014). The

Government of Tanzania committed to reform operations of the national utility company TANESCO to meet the new demand through low cost and reliable energy solution. The great dependence on costly thermal and alternative generation of energy sources has made the energy sector financially unrealistic.(Anon n.d.). Tanzania has world class and abundant energy sources such as solar energy and wind energy resources. (SimuSolar, 2021). Tanzania has embarked on more electrification projects and policies and this has made progress in the expansion of the national grid, increase in generation capacity through natural gas energy, provision of conducive environment or climate for home solar power and the publication of new standard rules for the power purchase agreement for small producers of power 2017; but still more work is needed to provide cheap, reliable and adequate electricity and other energy sources (SimuSolar, 2021). Electricity in Tanzania is mostly generated through natural gas but also hydropower contributes significant source of power to the national grid. (Lake, 2014). Tanzania has an installed capacity of 1,601.84 megawatts of electricity generation as of April 2020 from this generation capacity natural gas account for 892.72MW, hydro power accounts for the 573.70MW, Heavy oil power accounts for 88.80MW and Biomass power account for also the 10.50MW power generation. 73.2 per cent urban areas has electricity access compared to the 24.5 per cent rural areas with electricity access as of April 2020 according to the Rural Energy Agency and 65 per cent population in Tanzania resides in the rural areas and 78.4 per cent people in Tanzania are on national electricity (Lake, 2014).

The study seeks to investigates the extent to which the accessibility of electricity influences the productivity of the individuals in their households in Tanzania. Electricity Access is the independent variable while Rural Household Productivity is the dependent variable.

This paper contributes to the knowledge gap on electricity access & rural household productivity and presents the synthesis of research findings from some studies in Tanzania. While the subject is very relevant and timely as far as electricity access in the rural areas of Tanzania, the linkages between electricity access and the productivity of the rural household's rests largely uncultivated. Very few studies and literature are available in the existing literature development that talk about the problems concerned. Jorgenson, (1984) for example indicates that energy plays an important role in productivity increase in the united states. (Jung and Lee 2014) also examined the correlation effects between productivity growth and efficiency of energy using data level of Korean manufacturing plant and the study finds that electrification in the short path decreases productivity and also in the long path the of rate of productivity growth increases. (Montalbano and Nenci 2019) also studied

the link among energy efficiency, productivity & exports the findings show that there is significant impact between energy efficiency & productivity. the empirical evidence shows that energy efficiency has lower effects on productivity in export firms compared to the non-export firms. (Anon n.d.) in the perspective of South Africa and (Um, Straub, and Vellutini 2009) in Middle East and North African situation the study finds positive relationship between electricity generation and the productivity of labor. (Allcott, Collard-Wexler, and O'Connell 2016) finds that shortages of electricity reduces average level of output of industries especially textile in India by about 5 per cent. Likewise, (Alby, Dethier, and Straub 2013) argue that power supply reliability is positively associated with the total productivity factor in the manufacturing sectors especially garments of China, Pakistan, Ethiopia and Bangladesh. These studies while significant they concentrated on a single industry or country and drawn their conclusion centered on a particular industry or country that cannot be generalized for other countries or industries. Furthermore, the studies mentioned above does not use novel and solid econometrics approaches that are often required to draw reasonable policy recommendations. The study currently tries to fill the gap.

Energy use in most of the developed modern cities in Tanzania enhances every part of life. From the effects on productivity of work, the rooms people live inside that are controlled climatically, the transport systems people use for school or work and the way of leisure time people spend. With no accessibility to low-cost, dependable and abundant energies the way of life for the people would be different (Lake, 2014). Just take a picture of the developed cities in Tanzania such as Dar es salaam, Arusha and Dodoma city in the night the human activities that take place during the night hours in the urban cities or Metropolitan city areas are of modern development in people and their benefits are not equally spread in Tanzania (Kanagawa and Nakata 2008). A different photo of the night time in the rural areas or villages of Tanzania portrays a different story compared to the one of the urban areas and cities. For most of the people in these rural areas there are limited or no human activities after sun set to them refrigerated medicines and food stuffs are considered luxury. Modern technologies such as telecommunication like internet access, phones and television are scarce and transport facilities such as railway and road transport are expensive. The massive inequalities that exist in the access of energy sources especially electricity needs to be solved. The question to be answered in the study is to what extend does inequalities affect productivity of the people in the household who resides in the energy poor regions of rural Tanzania (Kanagawa and Nakata 2008).

The goals of the study will be to establish the total number of rural households that have electricity and how this results into increased social economic productivity, to find out whether there are rural

households that earn a living mainly because of the use of electricity and to establish any challenging situations that have limited the electricity accessibility in rural areas of Tanzania and what is being done by stakeholders to resolve this.

1.2. Electricity Sector of Tanzania

Tanzania is located in the East African region and connects the six (6) countries that are land locked to the Indian ocean and is the most populous sub-Sahara African country at the 6th position. The country is blessed with abundant source of energies like natural gas power, coal power, wind, geothermal, solar power, tidal power, hydropower, biomass power and wave (Power Africa, 2021) and (TanzaniaInvest, 2020). Tanzanian electricity sector currently comprises of over 80% power sourced from natural gas and hydropower based plants. The division is due to the desire by the government to increase diversification in the energy mix and the move away from the over dependency on hydropower and the potential supply risk foreseen with climate change. The country has installed capacity of 1602 MW power and Natural gas energy is the biggest contributor of power mix in the country to the national grid by about 892.7MW, hydropower also accounts to 573.7MW, Biomass 18MW, Heavy oil power account 88.8MW and solar 16.02MW. Some of the power in Tanzania are imported Zambia 5MW, Kenya 1MW and Uganda 10MW (ESI Africa, 2020).

The national utility company TANESCO is the one responsible for the transmission, generation and electricity distribution in the country is fully under the stewardship of the Tanzanian government for the 98 per cent of the electricity generated in the nation. In order to facilitate the rural electrification projects of the government they established rural energy fund (REF), rural energy agency (REA) and rural energy board (REB) to stimulate, facilitate & promote energy service access especially electricity in the rural areas of the country.

The consumption per capita of electricity in Tanzania is about 108kwh yearly in comparison with 550 kwh per year of sub-Sahara Africa average consumption and the average world consumption per year of 2500kwh. In the year 2019/2020 37.7 per cent households in the country's mainland have electricity compared to the 32.8 per cent in the year 2016/17 and in 2020 the country recorded the highest access to electricity of 84.6 per cent. According to the National Census 2012, 70 per cent people in Tanzania resides in the rural areas and 69.8 per cent people in the urban areas have electricity and 24.5 per cent households in the rural areas are connected to electricity in 2019/20 compared to 16.9 per cent in 2016/17.

Distribution of energy use

■ ELECTRICITY	■ SOLAR
■ GAS	■ GAS(BIOGAS)
■ LAMP OIL	■ CANDLE
■ FIREWOOD	■ PRIVATE GENERATOR
■ OTHER (SPECIFY)	

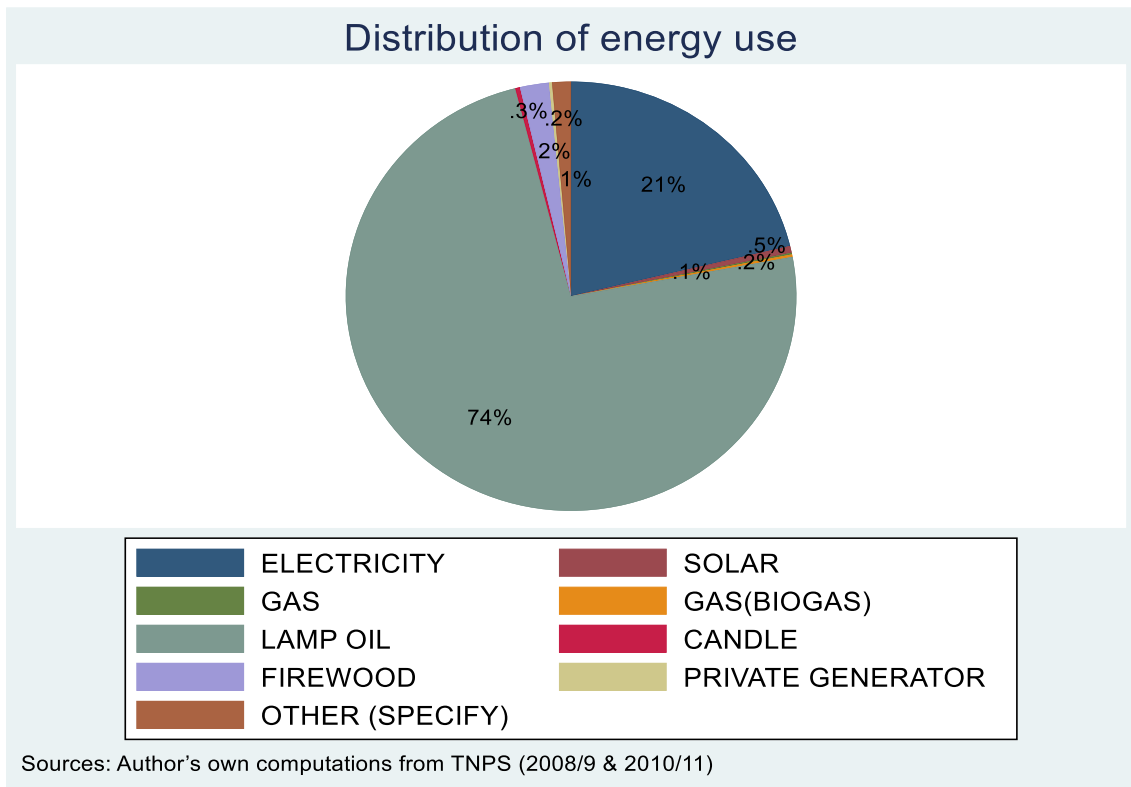Sources: Author's own computations from TNPS (2008/9 & 2010/11)

Figure 1: Electricity Distribution in 2008/2009 Tanzania

Figure1 shows the trend of energy use distribution in the rural households of Tanzania. The graph shows that 21 per cent of households in Tanzania rural areas have electricity and lamp oil is the major source of energies used in the rural areas of Tanzania with 74 per cent in the year 2008/2009.

Distribution of energy use

24%

65%

8%

1%

.2%

.9%

1%

.1%

ELECTRICITY • SOLAR • GAS • LAMP OIL • CANDLE • FIREWOOD • PRIVATE GENERATOR • OTHER (SPECIFY)

Sources: Author's own computations from TNPS (2008/9 & 2010/11)
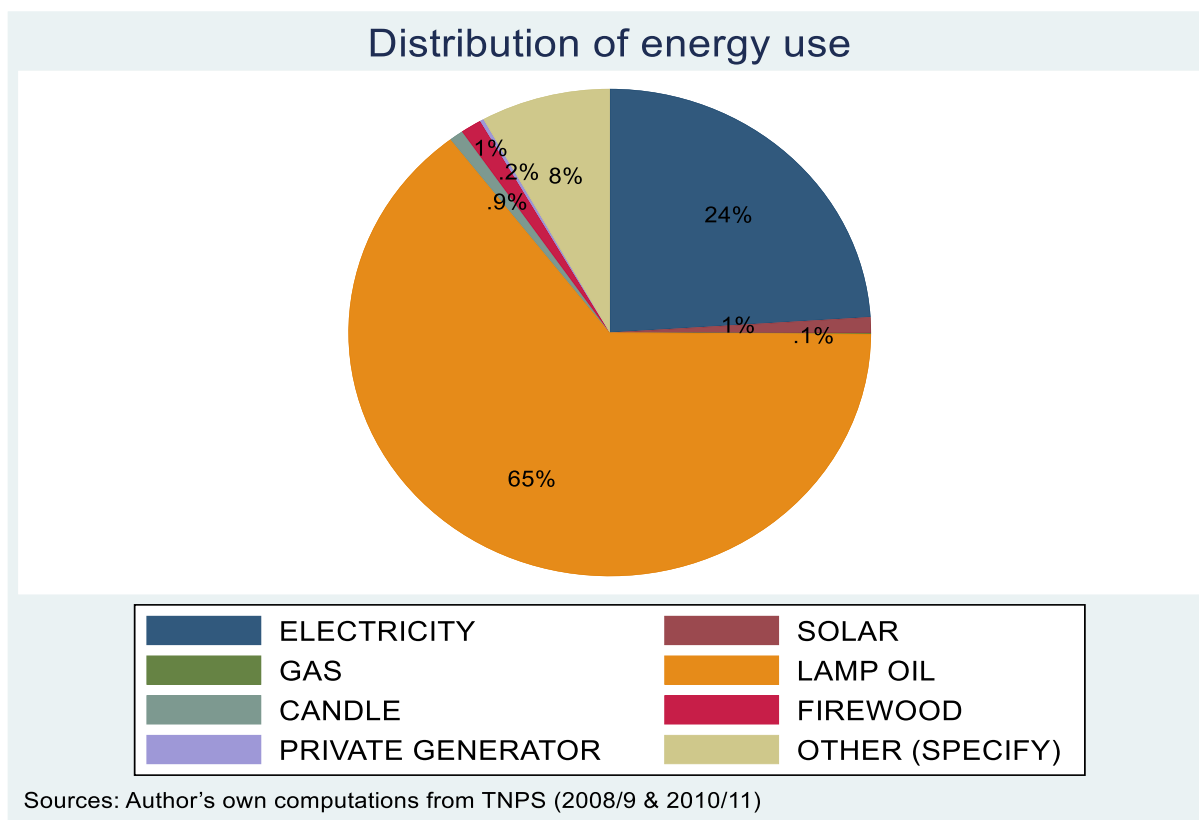
Figure 2: Electricity Distribution in 2010/11 Tanzania

Figure 2 show the trend of electricity distribution in the rural households of Tanzania across the two waves. In the year 2010/11 the percentage of electricity use has increased to 24 per cent compared to the year 2008/9 and lamp oil is still the highest energy source used in the rural areas of tanzania although with a reduction of 9 per cent i.e. from 74 to 65 per cent.

1.3. Statement of the Problem

Energy use in most of the developed modern cities in Tanzania enhances every part of life. From the effects on productivity of work, the rooms people live inside that are controlled climatically, the transport systems people use for school or work and the way of leisure time people spend. With no access to low-cost, dependable and abundant energies the way of lives for the people would be different (Lake, 2014). Just take a picture of the developed cities in Tanzania such as Dar es salaam, Arusha and Dodoma city in the night the human activities that take place during the night hours in the urban cities or Metropolitan city areas are of current development in people and their benefits are not equally dispersed in Tanzania (Kanagawa and Nakata 2008). A different photo of the night time in the rural areas or villages of Tanzania portrays a different story compared to the one of the urban areas and cities. For most of the people in these rural areas there are limited or no human activities

after sun set to them refrigerated medicines and food stuffs are considered luxury. Modern technologies such as telecommunication like internet access, phones and television are scarce and transport facilities such as railway and road transport are expensive. The massive inequalities that exist in the access of energy sources especially electricity needs to be solved. The question to be answered in the study is to what extend does inequalities affect productivity of the people in the household who resides in the energy poor regions of the rural Tanzania (Kanagawa and Nakata 2008).

The goals of the study will be to establish the total number of households in the rural areas that have electricity access and how this results into increased social economic productivity, to find out whether there are rural households that earn a living mainly because of the use of electricity and to establish any challenging situations that have limited the electricity accessibility in rural areas of Tanzania and what is being done by stakeholders to resolve this.

1.4. Objectives

Here are the objectives that the study will base on to measure the extent to which variables under study act upon each other.

1.4.1. Major Objectives

The major objective of the study is to investigates or analyze the influence of electricity access on household productivity in rural areas.

1.4.2. The Specific Objective

1. To analyze or investigate the impact of electricity access on labor productivity farm productivity & wage productivity.
2. To investigate the effects of electricity access on farm crop produce in the rural areas
3. To investigate the effects of electricity access on the working days on the farm by the rural household in Tanzania

1.5. Scope of the study

1.5.1. Content Scope

The study will concentrate electricity access on rural productivity with evidence from Tanzania under the indicators of household productivity being improved production in agricultural sector and

service sector that employs electricity as input. This can be evaluated through hours spent on agriculture activities, total days spent by members of household on the farm, total days spent by hired labor on the farm and how this translates into labor productivity, farm productivity and increased salaries and wages.

The study will seek to establish the connection between households with electricity access and labor productivity compared to households without electricity.

1.5.2. Geographical scope

Geographically 65 per cent of the people/population in Tanzania that resides in the rural area are considered for the study. The country has installed capacity of 1602 MW power and Natural gas energy is the biggest contributor of power mix in the country to the national grid by about 892.7MW, hydropower also accounts to 573.7MW, Biomass 18MW, Heavy oil power account 88.8MW and solar 16.02MW. Some of the power in Tanzania are imported Zambia 5MW, Kenya 1MW and Uganda 10MW (ESI Africa, 2020).

1.5.3. Time scope

 The study will consider the time frame between 2008 to 2011 of the years of survey the household panel data survey was done in Tanzania by Tanzanian National bureau of statistics (NSB) for first two waves.

1.6. Expected Outcome & Significance of the Study

1.6.1. Expected Outcome of the Study

The overall projected outcome of the thesis or research project is to successfully investigates the influence of electricity access on rural household productivity. The outcomes include; to provide empirical information on project evaluation of infrastructural development of the energy sector and provide policy makers more information to advance rural electrification programs at household level.

1.6.2. Significant of the Study

The study will be useful in the following ways:

To the general population and government of Tanzania, the study helps generate empirical information on the projects evaluation of infrastructural development that may strengthen the ability of residents in rural areas to better use the electricity as resource in labor productivity.

To the academia, the study helps cover literature gaps on the extent to which rural electrification influence social economic productivity in rural household sector of a developing country like Tanzania.

CHAPTER TWO

LITRATURE REVIEW

2.1. Introduction

This chapter presents a review of empirical work and existing literature on electricity accessibility and household rural productivity in Tanzania. The section reflects the state of reviews of the studies that emphasis on the accessibility to electricity and the rural household's development and also try to show the practical development accomplished in the earlier years and emerging new problems. The review of studies for the socio economic effects of the rural electrification projects in the less developed countries or nations started in the year 1980s. inside the framework of the world employment program research at the international labor offices, Fluitman (1983) studied the literature accessible on the electrification of rural areas, its impact on the rural development of industries and its effects on the socio economic goals of income generation and job/employment opportunities.

According to world bank (2009) the rural electrification programs or projects is the important element or component of government program in order to eradicate the level of poverty, improve on development imbalances and improve the way of life of the citizens in the country through the provision of cost effective, reliable, efficient and cheap source of lighting, health care service provision and better conditions of living. Vietnams strategic program to provide access to infrastructure such as electricity in the rural areas is one of the world's successful story in electrification projects of rural areas that was sequenced carefully and the rural energy projects has connected majority of the households in the rural areas of Vietnam to grid national electricity.

In the year 1975 electrifications among the rural poor household in Vietnam was 2.5 per cent according to the regional supply companies estimates (EVN 2001). At that moment, policies of electricity were combined with the objectives of the economic development programs of the nation that focused on the consumer goods production, food security and export of the commodities in the country (Hanh 1992). The use of electricity for productive purpose was the priority over the rural household extensions. In the mid of 1980s nevertheless with the 35kv construction of the line for distribution electrification increased in the areas that are densely populated and significantly the existing power lines of distribution improved. Electricity among the poor rural household increased from 14 per cent 1990 to 49 per cent the year 1993. The achievement was due to expansion and

connection of rural households in areas where electricity already existed but not increasing the national grid network in areas with no access to electricity (World Bank, 1994).

In the recent years the topic of electricity access and productivity has been reviewed and published in the scientific and grey literatures.

Amongst the grey literature regional and country specific evaluations and reports are supported by organizations donations (Khandker, Barnes, & Samad, 2009; Khandker, Barnes, Samad, & Minh, 2009; Khandker, Samad, Ali, & Barnes, 2012; UNDP Asia-Pacific, 2012; (World Bank, 2002). The productive use of energy through the GIZ-ESMAP study reviewed the effect of electricity accessibility on the economic development and although most of the literature shows positive effects of both electricity quality and use on the productivity of the firms, the degree of such effects are highly context and country specific (Attigah and Mayer-Tasch 2013). The report produced in the UK department for international development provided the summary of the effects of modern energy sources on the small enterprises in developing country economies (Meadows et al, 2003).

In accord the study of PRODUSE concluded modern energy sources can impact but does not certainly distress emergence of improvement, efficiency and productivity of small enterprises (Meadows et al., 2003, pg. 23). The independent world bank groups unit published the document that reviewed the working advancement made in estimating the social and economic effects of rural electrification on the low income communities of a country. Their findings indicates that rural areas electrification have positive effects on the local communities in relation of education improvement, increase in income generating activities locally, time saving, and improvement in the health of the people but the quantitative scientific evidence of the results from the study are limited (Independent Evaluation Group World Bank 2008). Bacon and Kojima. (2016) in their working paper from world bank reviewed the methods, findings and the robust of the study that indicates a strong relation between sources of energy, economic growth and poverty eradication. The objective of the study is to help project experts in finding consistent study with no severe working and data challenges.

Among the scientific literature the reviews analyze the increasing evidence and the methodological approach used for estimating the impacts or effects.

Ozturk (2010) focused on the literature review of energies especially the consumption of electricity on economic growth using the causality nexus at the level of country. The study highlighted that the empirical studies focused mostly on statistical tests for the roles of energy in generating economic growth or analyzing the direction of causality among the variables.

Cook (2011) analyze the literature review on roles and correlation of developmental infrastructure especially electricity on the social and economic development and economic growth in the rural areas, Brass et al. (2012) offer inclusive analysis on the core effects between the short period and long period educational, social, healthy and economic concerns of distributed generation programs and projects in the less developed countries. Most recently the authors (Baldwin et al. 2015) expanded their analysis on the distributed generation and development in the rural areas to shield the challenges of measure in the energy distribution systems.

Bonan, Pareglio, and Tavoni (2017) evaluates barriers, enablers and effects of energy access on the development results and the study indicates significant wellbeing effects of rural area electrification. Terrapon-Pfaff et al. (2014) analyze the effect and the sustainability of small scale projects of renewable energies in the less developed nations and the study suggest that most of the projects positively impacts on the sustainability of development in the countries.

Electricity access affects household farmers through the concentrated and wide margins or boundaries. Earlier research indicates that electrification of farm can improve and increase the crop yields or output of the farm and consequently increase on the level of incomes mostly through the implementation of irrigation pump system and other electric farm machines (Khandker, Barnes, and Samad 2013). This rise the value of the farm and the farmer can value every drop of water extracted from the irrigation pumps as the farm move to water concentrated and high valuation of crop produce (Mukherji, et al., 2010). It also permits farmers to increase the farming of their farm land since the capability of their labor force are no longer limited (Bhargava 2014). Basically electricity is a technology that saves labor for household farms to reduce on their reliance and expenses on the work force hired (FAO 2008).

Accessibility to electricity on the farm have positive spillovers on the farm through forward linkages inform of processing, harvesting, sorting, packaging and planting (Thornton 2017). This facilitates household farms in the reduction of wastes and increase the market of their surplus products on the farm. The interaction of electricity access on the farm with access to electricity in the local offices of government or home generates optimistic spillovers through the access of information for agriculture practices using mobile phone apps and televisions(Thornton 2017). This is possible to encourage household farmers to embrace good practice of agriculture to enhance profits and productivity. Furthermore provision and access of electric portal in the village or community offices of government helps farmers to connect with other farmers and also widen the market thus providing opportunities for better prices for their products (Jairath 2016).

The above papers mostly established that electricity access in the rural areas provides people with socio economic benefits that seems to be overvalued but there is still need for planning, design and evaluation of electrification projects in rural areas to utilize the positive effects and importance of electrification based investments.

CHAPTER THREE

METHODOLOGY, DATA SOURCES & DESCRIPTIVE STATISTICS

3.1. Introduction

This chapter presents the research methodology, area of study, data sources, descriptive statistics and the data analysis.

3.2. Research Methodology

To understand/analyze the effects of electricity access on the rural household productivity in Tanzania we use the Reghdfe (linear regression absorbing multiple levels of fixed effects) approach and because of the non-random nature of electricity access on rural household productivity we analyze the following equations.

$$Y_{hvrt =} \alpha + \alpha_1 E_{hvrt} + \Phi_v + \delta_r + \mathcal{E}_{hvrt} \qquad (1)$$

Where Y_{hvrt} is the vector of outcome or impact that includes the log of farm output productivity, log of wage farm productivity, log of labor farm productivity, total days spent by members of household on farm, total days spent by hired labor on the farm, total wages/salaries paid on farm to hired labor and total hours spent by members of household during households agricultural activities in financial terms for the household h in village v of the region r during the period of time t in Tanzania.

While E_{hvrt} represents the treatment variable defined as a dummy variable for the household h whether it has electricity or no electricity in village v of the region r of Tanzania at time period t.

Despite non-random nature of electricity access there is need to address the issue of endogeneity. We first include the Φ_v and δ_r to represent the community fixed effects and the regional fixed effects cater for the ignored regional & the cross community invariant time differences. Secondly we also include the household period of survey as the survey-year fixed effects λ_t to limit or control the spatial changes during household survey period and the ϵ_{hvrt} being the error term in the model.

To deal with the non-random nature of the access to electricity and unobserved factors that influence the use of electricity by the rural household. We introduce the demographic/household characteristics X_{hvrt} and estimate the following equation below.

$$Y_{hvrt} = \alpha + \alpha_1 E_{hvrt} + \eta_2 X_{hvrt} + \Phi_v + \delta_r + \lambda_t + \mathcal{E}_{hvrt} \qquad (2)$$

The Demographic/ household characteristics X_{hvrt} such as gender of the household head, the age of the households' head, level of education of household's head, the slope of the land, total households land area(hectare), sum of plots per households, size of the farm households, main distance to market, main distance to road and the size of household.

However, although there are some control variables in the model seen in the equation two above, there might be some confusing movements in the rural communities & households like other ignored factors such as political favors and the geography of the land that could affect the development of electricity infrastructure such as hydropower dams, solar plants and energy gas plants across the Tanzanian regions. Therefore, with the non-random nature of electricity distribution this may induce some biases in analyzing the effects of electricity access on the rural household productivity. So to deal with such problems we introduce the instrumental variables in the model to estimate the equation. The access to electricity is instrumented using the distance to the main market from the household in the community and main distance to road near the household F_{vrt} and estimate the equation below.

$$E_{hvrt} = \pi_0 + \pi_1 F_{vrt} + \pi_2 M_{hvrt} + T_{vrt} \qquad (3)$$

Where F_{vrt} being the instrument where we use main distance to market and main distance to road and instrument on the access to electricity, M_{hvrt} represents the covariates sets in the previous equation and I_{vrt} to cater for other unseen changes remaining of access to electricity. This sets the research methodology approach and preparing the household/individual and community features such as landscape conditions and the regional fixed effect, the distance to the main market from the household in the community and distance to the main road does not individually affect the outcomes. Endogeneity issues associated with electricity access may occur during the identification of the effects of electricity access on rural household productivity in Tanzania. To deal with this challenge we instrumented for the access to electricity and analyze its impact on the vector outcome such as total days spent by household members on the farm, total days spent on the farm by hired labor and the total wages/salaries paid to the hired farm labor by using the distance to the main market of the household as instrument from the two waves of the survey data of household farm combined with individual work placement together with the household energy use dataset.

3.3. Data Sources and Descriptive Statistics

To study the effect of electricity access on rural household productivity in Tanzania. We structure the household panel data using the two waves (2008/9wave and 2010/11wave) from Tanzanian national panel survey. The National panel survey waves were done by the Tanzanian national bureau of statistics Tanzania with support from the world bank through the LSMS-ISA program (Living standard measurement study-integrated surveys Agriculture program). The survey provides important and quality information on the household use of energy and the agricultural activities of the household. The table below provides the over view of the variables we are going to use in this study.

The NPS provides information on the labor productivity of the household, it has the number of hours the household member spends on household agricultural activities. Combing both the long rainy and short rainy seasons, we calculate the total days spent by household member on farm. We also compute the total days spent by hired labor on farm and drive the total wages paid to hired workers both men and women on the farm. (see Table 5. Appendix)

3.4. Demographic and Rural Household characteristics

Table 1. show the description and descriptive statistics of the study for the important variables used in the study. The main variables are from two waves of the national panel of data survey (NPS) supported by the world bank and executed by the national bureau of statistics Tanzania. The study uses the balanced panel data from the 26 regions of Tanzania and also uses data on electricity access, demographic and household characteristics. The table presents the description and descriptive statistics of the variables in the regression for the study and the variables used is got from the two national panel data survey of Tanzania. The rural household's productivity is measured in terms of log of wage productivity, log of farm output productivity, log of labor productivity etc. To define the households having electricity access if the source of light for the farm household is electricity through the response on the question "what is your major fuel used for lightening?" and a dummy variable is formed for the variable electricity access defined as the household with electricity access equal to one and zero otherwise.

The demographic and Household characteristics also affects the behavior of the rural farm households. The explanatory variables such as gender of household head, level of education household head, Age of the household head, sum of economically active members in the household, share of dependents in the household are included in the equation. Furthermore, rural household

productivity might be determined by the total wages/salaries paid to hired workers on the plots, total days spent by hired men and women and the total days spent by hired labor on farm.

The main distance to the market and main distance to the road next to the household are controlled. The variables main distance to market and main distance to the road near the household may affect the rural household productivity. Similarly distance to the main market and distance to the main road may also affect the access to electricity as households who leave far away from the markets and roads are negatively affected since most of the national grid lines pass the roads and the demand for electricity is more near the market areas.

The agricultural information that are included are total household land area measured in hectares, the number of plots per household, the size of the farm household in hectares, rice farm production, beans farm production, maize farm production and the total days spent by household members on farm that contributes to the level of farm output and determines the level of rural household productivity.

Table 1: Descriptive statistics of the demographic and Household characteristics of the study variables.

	Mean	Standard Deviation	Minimum	Maximum
HH head is Male	0.76	0.43	0	1
Hh head's Age	48.5	15.7	18	105
hh head ever went to school	0.72	0.45	0	1
Number of plots per hh	5.01	7.40	1	100
Total hh land area (hectare)	1.25	1.21	0.049	8.50
The size of farm hh	5.55	3.09	1	55
Main distance to market	6.67	4.84	0	20
Main distance to road	2.11	3.06	0	50
Economically active members in hh	2.81	1.71	0	24
Total Wages paid to hired workers on plots	92191.8	172517.7	50	2548500
Total days spent by hired women	23.1	35.8	1	488
Total days spent by hired men	25.2	47.8	1	862
Total days spent by hired workers	35.5	59.7	1	912
Total days spent by hh members	217.6	276.9	1	4354
Electricity access	0.073	0.26	0	1
Share of dependents in hh	0.25	0.22	0	1
Rice	6.44	1.23	2.09	10.6
Maize	6.48	1.27	1.44	11.5
Beans	4.90	1.15	1.44	10.6
Log of farm Productivity	5.69	1.15	0.00072	10.3
Log of labor Productivity	0.97	0.78	0.0000060	5.10
Log of wage Productivity	8.43	0.91	2.31	12.6
Observations	4543			

Sources: Author's own Computations from Tanzanian NPS (2008/9 and 2010/11 Waves)

Figure 3 illustrates the distribution of the total household land area among the farm household in the two waves according to the national panel datasets used for the study and the figures show how household land area are concentrated among the farm households in the 26 regions of Tanzania and most of the farm households have between one and four hectares of land in the country.

Household Land Area Distribution in Hectare

Source: Author's Calculation Using TNPS (2008/9 and 2010/11 Waves)
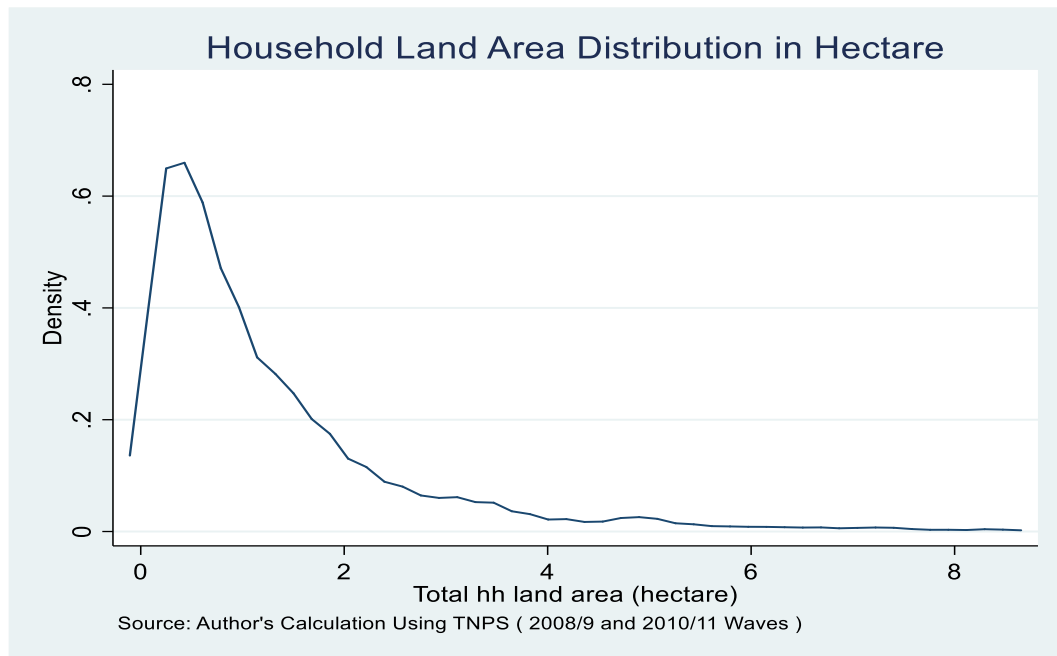
Figure 3: Household Land Area Distribution Hectare

To demonstrate the linear relationship of labor productivity and electricity access and farm productivity and electricity access over the two waves from the datasets in figure 4 and figure 5 separately. Figure 4 show the correlation between labor productivity and electricity access. The study shows a positive relation between labor productivity & electricity access and its confidence interval is increasing gradually outward from the fitted line. Furthermore, Figure 5 show the linear relationship between farm productivity and electricity access and there is positive linear relationship the two variables. The confidence interval line is increasing outward from the fitted line between the variables of farm productivity and electricity access.

Figure 4: Relationship between Labor Productivity and Electricity access

Figure 5: Relationship between Farm Productivity and Electricity access
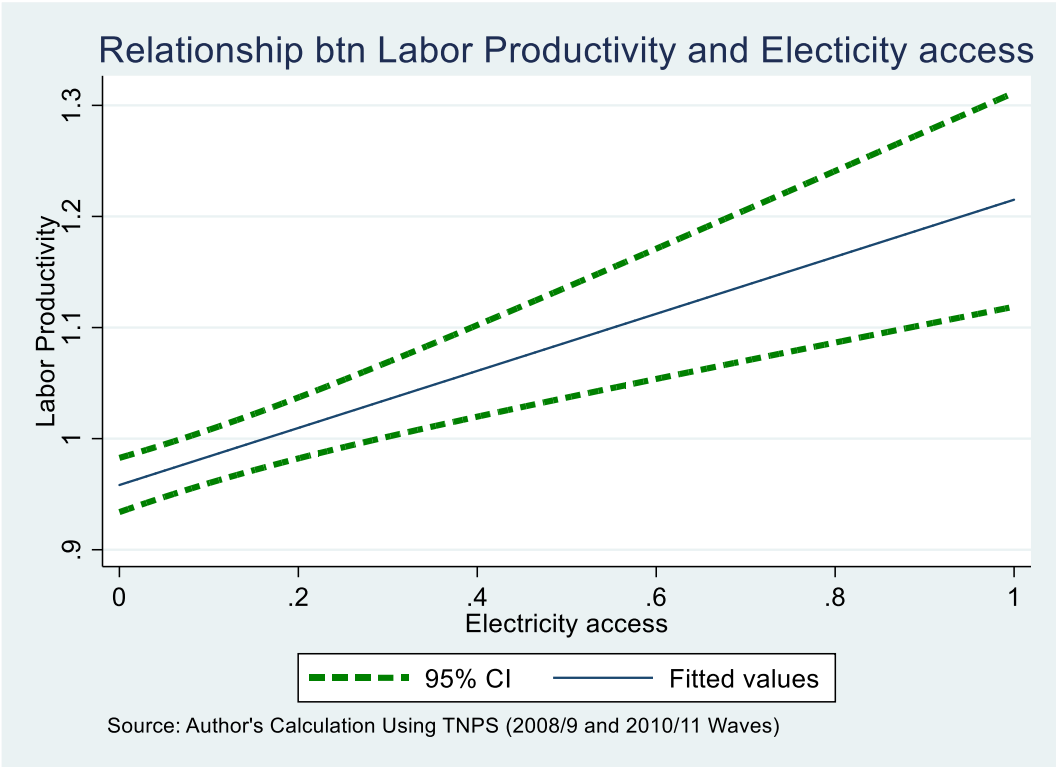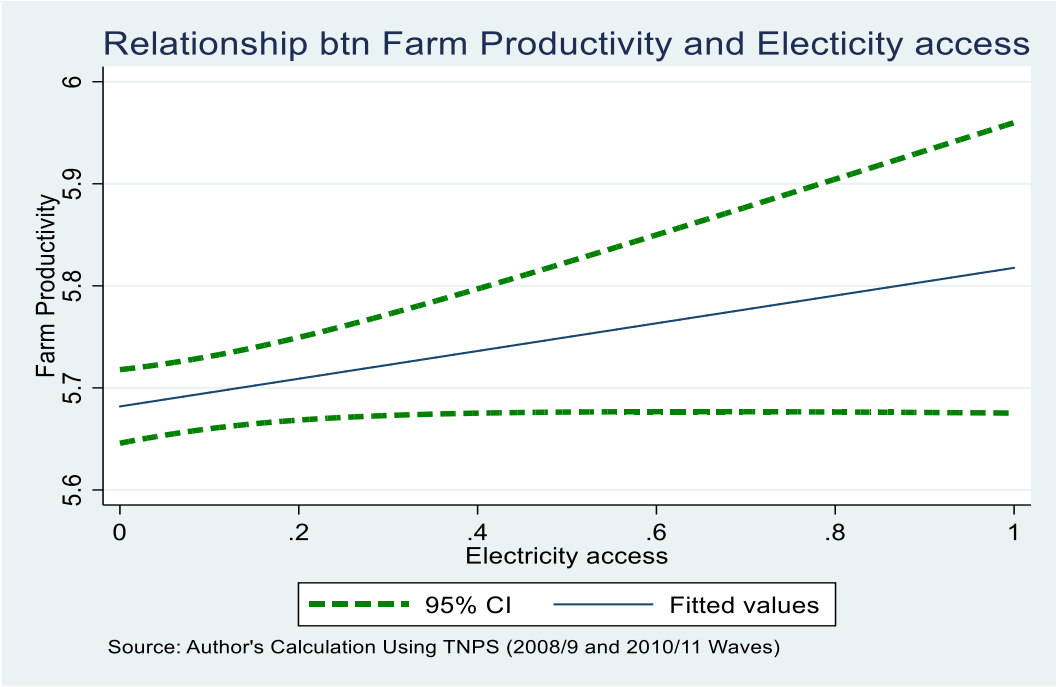
CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Introduction

This section presents the result and debates for the different linear regression estimates centered on the various outcome measures of the household from the Tanzanian NPS of the two waves (2008/9 and 2010/11 Waves) done by Tanzanian national bureau of statistics with support from world bank.

4.2. Electricity access & Labor productivity, Farm productivity and Wage productivity.

The results from the Regressions in Table 2 indicate electricity access has statistically significance and positive effect on labor productivity of the household with approximation of about 22.3 per cent increment compared to those with no electricity and the impact is lower in the households led by male. This is in line with (Gilberto 2012) empirical findings on the effect of electricity access and paved roads on the agricultural labor productivity.

The study further indicates that there is statistically insignificant negative correlation between electricity access and the farm output productivity of the households with electricity. Specifically, the study finds that electricity access is associated with a decrease in farm productivity of the household with electricity. (See Table 2). The findings show that there is a reduction of around 3.2 per cent in farm productivity of the households with electricity access compared to other households with no electricity. Interestingly in a male headed household the study indicates that there is significantly positive relation among electricity access & farm output productivity of households with electricity access compared to those with no electricity.

The study also indicates that there is statistically significant impact between electricity access and farm wage productivity of the hired workers on the farm of the households with electricity. The study finds that electricity access is associated with raise in farm wage productivity for the hired workers on the farm and the results show that there is an increase of around 24.3 per cent in farm wage of the households with electricity compared to those with no electricity and the rise in the farm wage productivity of the hired workers on the farm is related with reduction in the total days spent by members of household with electricity on the farm.

Table 2: Electricity, Labor Productivity, Farm Productivity and Wage Productivity

VARIABLES	Labor Productivity	Farm Productivity	Wage Productivity
Electricity access	0.223***	-0.032	0.243***
	(0.075)	(0.111)	(0.094)
Total hh land area(hectare)	0.132***	-0.225***	0.044**
	(0.012)	(0.017)	(0.017)
Number of plots per hh	-0.002	0.016***	0.000
	(0.002)	(0.003)	(0.002)
Household head is male	0.018	0.124***	-0.006
	(0.029)	(0.046)	(0.077)
The size of farm hh	-0.019**	0.062***	-0.001
	(0.008)	(0.012)	(0.014)
Age of household head	-0.020***	-0.002	-0.004
	(0.005)	(0.009)	(0.011)
Share of dependents in hh	0.063	-0.095	-0.156
	(0.060)	(0.099)	(0.136)
Education of hh head	0.070**	0.174***	-0.033
	(0.028)	(0.046)	(0.072)
Main distance to market	0.000	0.010**	-0.003
	(0.003)	(0.004)	(0.005)
Distance to main road	-0.011**	-0.010	-0.019*
	(0.004)	(0.007)	(0.011)
Constant	1.428***	5.420***	8.566***
	(0.133)	(0.222)	(0.276)
Observations	3,223	3,225	1,253
R-squared	0.254	0.179	0.177
Region FE	YES	YES	YES
Year of Survey FE	YES	YES	YES

Note: Robust standard errors in parentheses*** $p<0.01$** $p<0.05$* $p<0.1$. Data is from the two waves of TNPS. Electricity access refers to the household that at least owns electricity. The dependent variables indicators are labor productivity, farm productivity and wage productivity. Sources: Author's own computations from TNPS (2008/9 & 2010/11)

4.3. Electricity access & Farm crop producion by rural Tanzania

The results from the regressions in Table 3 shows that there is a positive and satatistically insignificant impact of access to electricity on rice farm production in the farm. The study discovers that electricity access is associated with increase in rice farm production of the household with electricity. The findings show that there is an increase of about 4.4 per cent rice yield of the households with electricity access in comparison with the ones with no electricity and the increase is more high in household headed by male gender with electricity. This is inline with (Pimentel 2009)

on the energy as input in rice production that energy input such as fossil fuel increases the yield of rice farm production in developed and developing countries.

The study further indicates that there is statistically insignificant correlation between access to electricity and maize farm production of the households with electricity. The study finds that electricity access is attributed with increase in maize farm production of households with elecricity. The findings indicates that access to electricity increase maize farm production with about 45.2 per cent crop yield of households with electricity compared to those without electricity access and the increase is lower in the households headed by the male gender with electricity. In household headed by male with electricity access, the study indicates that there is positive and statistically significant impacts or effects of electricity access on the maize farm production and the findings shows that electricity access increases maize farm yiled by about 10.8 per cent of the household with electricity compared to those with no electricity.(See Table 3)

The results from the regression in Table 3 also indicates that there is positive and statistically insignificant effects between access to electricity and beans yield production of households with electricity. The study indicates that in the study electricity access is associated with increase beans farm productivity of the household with electricity. The results indicates that electricity access increases beans yield production by about 6.2 per cent of household with electricity access in comparison with the ones with no electricity. Intersetingly in a household where the head is male the study indicates that there is significantly positive correlation between electricity access and beans farm production of the household with electricity and the findings of the study indicate that electricity access increases beans yield production by about 25 per cent of households with electricity in relation to the ones with no access to electricity. The increase in the crop yields can be attributed to the positive spillovers on backward linkages due to electricity access interaction at the farm such as access to data related to agricultural top practice. through television and mobile phones and this encourage adoptation by farmers to the practices to enhance their crop productivity. (See Table 3)

Table 3: Estimation Effects of Electricity access on crop produce in the Farm

VARIABLES	Rice yield	Maize yield	Beans yield
Electricity access	0.044	0.452***	0.062
	(0.138)	(0.164)	(0.161)
Total hh land area(hectare)	-0.353***	-0.234***	-0.312***
	(0.057)	(0.016)	(0.035)
Number of plots per hh	0.003	0.009***	0.005
	(0.007)	(0.003)	(0.004)
Household head is male	0.123	0.108**	0.250**
	(0.091)	(0.054)	(0.101)
The size of farm hh	-0.039*	0.038**	0.002
	(0.023)	(0.015)	(0.041)
Age of household head	0.010	-0.036***	-0.010
	(0.018)	(0.012)	(0.017)
Share of dependents in hh	-0.061	-0.277**	-0.084
	(0.198)	(0.116)	(0.211)
Education of hh head	0.172*	0.081	-0.057
	(0.088)	(0.054)	(0.103)
Main distance to market	0.017*	0.006	0.001
	(0.009)	(0.005)	(0.010)
Distance to main road	-0.005	-0.009	0.014
	(0.018)	(0.007)	(0.015)
Constant	6.682***	7.321***	5.508***
	(0.458)	(0.297)	(0.453)
Observations	707	2,102	746
R-squared	0.360	0.288	0.351
Region FE	YES	YES	YES
Year of Survey FE	YES	YES	YES

Note: Robust standard errors in parentheses*** $p<0.01$** $p<0.05$* $p<0.1$. Data is from the two waves of TNPS. Electricity access refers to the household that at least owns electricity. The dependent variable indicator is crop produce namely rice yields, maize yields and beans yields and was calculated by summing up all the crop harvests in the short rain and long rain seasons. Sources: Author's ownomputations from TNPS (2008/9 & 2010/11)

4.4. Electricity access & The Working Days

Table 4 investigate/estimate the effect of electricity access on the time spent on the farm. This is to study the behavior of the ruarl household whether having access to electricity reduces or increases the time/ days spent on the farm.

Table 4: Estimates of electricity access and the time spent on the farm

VARIABLES	Days spent by hired Women	Days spent by hired Men	Days spent by hired Workers	Days spent by hh Members
Electricity access	0.432***	0.440***	0.279**	-0.447***
	(0.119)	(0.124)	(0.137)	(0.092)
Total hh land area(hectare)	0.117***	0.125***	0.144***	0.108***
	(0.022)	(0.023)	(0.027)	(0.012)
Number of plots per hh	0.029***	0.023***	0.017***	0.024***
	(0.004)	(0.004)	(0.004)	(0.003)
Household head is male	0.037	0.067	0.191**	0.225***
	(0.046)	(0.047)	(0.087)	(0.039)
The size of farm hh	-0.011	0.002	0.063***	0.122***
	(0.011)	(0.011)	(0.018)	(0.008)
Age of household head	-0.003	-0.009	0.011	0.032***
	(0.008)	(0.008)	(0.014)	(0.006)
Share of dependents in hh	0.006	0.001	-0.135	-0.349***
	(0.097)	(0.098)	(0.170)	(0.081)
Education of hh head	0.101**	0.162***	0.196**	0.035
	(0.046)	(0.048)	(0.092)	(0.035)
Main distance to market	0.001	0.001	0.007	0.004
	(0.005)	(0.005)	(0.007)	(0.003)
Distance to main road	0.008	-0.005	0.022	0.019***
	(0.008)	(0.007)	(0.014)	(0.005)
Constant	0.208	0.325	2.117***	3.612***
	(0.206)	(0.214)	(0.370)	(0.164)
Observations	3,488	3,488	1,361	3,404
R-squared	0.123	0.138	0.161	0.371
Region FE	YES	YES	YES	YES
Year of Survey FE	YES	YES	YES	YES

Note: Robust standard errors in parentheses** $p<0.01$ ** $p<0.05$ * $p<0.1$. Data is from the two waves of TNPS. Electricity access refers to the household that at least owns electricity. Dependent variable indicators are days spent on the farm by hired women, hired men, hired workers and household members on the farm and was calculated by summing the days spent in the short rain seasons and long rain seasons.

Sources: Author's own computations from TNPS (2008/9 & 2010/11)

The results of the regression from Table 4 indicate that there is statistically significant and positive impact of access to electricity on total days spent by both men and women on farm. The study indicate that access to electricity increase the total days spent by both men and women on the farm for rural household with access to electricity. The effect of electricity increase the total days spent on the farm by men by about 44 per cent and Women by about 43.2 per cent of rural household with electricity access compared to the rural household without access to electricity.

The findings further show that there is positive relation between electricity access and the total days spent on the farm by hired labor. The study reveals that electricity access increase the total days spent on the farm by hired labor for rural household with access to electricity. The effect/impact of access to electricity increase the total days spent by hired labor or workers on the farm by about 27.7 percent of rural households with electricity compared to those rural household without access to electricity. The results of the regresssion from Table 4 also shows that there is differential gender bias in the total number of days of farm workers in rural households hired and the study show that rural household with access to electricity hire 44 percent men and 43.2 percent women than the rural household with no access to electricity.

The results of the regression from Table 4 indicates that there is statistically significant and negative effects of electricity on the total days spent by members of household on farm. The study shows that access to electricity is attributed to reduction in the total days spent on the farm when the rural households have electricity and there is a reduction of about 44.7 percent in the total days spent by members of household on the farm in comparison to the household with no access to electricity.

CHAPTER FIVE

CONCLUSION AND POLICY IMPLICATIONS

The study investigates the effect of electricity access on the rural households productivity using the two waves of household and individual balanced panel data (2008/9waves and 2010/11 waves) from NPS. The study use the estimation strategy of fixed effects to examine how the use of electricity in rural areas affect household through its effect on the rural productivity of households in Tanzania.

The results show that electricity access significantly increases labor productivity. The findings from this study show that access to electricity increase the wage productivity of the hired workers on the farm for the rural household and this is also associated with reduction in the total days worked by members of household on farm activities. Additionally the study show that electricity access also increases crop produce on the farm of the household with electricity access. The findings from the study shows electricity access significntly increases rice farm productivity by about 4.4 per cent of the household with electriciity. The study further shows accessibility to electricity increase maize farm productivity by 45.2 per cent of household with electricity. The study also indicates that access to electricity increase beans farm productivity by about 6.2 per cent of crop produce. The findings from this study it indicates that the total days spent by hired workers on farm increase by 27.90 per cent of rural household with electricity access and the study also reveals that access to electricity increase the chances of hiring more men to work on the farm.

The findings of the study shows that the study has some policy implications. The study indicates there is positive effects of electricity access on farm crop production such as rice, beans and maize this suggest that effective, relaiable and cheap electricity generation and supply can increase more the farm crop production.

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APPENDIX

Table 5:Appendix A.1 Data Description and sources

Data **Dependent Variable** • Rural household productivity	Measurement/Indicator	Computation
Productivity indicators • labor productivity	Value added per economically active members in hh	Total farm output divide by number of economically active members in hh
• Farm productivity	Farm yields/output	Adding the food crop yields of maize, sorghum, Rice, groundnuts and cassava
• Total number of days spent by members of households.	Days	Combining the short rain and long rain season information plot
• Total days spent on the farm by hired worker's women and men	Days	Combining the short rain and long rain season information of plot
• Total wages paid to hired labor/workers.	Economic values/money value	Combining the short rain and long rain season information of plot
Dummy variable	1 if the household has electricity	0 otherwise
Controls	Demographic/household Characteristics	• Gender • Household Age • Hh head education Level • Distance to the market and main road from hh • Slope of the land • Farm size

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