RURAL ELECTRICITY FOR CONSUMERS' SOCIO-ECONOMIC IMPROVEMENT IN KASULU AND UYUI DISTRICTS, TANZANIA

RURAL ELECTRICITY FOR CONSUMERS' SOCIO-ECONOMIC IMPROVEMENT IN KASULU AND UYUI DISTRICTS, TANZANIA

BY

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A Thesis Submitted in Fulfilment of the Requirements for the Award of Degree of Doctor of Philosophy of Moshi Co-operative University

Moshi

2020

DECLARATION

I**,** Bikolimana Giliadi Muhihi declare that this thesis is my original work and that it has not been presented and will not be presented to any other higher learning Institution for a similar or any other academic award.

Signature

Date 23rd November 2020

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CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by Moshi Co-operative University a Thesis titled "**Rural Electricity for Consumers' Socio-Economic Improvement in Kasulu and Uyui Districts, Tanzania**" in fulfilment of the requirements for the award of a degree of Doctor of Philosophy of Moshi Co-operative University.

Dr. Leopold Pascal Lusambo

Supervisor`s Name

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Supervisor`s Signature

Date: 23rd November 2020

DEDICATION

To my family; Parents, Mr. Julius Muhihi and Mrs. E. Muhihi; my beloved wife, Mwl. Hilda. J. Karlo; my son Davidson, B.M (King) and my daughter Davina, B.M.

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ABBREVIATIONS AND ACRONYMS

ANOVA:	Analysis of Variance
ATTU:	Attitude Toward Using
BIOU:	Behavioural Intention of Using
CA:	Catastrophic Approach
CAIDI:	Customer Average Interruption Duration Index
CAR:	Conventional Affordability Ratio
CI:	Confidence Interval.
CTI:	Confederation of Tanzania Industries
DAAD:	*Deutscher Akademischer Austauschdienst*
DEA:	Development Assets
DFID:	Department for International Development
EJuT:	Energy Justice Theory
EWURA:	Energy and Water Utility Regulatory Authority
ESKOM:	Electricity Supply Commission (ESCOM)
ESMAP:	Energy Sector Management Assistance Programme
FGD:	Focus Group Discussion
FPR:	Five Percent Rule
GDP:	Gross Domestic Product
HDI:	Human Development Index
IA:	Impoverishment Approach
ICC:	Intra-Class Correlation Coefficient
ICT:	Information and Communication Technology
IEA:	International Energy Agency
IMO:	Individual Motivation
IPA:	Innovation for Poverty Alleviation
IPMA:	Importance Performance Map Analysis
IRENA:	International Renewable Energy Agency
kWh:	Kilowatt hour
LEDCs:	Lowest Economically Developing Countries
LPG:	Liquefied Petroleum Gas
MD:	Doctor of Medicine
MDGs:	Millennium Development Goals
MoCU:	Moshi Co-operative University

MPI:	Multi-Dimensional Poverty Index
MTF:	Multi-Tier Framework
MW:	Megawatt
OLS:	Ordinal Least Squares
OP:	Out of Pocket
PEOU:	Perceived Easy of Using
PL:	Poverty Line
PLS-SEM:	Partial Least Structural Equation Model
PPP:	Public-Private Partnership Policy
PRM:	Poisson Regression Model
PSM:	Propensity Score Matching
PU:	Perceived Usefulness
PV:	Photovoltaic
RBV:	Resource-Based View
REA:	Rural Energy Agency
REB:	Rural Energy Board
REPOA:	Research on Poverty Alleviation
RMS:	Research and Marketing Strategies
SA:	Southern Asia
SACCOS:	Savings and Credit Co-operative Societies
SAID:	System Average Interruptions Duration
SAIDI:	System Average Interruption Duration Index
SAIF:	System Average Interruptions Frequency
SAIFI:	System Average Interruption Frequency Index
SUA:	Sokoine University of Agriculture
SCA:	Sustainable Competitive Advantage
SCADA:	Supervisory Control and Data Acquisition
SDGs:	Sustainable Development Goals
SE4ALL:	Sustainable Energy for All
SSA:	Sub-Saharan Africa
TAM:	Technological Acceptance Model
TANESCO:	Tanzania National Electric Supply Company Limited
TCRA:	Tanzania Communication Regulatory Authority
TDV:	Tanzania Development Vision

TV:	Television
TZS:	Tanzanian Shillings
URT:	United Republic of Tanzania
USA:	United States of America
VICOBA:	Village Community Bank
WB:	World Bank
WHO:	World Health Organisation

EXTENDED ABSTRACT

Electricity is one of the ingredients of development in rural areas. Through Rural Energy Agency and state energy utility, substantial efforts have been made to improve access to and leading to reduction of electricity poverty. With undeniable reality on improved access to electricity, the status of whether electricity supplied is of quality for socio-economic improvement was sluggish. Thus, the study was conducted in rural areas of Kasulu and Uyui District to (i) examine affordability of electricity, (ii) assess reliability of electricity (iii) determine the influence of electricity on the adoption of ICT and (iv) determine the influence of electricity on household income. The sample size was 374, probability technique was used to select respondents who filled the supplied questionnaire in quest of data collection. The results showed that 61.76% of the respondents in the lowest income quintile did not afford electricity connection because they spent up to 33% of annual income on connection cost; this was above an agreeable threshold of 10%. On consumption, electricity was affordable; respondents had spent no more than 5% of monthly income on electricity while consuming between 40-57 kWh per month above the basic need electricity of 30kWh. Moreover, using a scale, index measure and trend analysis, it was found that reliability of electricity was ensured because the system was available most of the time consumers wanted to use power. In Kasulu and Uyui Districts respondents had spent 6 and 15days without electricity in 2018 due to unplanned outages; confirming reliability. On ICT adoption, the poison regression results showed that electricity connection, age of household head, income and the need for information predicts ICT adoption in terms of gadgets. There was a shift of paradigm in mobile phone ownership from feature phone to smart phones which eased access to information about politics, weather and market for farm produce. Moreover, on household income, the PLS-SEM results showed that quality electricity (reliability, affordability and voltage stability) is far powerful in predicting household income by reducing cost on services like milling. It also stimulates small enterprises and improves job creation among the householders. While electricity remains a significant ingredient in attaining socio-economic development in rural areas, through EWURA, connection cost should be made on instalment to relieve customers from high connection costs. Moreover, TANESCO is argued to use SCADA on distribution lines to monitor outages incidences.

CHAPTER ONE

1.0 Introduction

1.1 Background to the Problem

Globally, modern energy is recognised as a quantum driver of most socio-economic development. However, there is no guarantee of such phenomenon because development is a function of resources complementarities (International Energy Agency, IEA, 2013). Modern energy (fuels) includes electricity, liquid fuels (Kerosene) and gaseous fuels, including liquefied petroleum gas (LPG) and natural gas (Legros *et al*., 2009); of all, electricity is a superior energy carrier toppling the energy ladder (Okonkwo & Odularu, 2009). In rural areas of the developing world, electricity agenda has been an "abandoned priority" for decades (Oseni & Pollit, 2015). This could be due to poor economic motives in the areas. Although electricity is important, it is "not electricity" per se which drives development, but "quality electricity" enhanced by voltage stability, availability, reliability, affordability, adequacy, safety and convenience (Culver, 2017). Of all the quality issues, reliability and affordability mostly draw the concern of consumers and suppliers because they determine level of supply and consumption which in turn bring the visible impact of electricity availability.

While electricity is considered a panacea to most social and economic issues like education, health, income, ICT and appliance assets (Bernad, 2012), about 1.2 billion people (17% of the world's population) lack access to electricity (IEA, 2015). Further it was explained that about 85% of those who lack access to electricity reside in low economically developing countries (LEDCs). Those with access (83% globally) are troubled by low quality signalled by flickering supply and unaffordability (IEA, 2015). These problems are more pronounced in rural Sub-Saharan Africa, Developing Asia and Latin America (Legros, *et al*., 2009). Thus, succinctly, it is important to have access to quality electricity with expectation to stimulate a wider array of development (Bernad, 2012). While the struggle for electricity remains real in Sub-Saharan Africa, Western America, Europe and North Africa have achieved nearly a universal access to quality electricity by 97- 99% (World Bank, 2017) and so development gain is higher in countries with quality electricity.2145129

Due to poor production, unaffordable and unreliable electricity in Sub- Saharan Africa (SSA) consumption has been restricted. For example, the World Bank (2014) enumerates that the average per capita consumption is estimated to be 488 kWh per annum, equivalent to the 5% of the USA per capita consumption. Similarly, it was reported that the 488 kWh is pushed up by the inclusion of South Africa with high electricity access rates in the region (Avila, Carvallo, & Shaw, 2017); if excluded, the average annual per capita consumption shrinks to 150 kWh (WB, 2014). The situation is worse in some other countries. For instance, until 2016, Eritrea had 51 kWh, Central African Republic 36 kWh, Liberia 69 kWh, Kenya 162 kWh, Uganda 70 kWh, Chad 16 kWh, Guinea-Bissau 17 kWh, while Tanzania had per capita consumption of electricity of 95 kWh per annum (Environmental Energy Service , 2018).

In 2019, Tanzania climbed in terms of per capita consumption of electricity to 108 kWh. This was after cutting metre rental charges and increased life line tariff in rural areas from 50 kWh to 70 kWh per month. Indeed, the per capita consumption is very small compared to Sub-Saharan Africa's average consumption of 550 per annum (Avila, Carvallo, & Shaw, 2017). In fact, if the level of consumption is not improved, it only brings to a simple interpretation that development is still at stake regardless of the rural and urban boundaries. If electricity is not consumed, one could ask, how it can be used to attain income, health and ICT adoption. In fact, the first indicator of whether electricity is serving the course is the level of consumption (Akinlo, 2008)

The developed countries like Norway have 24006 kWh, per capita consumption of electricity, Canada 14930 kWh and USA 12077 kWh (Environmental Energy Service , 2018). Although the comparison is not fair, the reality is, a Tanzanian can spend 222.3 years to consume the amount of electricity consumed in one year by a Norwegian. Developed countries entirely depend on electricity for heating, cooking, washing and in all sorts of lives. This is contrary to poor countries where electricity is mostly used for lighting; though Bezzera *et al*. (2017) argue against that "there is the power of light in socio-economic and environmental problems". In fact, consuming less while connected to poor quality electricity system is less meaningful on the reason that it does not change the course in terms of the desired benefits (Abdisa, 2018). It can exacerbate adverse negative impacts by forcing consumers to spend more on backup sources, thus, affecting their financial strengths, cause inconveniences and increased feelings of vulnerability (Minnaar, Gaunt, & Nicolls, 2012)

Most notably, unreliable and unaffordable electricity could spur usage and consequent risks associated with alternative fuels such as paraffin and candles (Minnaar *et al*., 2012). Moreover, with poor quality electricity, its consumption becomes low, hence, income generation in rural areas through local businesses become limited, an improvement in ICT adoption and domestic appliances could remain poor too. These claims are supported by Taneja (2018) who explicates "without improving consumption density, rural areas are likely to remain poorly-developed, limiting human and economic development". Poor quality electricity does not only limit arrays of development opportunities, but also leads to food spoilage leading to the cost of replacing it (Herman, Gaunt, & Tait, 2014) . Thus, an entry point towards assessing the effect of electricity is quality assessment because that is what matters for first and all the time.

Investment efforts in reducing electricity poverty have led to the decline of the population without electricity from 1.2 billion people in 2015 to 1.06 billion people (IEA & WB, 2017). Equally, the world's electrification rate has increased from 77.7% to 85.5%. This progress has also benefited rural access at the global scale which increased from 63% to 73% while urban centres had 97% (WB, 2017). In fact, improved access to electricity in urban areas is a milestone because since 2000 world's urban has received 1.6 billion people as new entrants, consequently, increasing the number of people with access to clean energy (WB, 2017). Sub-Saharan Africa (SSA) has moderate improvement from 26.5% to 37.5%, thus making 609 million (6 out of 10) people to remain off-electricity services compared to 620 million people in 2015 (WB, 2017). Thus, referring to SSA and putting the matter in a nutshell, it is suggested that lack of electricity connection dramatically affects health, income, limits opportunities and widens the gap between the poor and the rich (Adam, Brew-Hammond, & Essandoh, 2013)

1.1.1 Rural electrification strategies in developing countries

Sub-Saharan Africa had an electricity demand of 432 TWh until 2010; to date, only 96 GW has been installed. This is equal to the capacity that China could install in one or two years (International Renewable Energy Agency (IRENA), 2018). In SSA, only South Africa has good electricity access and per capita consumption of 3904 kWh; she produces nearly 50% and more of the amount of electricity produced in Africa (Avila *et al*., 2017). In response to poor production and quality electricity, there are multiple tangible strategies put forth in the process of picking up. In Uganda, Kenya and Tanzania, strategies include the extension of National Grid, Micro Hydro Power (up to 1MW), Mini Hydro Power (up to 10 MW), Mini-grids (less than 10MW) and Photovoltaic (PV) which produce varying amount of electricity (Ordano, Sawe, Swai, Katyega, & Lee, 2018). Currently, there are 7,500+ mini-grids planned for developing countries; they are fuelled by diesel, something which could affect positively the reliability (Energy Sector Management Assistance Program (ESMAP), 2019). The strategies represent the reliable means of ensuring access to electricity by the rural areas that are unlikely to be connected to the grid (Ordano *et al*., 2018). The authors further claimed that mini-grid electricity generated suffices for productive use such as the operation of domestic appliances (TV and Radio), grain milling and acceleration of home-based business.

Until recently, statistics indicate that in Tanzania, more than 109 mini-grids are registered to supply electricity in rural areas via the national grid and stand-alone mini-grids (Sarakikya, Ibrahim, & Kiplagat, 2015). Additionally, TANESCO has 29 solar power plants that produce 7MW (EWURA, 2018). The mini-grids will remain to be a key strategy in accelerating access to electricity in rural SSA. This is because of the reason that they are cost-effective than grid extension. On that, the WB (2017) noted that the comparison between diesel and hybridised mini-grids in Africa showed potential savings ranging from 12% to 20 % depending on oil prices. However, their cost in terms of operations and business return could have a huge mismatch although IRENA (2018) confirmed that mini-grids are believed to have high reliability because they are manageable

In Tanzania, rural electrification impetus increased from 2000s after stabilization of institutional and legal frameworks. These include Rural Energy Board (REB) and Rural Energy Agency (REA) as manifested in the Rural Energy Act of 2005. Energy and Water Utility Regulatory Authority (EWURA), Electricity Act of 2008, National Energy Policy of 2003 (revised in 2015), Public-Private Partnership Policy (PPP) of 2009 and PPP Act of 2010. The efforts have brought noticeable increase of rural electricity connection from only 1% in 2003 to 24% in 2020 and from 9% in 2003 to 35.56% in 2020 nationally (Africa's Power Journal, 2020). Further, the efforts have made Tanzania to be among the top ten countries with highest mini-grids developers in the world (Knuckles, 2019). Villages connected to electricity increased from 2,018 in 2015 to 9,112 in 2020 (Africa's Power Journal, 2020). With such improvements in electricity supply and access in rural areas including Kasulu and Uyui district; the questions remain; first, how reliable and affordable is electricity to rural households? Second, how is electricity being used in improving socio-economic dimensions?

1.1.2 The quality concern for rural electricity

Reliability and affordability of electricity are commonly mentioned but has been underrated in the literature. Reliable and affordable electricity is a prerequisite for any development. Thus, underrating it is undermining the desired development, for example, unreliable electricity in Tanzania, had led to 10% loss of GDP in six regions (Confederation of Tanzania Industries (CTI), 2011). Equally, IEA and WB (2017) reported that with increasing access to electricity the statistics could misrepresent vital information by reflecting a simplistic aspect of access that hide issues of reliability, affordability and duration of supply.

Access to electricity is beyond connection, because despite of that; duration of supply, reliability and affordability could hinder efficient use in improving access to information and income generation. Reliability and affordability are quality criteria that determine consumption and output of its use (Culver, 2017). With quality concern and as the result of empirical analysis, the present study argues convincingly that the key aspects of quality electricity need a thorough analysis first. This was important to be able to infer whether the socio-economic effects we see come from quality electricity or otherwise. In this study, assessing quality issues of electricity (affordability and reliability) is an entry point towards an assessment of socio-economic indicators such as appliances, expenditure on backup fuels and income.

1.1.3 Debate on affordability and reliability measurement

1.1.3.1 Affordability of electricity

Affordability of energy raises concern because it is closely related to the poverty of consumers (Fankhauser & Tepic, 2005 and Milne, 2014;). Niëns & Brouwer (2013) asserted that the issue of affordability arises when Out of Pocket (OP) is involved. Unchecked price of electricity affects the economically disadvantaged population which might fail or scale down consumption (Sari *et al*., 2017). Electricity being affordable is not the same as being low-cost or cheaper, rather the ability to pay for necessary levels of consumption or consumption within normal spending patterns (Kayode, Farshchi, & Ford, 2015). Different indices measure of affordability exist; Betraud (2016); Haurin (2016); Renne *et al*. (2016); Deller and Waddams (2015); Milne (2014); Sautenkova *et al.* (2012) and Ranasinghe (2011) suggested residual income ratio of an index utility price to household disposable income and ratio of median to utility median price. These indices might not present the true burden of expenditure on electricity at the household.

Rademaekers *et al*. (2016) suggested ratio of income-expenditure, consensual and outcome-based approach to measuring energy poverty (Table1.1). Haurin (2016) suggest each of those measures to be used according to the performance for specific criteria; such as policy evaluation and decision making. In fact, of all measures; expenditure-based measure is commonly used; it is supported by Niëns and Brouwer (2013) and (Gawel, Sigel, & Bretschneider, 2011). The measure is termed by Niëns and Brouwer (2013) as a catastrophic approach based on conventional affordability ratio (CAR) or Price Income Ratio (PIR). It requires the household to spend a specific threshold of income on electricity (Rademaekers *et al*., 2016). With PIR, different thresholds are used; for example, the UK uses it with 10% rule (Milne, 2014) which was first proposed by Brenda Boardman in 1991; it has been a stable measure for decades. Hills (2012) poses a worrisome argument that 10% rule is that much sensitive to the price of electricity. Further, Hills (2012) argues that if the price of electricity is increased, the household should respond by increasing their spending amount or scale down expenditure in other aspects.

Table 1.1 : Approaches to energy affordability measures

Approach	Rationale	Justification and challenges
Expenditure-based	• Expenditure-based metrics accurately capture affordability of adequate energy services for those on a low income.	• Captures key features of energy poverty • Applied worldwide • Capture severity by use of different thresholds • Survey challenge • sensitive to energy prices
Consensual-based	• It is based on self-reported indicators • can provide an effective way of understanding perceived energy poverty and more explicit insight • It could be a backstop	• Commonly used to date for assessment • Can stand as a complementary indicator • It has no adequate power to allow effective quantification
Outcome-based	• The indicator family provides a proxy for energy poverty based on outcomes • It can use two possible approaches – using utility data or focus on health outcomes	• The measure of actual outcomes • For utilities, brings utilities in as key stakeholder to help provide solutions • Access to the utility may be difficult • Narrow proxy measure • Many different factors impact health outcomes in addition to energy poverty

Source: Rademaekers *et al.* (2016)

In Table 1.1, the PRI is also used by the WB (2002) and a threshold of 10 % to 15% was suggested. Equally, WHO (2004); IPA Energy (2003) and Lusambo (2009) suggested that a total household's expenditure on energy should not exceed 10%. Thus, spending more than 10% or 15% of the household income on electricity is "unaffordability". Ranasinghe (2011) used 10% threshold and found that households with Rs. 1,000 per capita incomes (lower quintile) spent 15% share of income on electricity consumption in Sri Lanka. This was inferred as "unaffordability". The present study adopted a PIR at 10% because it best fits for rural energy affordability assessment based on connection given the price of rural electricity and associated criteria.

The debate on energy affordability measures remains a "paradox in energy studies". In areas where some energy sources are freely available it could be difficult to gauge affordability; and for that the threshold for affordability should not be large. Thus, Kojima and Trimble (2016) proposed 5% of the household's monthly income as a measure of consumption affordability. In fact, the MTF provides a basis for share income parallel to basic need electricity (30kWh) per month (Kojima & Trimble, 2016). This means that a household should spend no more than 5% of the total monthly income to purchase 30 kWh of electricity. Contrary, Ranasinghe (2011) suggested a 48 kWh as basic need electricity. This threshold could be difficult to adopt because rural people have limited use of electricity. The FPR (Five Percent Rule) is however criticised. Winkler *et al*. (2011) checked it and argued that spending little (5%) under *Ceteris Paribus* signifies unaffordability and economic stress to customers. In fact, the claim by Winkler *et al*. (2010) sounds equivocal because what is important is not only the share of income spent on electricity but also the amount of electricity (kWh) consumed by the household. Additionally, affordability is commonly checked with regard to low earning individuals who on minor shocks lose economic stability.

The reality is, when dealing with electricity alone, a 5% share with 30 kWh basic need electricity is acceptable and sound ideal because, in rural areas, electricity could be complemented with other sources of energy. On the same, 30 kWh is deemed to suffice the operation of domestic appliances like TV and mobile phones which in the presence of electricity are likely to be basic needs. Finally, in unceasing recognition of affordability measures, Niëns and Brouwer (2013) suggested another measure "Impoverishment Approach (IA*)"*. It is based on the proportion of the population that falls below the poverty line (PL) after spending on electricity. With that, IA ascertain that consumer should remain relatively stable positioned on Poverty Line (PL) after expenditure on electricity for upfront charges and monthly bills. However, this measure could hardly be relied upon because some consumers might already be closer to the poverty line, thus, any economic shock would lead to their downfall.

Generally, in Tanzania reliable information about affordability of electricity in rural areas is limited and exist with sluggishness. To the best knowledge of the present author, only two studies highlighted affordability in Tanzania. Golumbeanu & Barnes (2013) reported that electricity connection charges were higher and could amount to unaffordability. In fact, Golumbeanu & Barnes (2013) did not indicate to "whom" electricity might not be affordable. Consequently, Maliti & Mnenwa (2011) compared affordability of kerosene, electricity, charcoal and firewood among the poor in urban areas. On their analysis, Energy Transition Theory was used. It was reported that on upfront cost electricity was more expensive than gas and charcoal. On consumption, cooking on electricity was expensive. The household used 11.5% of total expenditure on energy while on electricity alone about 51 kWh was used per month. This is a normal phenomenon in urban areas where households have substantial electrical appliances to hike energy. The results by Maliti & Mnenwa (2011) could not be generalised to rural areas because the urban poor differ from rural poor who are mostly vulnerable to economic shocks. Thus, affordability still needs to be taped in rural areas where income vulnerability is a common feature.

1.1.3.2 Reliability of electricity

Supply of reliable and affordable modern energy to all Tanzanians is one of the energy policy statements of Tanzania (United Republic of Tanzania, 2015). Reliability of electricity is explained by Prada (1999) as the probability of an electric system to perform its function adequately for the period intended under operating conditions. Consumers usually expect a continued supply of electricity from a system which can withstand instabilities. The energy utility company with reliable supplies can save cost emanating from fixing unpredictable outages, hence, concentrate on increasing connection up to 0.67% (Millien, 2017). On the same, consumers can make full use of it to cut cost on backup sources. For that, it is deduced that even if electricity is available and affordable, the first question most consumers would keep in mind is its “reliability”.

Regarding the duration of supply, it is argued that duration and hours of supply of electricity should not be a worrisome thing to those connected in rural areas. Otherwise, the expectations could remain listed. Millien (2017) enumerated that severe blackout of electricity cause uncertainties which affect households’ and firms’ productions process. In furtherance, it could lead to prolonged inefficiencies in the profitable use of electricity. Reliability is less considered in rural areas, especially at the domestic level. This is mainly related to the lack of comprehensive economic undertakings in the areas. Due to its possible effects at the household, it requires unique attention because the economic and social costs of the outage is reported to increase exponentially with the severity of the incidence (Kaseke, 2011).

Various factors contribute to poor reliability of electricity. The factors differ with geographical location; for instance, in the USA, weather is responsible for large outage incidents by 100% and 80% medium outages incidents (Kenward & Raja, 2014). Further, the authors showed that tropical storms and hurricanes are responsible for outages by 18%, while tornadoes do by 3%. The outages are costly to contain. They cost between 20 to 50bn US Dollars annually from interruptions of not more than 5 minutes (Kenward & Raja, 2014). Although the outage duration is small, the persisting frequency of outage could still hike the loss. In South Africa, Minnaar *et al*. (2012) have highlighted more causes of system outages: lightning, fires, pollution, bird streamers, wind and storms. Due to bad weather and ageing infrastructure, ESKOM South Africa, until January 2020 had shed more than 6000 MW (Conversation, 2020). This has led to power rationing, business decline and domestic activities failures as it cultivated extra expenditure on backup fuels and devices, more in rural areas. The intensity of reliability problems of electricity especially in SSA is indicated by Shivakumar (2014) in Table 1.2. While statistics have substantiated the varying intensity of outages in Nigeria and Senegal, the truth remains that these two countries indicate a typical scale of a problem in poor countries.

Table 1.2 : Prevailing status of electricity outages

Indicator	Senegal	Nigeria	SSA	World
Number of outages in a typical month	25.8	26.3	10.7	8.6
Duration of typical outage	2.3	8.2	6.6	4.0
Loss due outage (percentage of sales)	5.1	8.9	6.7	4.8
Percent of firms owning a generator	90.7	85.7	43.6	31.6
% of firms identifying electricity as a major constraint	57.5	75.9	50.3	39.2

Source: Shivakumar (2014)

Shivakumar (2014) indicated that the consequence of supply interruptions differs from one consumer to another because there are different types of end-users. For example, a households with refrigerators and cook stoves will experience different effects from the one which uses electricity for lighting only. Likewise, interruption on business will have different effects from that of a household. One of the greatest shortfalls in assessing reliability is less consideration on the specific time of the outage incidences. For that, it has carried an important meaning in this study because not all outages pose threats to consumers. For instance, outage during late hours of the night could not be a concern to most of the household as compared to outage incidences during evening hours.

Measuring reliability of electricity system is another aspect which is contented by energy economists. Reliability can be checked on two aspects; from the suppliers' side; this approach is criticised because of the fact that the utility tends to over-report reliability level. Then, from the consumers' side, this is commonly appreciated because consumers' views are important and tend to be valid. There are several indices used for measuring reliability of electricity. However, the commonly used indices according to the WB (2016 b) and Herman *et al*. (2014) are:

(i) System Average Interruption Frequency Index (SAIFI). The index provides important information about system interruption frequency per customer. Indeed, the index indicates the probability of electricity consumers to experience outage or blackouts within a given time frame. With this measure, outages threshold are decided, but the system with the lowest SAIFI values is considered reliable. SAIFI is represented by that ratio of the total number of customers interrupted divide by the number of customers served.

(ii) System Average Interruption Duration Index (SAIDI). This indicates the total duration of interruption for the customer during a specific period such as a monthly or annual basis. Minaar *et al.* (2014) indicated that for SAIDI, each interruption to a customer during a sustained period is multiplied by the duration experienced and then summed to total customer minutes. It is then divided by the number of customers on the system, it is expressed in minutes.

The two indices measure are criticised for various reasons: first, they require sophisticated technology for data collection. The WB (2016b) while pledging them indicated that Supervisory Control and Data Acquisition (SCADA) should be in place. SCADA for reliable data acquisition can hardly be deployed on distribution lines especially in poor countries where utilities are not making profit. Similarly, Chatterton (2014) reported the importance of SCADA, but he also proposed the use of daily operation logs for collection of information. Thus, the best way for this is to compare consumers' information on reliability and utility supplier's information on the same. Second, SAIFI and SAIDI toolbox tend to evaluate all outages on an equal basis whether planned or unplanned (Keogh & Cody, 2013). Arguing on the same, Shivakumar (2014) posited that the indices have paucity as they count all kind of outages without reconciling the time of the day outage occurs. Again, the cure for this is to embark on consumers' view because they can judge well the system. Finally, because data were not collected by using SCADA, it would be difficult to report outage index on each customer in the study area, instead, a System Average Interruption Frequency (SAIF) and System Average Duration Index (SAID) were used to measure reliability.

1.1.4 Discussion on Electricity and Socio-Economic Development

The socio-economic improvements refer to all possible positive effects including income, human health, education, access to information and technologies and assets ownership (European Chemicals Agency, 2011). It also refers to the changing status in the social and economic standings or class of an individual or group. Socio-economic status defines the levels of life an individual or community have attained. Sen (2009) equates well-being and capability with socio-economic improvements which are based on an increased range of choices. Indeed, socio-economic improvement of the rural areas is a feasible state's agenda. This is because, first, about 70% of people live in rural areas lacking possible adequate stimulant of development (United Republic of Tanzania, 2015). Second, most of the rural socio-economic dimensions indicated in Sustainable Development Goals (SDGs) are centred on modern energy (electricity) (Figure 1.1). For example, to achieve such goals, ending poverty of all forms, hunger, education, clean energy, water and economic growth, electricity could play a significant role because the dimensions have a direct link.

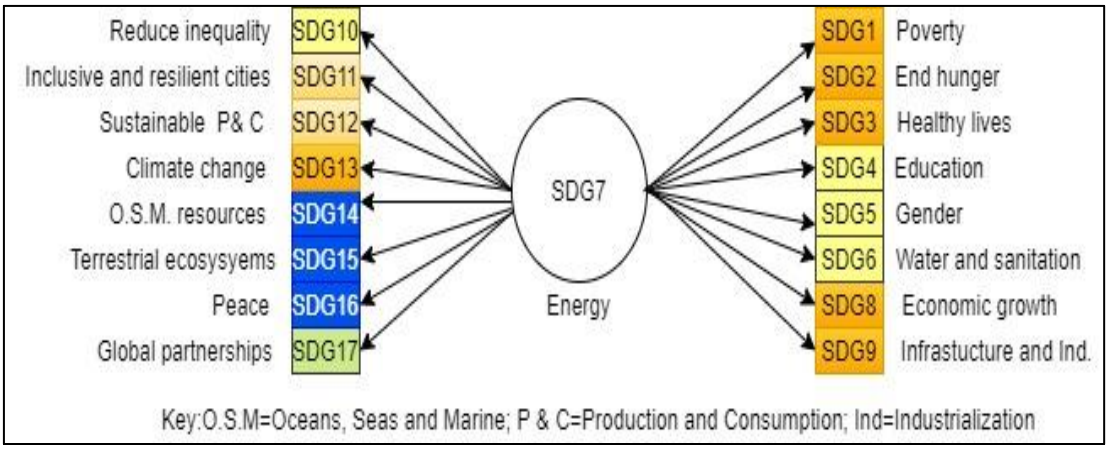

Figure 1. 1 : The modern energy and sustainable development goals

Source: World Bank (2017)

Kimambo (2012) substantiated that energy is a forgotten post-millennium development goal (MDGs) vibrant to supplement burning rural issues; income poverty reduction, health, environment, gender equality and empowerment. In fact, some MDGs failure were attributed to "*inter alia*" electricity poverty and failure to integrate it in improving business, health, education and assets ownership. At present due to its importance, modern energy is a remembered aspect of development through Sustainable Development Goal 7 (SDGs) "to ensure access to affordable, reliable and sustainable modern energy for all*"*. In short, electricity is on top of the development agenda in Sub-Sahara Africa (Adam *et al*., 2013)**.** In applauding it, Ahlborg *et al*. (2015) noted that electricity is a unique energy carrier that is purposively applied in almost all aspects of daily life.

In unceasing recognition of modern energy in the development of the rural areas, Kanagawa and Nakata (2008) posited that electricity is essential for the modern development of communications, industries and the build-up of public services including education and health. Although electricity is purported as a driver of most socio-economic dimensions; some scholars (Lenz *et al*., 2016; Barron & Torero, 2014) argued that it is not the only catalyst. The enabling factors of capital and home business management skills must prevail for electricity to be useful. In fact, this is a binding argument and that electricity alone can hardly be analysed as a sole driver of development dimensions. In fact, there is a wide array of inconsistent and equivocal inferences about the influence of electricity on socio-economic dimensions of interest at the household, national, regional and international levels.

Ordano *et al*. (2018) argue that there is evidence that electricity improves rural people's welfare. The authors suggested that electricity from the mini-grid, have had a better contribution on improved access to information, the establishment of enterprises such as mechanical workshops, sunflower and palm oil and fruits processing industries. However, this was only possible due to financial services accrued from immediate sources like Village Community Banks (VICOBA) and the unique Savings and Credit Co-operative Societies (SACCOS). Factually, Ordano *et al*. (2018) send a message that even if electricity is available, yet, access to financial resources must also be ensured for a better and quick take-off. Nonetheless, scholars like Aklin *et al*. (2018); Aklin *et al*. (2017) and Dinkelman (2011) posited that electricity in rural areas accelerate income saving and female empowerment through small business. Electricity, in fact, attract roadside vendors which play roles in women economic empowerment.

However, with all the pledged benefits of electricity, there is a little unclear clarity on whether the attained benefits come from quality electricity or it is just the effect of confounders. The reality is, the intervention of other driving or mediating factors for electricity to be productive must have to exist (Barron & Torero, 2014). Another paucity is that, through Propensity Score Matching (PSM), Khandker, Barnes and Samad (2009) found that rural electrification has a significant influence on household income, expenditures and education as well. The results could have been affected by the presence of endogeneity and unobservable factors. Equally, Torero (2014) posed critique that factors like individual or the degree of people's motivation and dynamic behaviour of consumers could if not counted plunge the results into jeopardy.

The literature is more divided about the influence of electricity on socio-economic dimensions; for instance, Independent Evaluation Group (2008); Van de Walle (2003) and Torero (2012) pronounced the prevalence of the impact of rural electrification on earnings, education through increased hours of study time of up 20 minutes. Moreover, the authors listed down some more benefits including, time savings from domestic duties, increased leisure time on TV and widened opportunities in nonfarm activities. The reality is, the impact of rural electrification might be there, but the question to be answered remains; it is unclear if the impact we see is the results of variable selection or analytical methods used. Torero (2014) listed immediate effects of electricity such as reduced expenditure on kerosene, improved education and information access. The author also listed improvement of health through reduced indoor pollution and productivity through increased total hours of work. Torero (2014) did not link reduced kerosene cost with increase of income. Further, he explains the change in total income as the long-term effect. The fact is, income could be a long- or short-term effect depending on the variable under observation, for instance reducing expenditure on kerosene could increase income.

Mazumder, Keramat, and Rubel (2011) advocated that with rural electrification, living conditions have been improved; fuel cost was reduced while increasing consumption of modern energy by 1010 hours per year. There was electrical appliance for the household, efficient lighting leading to reduced use of dangerous sources of energy. Further, the authors reported that, although electrified villages had 10% higher annual cash income than those not connected; yet, the direct influence of electricity on income had weak evidence. This was supported by the regression results which indicated that factors like land holding household, size of the livestock and number of workers were more significant contributor to income than electricity. These results, in fact, draw the views of Lenz *et al*. (2016) who viewed electricity as less enough. The results by Mazumder *et al*. (2011) lacks key information about the quality of electricity. The absence of direct effects of electricity on the income might be due to poor reliability and affordability among consumers. Inference about the impact of electricity without being backed with its indicators for quality could be inconsequential with questionable reliability.

1.2 Statement of the Problem

The rural communities in Tanzania experience sluggish socio-economic indicators; health, education, domestic valuable assets and access to information and communication technologies (URT, 2017). However, poor income is one of the most pronounced glitches. For instance, in Western Tanzania, 36-48% of the population lives below the basic need poverty line (Kilama, 2016). While electricity supply has emerged as a panacea to rural issues, the questions about its affordability and reliability in relations to short and long-term socio-economic effects are overlooked (Stern, Burke and Bruns 2016; Carranza and Meeks 2016; Shivakumar 2014; Chakravorty, Pelliz and Marchand 2012), leading to a skimpy understanding of the impact (Kembo, 2013). Bridge, Adhikari and Fontenla (2016); Magnani and Vaona (2016); Lee, Miguel and Wolfram (2016); Peters and Sievert (2015); Akpan, Essien and Isihak (2013); Rud (2012) and Dinkelman (2011) inferred that electricity can increase up to 34% of household income through small businesses, it also improves women employability and their earnings: these are long time benefits.

Moreover, Barron and Torero (2014); Khandker (2012); Nakata and Kanagawa (2008) enumerated that electricity improves education by increasing up to 22 minutes of study time; it also improves health by relieving consumers from health-hazardous energy sources of which 20,229 people died from pollution in Tanzania in 2012 (Stiles & Murove, 2015). Meticulously, Béguerie and Pallière (2016); Mazumder *et al*.(2011) and WB (2008) argues to the contrary that there is weak evidence of the impact of electricity on household income. There is paucity in most inferences (Bridge *et al*., 2016; Lee *et al*., 2016; Magnani and Vaona, 2016;), due to: first, quality aspects of electricity were not reported; second, some long-term indicators like education are gauged as short term, against Torero (2015) and Mazumder *et al*. (2011) who reported that some impacts are difficult to capture in a short time; third, electricity has been modeled as a sole predictor of income while, in fact, the effects can hardly come from a single factor. Thus, unlike previous studies (Barron &

Torero, 2014; Barron & Torero, 2014 and Khandker, 2012); this study ventured into the assessment of the influence of quality electricity on consumers' socio-economic dimensions, especially appliance assets, ICT adoption, expenditure on backup fuels and income.

1.3 Objectives of the Study

1.3.1 Main objective of the study

The main objective of this study was to assess the rural households' short- and long-term socio-economic improvements emanating from rural electrification.

1.3.2 Specific objectives

The study specifically: -

i) Examined affordability of electricity from the utility company to rural consumers
ii) Assessed reliability of electricity for domestic expenditure on lighting fuels to rural households
iii) Determined the influence of electricity on Information and Communication Technologies (ICT) adoption
iv) Determined the influence of quality rural electricity on household income acquisition

1.4 Research Questions and Hypotheses

Regarding objective one and two, exploratory research questions were formed to depict and explain quality issues of electricity supplied while hypotheses delved into the reflection of objective three and four.

1.4.1 Research questions

The study was guided by the following key questions

(i) How affordable is electricity from the utility among rural consumers?
(ii) How reliable is electricity supply among rural consumers?

1.4.2 Hypotheses

The study strived to test the following null hypotheses

(i) **H_0**: Affordable electricity has no significant influence on the domestic electrical appliance ownership
(ii) **H_0:** Outage incidences do not exacerbate the difference in expenditure on

lighting fuels before and after electricity connection

(iii) **H_0:** Electricity has no significant influence on ICT adoption in rural areas

(iv) **H_0:** Quality rural electricity has no significant influence on rural household income

1.5 Justification of the Study

Access to modern energy which is affordable and reliable is a national and global agenda. Looking back at Sustainable Development Goal 7 (SDG7), Tanzania desires to attain universal access to affordable and reliable modern energy for all by 2030. This is by increasing investment in electricity supply, especially in rural areas. On that, there is an expectation that modern energy can be used to heal some ill socio-economic dimension like education, reduce income poverty by promoting small enterprises and access to information through the use of modern ICTs. Thus, this study cuts on edges of the key energy issues, hence, the study informs energy policymakers, utility regulatory authority and development planners on whether electricity supplied is affordable and reliable; and if there is an integration of electricity in socio-economic improvements. Electricity pricing and reliability are mostly contended issues that limit consumption, thus reliable information on these parameters is useful in the evaluation of the investment costs.

Moreover, the study is linked with Tanzania Development Vision 2025 which is based on transforming Tanzania into a middle-income country. This aspiration is imbued with nurturing an industrial economy, attain high-quality livelihood and the competitive economy at the state and local level. These are obtained by instilling modern energy and improve consumption. Although information indicates that Tanzania is in the lower-middle-income category some other aspects of social and economic development like increasing household’s income still needs to be accelerated. Thus, the current study brings some aspects on board. For example, the levels of information and communication technology adoption and how electricity has been helping the rural poor to improve their income. Notwithstanding TVD 2025, the results are also lined with Tanzania Energy Policy 2015; Tanzania National Natural Gas Policy 2013 and Tanzania Power System Master Plan 2035, all based at increasing production and reduction of cost of electricity and integrate it with socio-economic development especially in rural areas where 37.6% lives below the poverty line (URT, 2015)

1.6 Summary of Theories, Framework and Model Used

The study was guided by Energy Justice Theory (EJuT), Multi-Tier Framework (MTF), Technological Acceptance Model (TAM) and the Theory of Resource-Based View. The clarity is made in section preceding sections from 1.6.1-1.6.4

1.6.1 Energy Justice Theory (EJuT)

Energy Justice Theory (EJuT) was propounded by John Rawls in the 1970s. It draws its ideas from different social theories and instigates them in the energy context (Sari, *et al.*, 2017). EJuT establishes that there must be fairness accounting for justice being provided on to both consumers and energy utilities. The theory advocates sharing equitably benefits and burdens of energy service, provision of safe, affordable and sustainable energy. The theme underlining the theory is that there must be a well and adequately functioning transparent system financially sustainable and be able to meet the need of all stakeholders. It is of the view that energy is a basic right, it comes from our own environment, thus we all deserve access to it. Simcock (2016) asserted that in energy service there is an injustice of price, access and consumption costs which form a clear cut of concern in this study.

Jenkins, Heffron and McCauley (2013) highlighted that the assumptions of EJuT is built on its three tenets, namely (i) procedural justice; this encompasses the decision-making framework with eight principles: availability, affordability, transparency and accountability, sustainability, intra-generational, inter-generational, equity and responsibility. In light of this study, this tenet is the result of legal frameworks and policy output. Electricity has to be “available”; price of access be “affordable” to all groups of consumers to eliminate injustice. (ii) Distributional justice: electricity needs to be accessible to consumers of different capacities. (iii) Recognition justice: it is based on the view that social inequalities exist, therefore the rural communities should be provided with electricity basing on their economic context.

EJuT is integrated into this study to execute objective one which is based on affordability of electricity. The reason is that it explains well that access to modern energy is a basic need and because energy is the result of environment, it should be equally accessible to consumers regardless their social and economic status (consumers of different income quintile). To that end, it is argued that unaffordable electricity is “injustice” to consumers. Although the theory offers the best narration of justice, it has a backdrop in explicating the amount of electricity to be consumed and the duration of supply that could indicate the prevalence of justice or injustice to consumers. Thus, it is complemented by the Multi-Tier Framework in section 1.6.2

1.6.2 The Multi-Tier Framework (MTF)

The MTF was developed by the World Bank in 2011 and the Energy Sector Management Assistance Program (ESMAP) for the purpose of attaining Sustainable Energy for All (SE4ALL). According to ESMAP (2015), MTF measures various aspects of electricity quality such as affordability and reliability. The essence of the framework is that access to electricity does not end at electricity connection. Consumers can remain connected to electricity at the same time remain electricity poorer. This is due to the failure to pay and consume an adequate level of electricity. The MTF does not only inform affordability on the binary basis but also whether electricity served is meaningful on usability status especially from the consumers' point of view.

The MTF remains to be one of the most recently used frameworks in energy studies. It advocates that consumers of different levels (Tiers) require a different amount of electricity coupled with respective appliances. It divides consumers into Tier 0-Tier 5. The framework advocates that rural consumers should not spend more than 5% of household income to consume 30 kWh of electricity per month. It further indicates the usability of electricity in the household. The types of appliances to be used at different Tiers are also indicated. For example, TV, radio, fridge and metal iron. Thus, EJuT and MTF guided execution of the first objective because they direct and provide indicators of affordability. Further, EJuT and MTF sates that connection and consumption cost be of just price to consumers of all categories. MTF also indicates clearly the amount of power to be consumed for sustenance and the nature of appliances to be used.

In this study, the MTF was also used to measure reliability of electricity for objective two. The MTF provides power quality descriptions for different tiers of users. It delineate on the specific duration of supply consumers should receive electricity service: For example, consumers in Tier 4 and 5 should receive not less than 16 and 22 hours per day while evening supply should be greater than 4 and 5 hours. ESMAP (2019) revealed that MTF provides better guidance in the assessment of electric system reliability based on important metrics and indicators encompassing: maximum disruptions for unplanned incidences be 14 and 3 per week for Tier 4 and 5 coupled with annual SAIFI less than 730 and 156 respectively.

1.6.3 Technological Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was proposed by Fred Davis in 1985. It is an information system theory that models how individuals come to accept and use the technology (ICT) (Davis, 1989). TAM explains the key factors influencing the behaviour of a person with regard to accepting and using the available technology. Venkatesh and Davis (2000) explained that the information system community still consider TAM as a parsimonious and powerful theory due to its wide use in word processor, e-mail and hospital information system. This was supported by Lee, Kozar and Larsen (2003) who confirmed that of all the theories, TAM is the most influential and commonly employed for describing individual’s acceptance of information system. TAM is preferred due to its flexibility of fitting a range of external variables in studying technology.

TAM assumes that ICT acceptance is determined by two foremost user motivation variables: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) aligned with Attitude Toward Using (ATU). The outcome variables are behavioural intentions and technology use. Marangunić & Granić (2015) proposed that PU and PEOU can explain directly and indirectly the outcome variables (behavioural intentions tied with technology use). PU is the subjective probability that using a specific technology will increase life efficiency or performance while PEOU is the degree to which the user expects the technology to be free of effort (Islam, 2011).

PU and PEOU are accompanied by external variables which are conceptualized depending on the environment and personal capabilities. The variables could include: education, age, and marital status and operation incentives like electricity. In this study, electricity is an external variable which in its presence, PU, PEOU and ATU of ICT users (Mobile phones, TV, computer and radio) can be positive and hence build a sense of BIOU and develop actual use behaviour. Contrary to electricity availability, the study assumes that ICT users in rural areas are deemed to lugubrious state due to lack of driving force in information access.

1.6.4 Resource-Based View (RBV)

Resource-Based View (RBV) was developed by Wernerfelt in 1984 but was popularised by Barney in 1991 (Montgomery , 1995). RBV is a popular theory for studying the firm's Sustainable Competitive Advantage (SCA) and general performance. In fact, RBV determines strategic resources that help an organization to grow. In this study, the unit of analysis is the household. Therefore, the household is viewed as the heterogeneous organization which requires diverse resources (assets) and favourable conditions to attain the income goal. The reality is, income goal could be a function of different types of resources like electricity, individual motivation, land and other capabilities that have a different scale and intensity of effects (Barney & Clark, 2007). According to Barney (1991) resource is anything that adds on strength of a household; it is anything that helps a household to implement its strategies and attain the desired goal. The resources include physical, financial, human and household capital resources.

The RBV assumes that to attain income goal, tangible and intangible internal resources must fully be used. On that, the clarity is given by Barney (1991) who poses the assumptions for resources that they must possess some attributes: (i) Valuable; the valuable resources (quality electricity) are those which contribute and enable the household to implement strategies and attain the goal. (ii) Rareness; this implies that a household should have unique resources like electricity to be able to use them to attain predetermined aims. (iii) Imperfectly imitable; resources should be able to give strength to the household as compared to when the resources were not available. (iv) Non-substitutable; this is an important prerequisite for resources to be able to generate benefits to the household, in fact, there should be no equivalent resources to substitute the other if sustainable goal achievement is sought. All these attributes of the resources are identified as VRIN resource. Therefore, to undertake the fourth objective and for theoretical model development, intangible valuable resources like quality electricity and human behavioural assets such as individual motivation which is a driver of decision making in income generation in the complex environment were considered (Guay *et al*., 2010)

1.7 Conceptual Framework

The conceptual framework as provided in Figure 1.2 is the result of a comprehensive empirical review. It depicts that, quality rural electricity is hinged on mini-grids and grid extension in most rural areas of Tanzania. Success in electrification depends on hard inputs like machines, while soft inputs include running capitals to power machines. However, for electricity to bear results on socio-economic dimensions, analysis of the quality criteria cannot be adjourned, thus, forming a paramount part of the study.

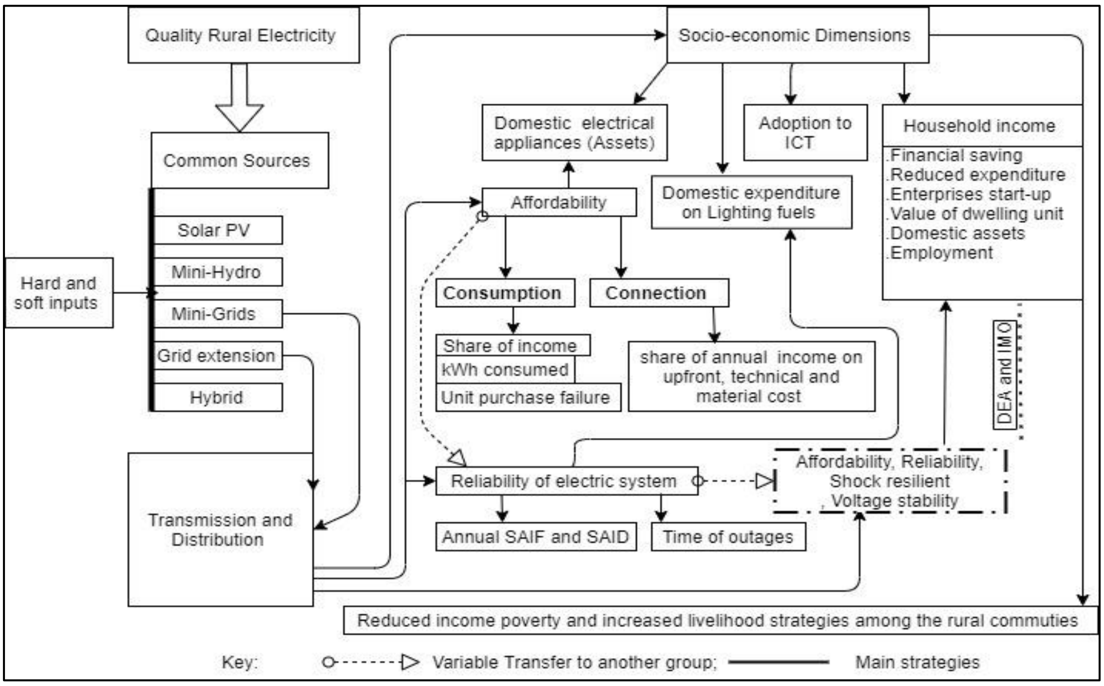

Figure 1.2: Conceptual framework

Source: Modified from Kojima and Trimble (2016); URT (2015)

From Figure 1.2, the most pronounced electricity quality issues include reliability and affordability. Thus, it is assumed that improvement of socio-economic issues does not come from electricity but quality electricity. Electricity needs to be affordable on connection and consumption. This is important because it relieves the household from being dragged into unnecessary borrowings. The socio-economic variables that are directly linked to affordability of electricity include electrical assets which are considered to be wealth indicator responsible for accentuating well-being and household cohesion. On the same, reliability of electricity regulates the amount of electricity incurred on backup fuels for the household.

The poor reliability as indicated by annual System Average Interruption Frequency (SAIF) and System Average Interruption Duration (SAID), could force the household to spend more from expenditure basket than the normal spending, something which could lead to transient poverty. Generally, ICT adoption and household income are assumed to be affected by quality electricity which is reliable, resilient to shocks and with voltage stability. All these have roles in accentuating consumption which in turn creates feasible effects in saving expenditure for backup fuels, attract small enterprises growth and employability. Along with the effect of electricity, some other factors like Development Assets (DEA) (such as land, access to financial resources) and Individual Motivations (IMO) are assumed to play role in influencing household income. This is because electricity is not the only resource in our local environment, hence, various observable and unobservable factors can complement and moderate some effects of electricity. The DEA and IMO are testified as possible complementarities for acquiring household income and improve the livelihood strategies and outcome.

1.8 General Methodology

1.8.1 Philosophical underpinnings of the study

Positivism philosophical stance was adopted by this study. Positivism is the clear cut of the scientific study of social patterns. Epistemologically, positivism’s goal is to describe the phenomena that we experience now coherently in the social world. The problem experienced is commonly felt and be solved by indicating the greater degree of unanimity in the undertaking. This philosophical stance emanates from the work of Auguste Comte (Saunders, 2016). The author narrates that Positivism provides the importance of what has been found; it renders an emphasis and focuses on scientific realistic methods designed to obtain information and facts without being influenced by human biases (Crotty, 1998).The absence of human influence depicts that positivism is based on objectivism approach, which epistemologically seeks to discover the truth about the social world, thus, embraces factual and realism (ontology) (Levers, 2013).

In fact, positivism entails studying observable social realities to make generalised inferences (Steinmetz, 2005). Positivism is also based on large data utilization to maintain objectivity. Consequently, there is the relevance of positivism philosophical stance with the current study because the problem under investigation entails objectivism approach in all its process of execution, from data collection, analysis and interpretation. It makes use of the large sample size; it employs scientific methods on data analyses such as the use of multi-variate inferential statistics. Likewise, it includes observable and quantitatively measurable facts. Further, issues of causal relations and prediction like those based on the influence of electricity on household income and hypotheses testing form the process of this study. Thus, making it imperative to use positivism. Referring to the theory underpinning the study, it was important to opt for positivism due to its deductive elements which is useful in postulating the theories chosen.

1.8.2 Description of the study areas

The study was conducted in two districts, Uyui (Tabora Region) and Kasulu (Kigoma Region). The districts are found in the regions which mainly form Western Tanzania. The two districts were entirely off-grid; however, in 2012 they were electrified through different modalities. Kasulu depends on mini-grids while Uyui is being served through grid extension, an installation which was done during the first phase of electrification through REA in 2012. Eight villages were selected, where four were from each district based on being connected to electricity for phase one programme. Generally, the reasons for selection of these areas are: first, they are earlier beneficiaries of rural electricity through rural electrification programme in Western Tanzania.

The study areas being earlier recipient of electricity made it made it possible to evaluate the effects of electricity based on short and long-term socio-economic indicators. Second, the districts are in regions with daunting socio-economic status in terms of assets (URT, 2012) and income; for example, statistics indicate that the regions have the lowest level of human development with TZS.1 075 268/= GDP per capita (URT, 2016). They have 0.4 localised Human Development Index (HDI) (URT, 2017) which is lower. Similarly, the areas have higher Multidimensional Poverty Index (MPI) of 56% for Kigoma while Tabora was 65% (URT, 2017). Lastly, the districts depend on different models of electrifications: mini-grids and grid extension, thus, it offered an array of factors to compare reliability of electricity from the two models. In reality, the study areas have salient features which can be used to depict if the investment efforts in electricity supply are paying on the ground after being marginalised for decades.

1.8.3 Research design and approaches

The study adopted a cross-sectional design embedded with descriptive and analytic approaches. The design is based on multiple case studies where data is collected from different participants while variables are observed without being influenced (Marczyk, Dematteo, & Festinger, 2005). In this study, various cases ranging from affordability of electricity to different consumers groups of varying income quintiles were coherently subjected under investigation. These process makes it relevant for the chosen design. Moreover, the design is best for the population based survey which aims at studying prevailing characteristics in a population with multiple variables (Marczyk *et al*., 2005). Additionally, Graziano and Raulin (2004) posited that the main outcome measure obtained from cross-sectional study design is for generalization of the prevalence of the phenomena, such as whether electricity has influence on the prevalence of income growth and ICT adoption in rural households. The design allows integration of multiple task and approaches based on the qualitative, description of phenomena and predictions. Thus, the descriptive approach was adopted because the study entails a rigorous description of variables based capturing views and opinion of the people: For instance, how affordable was electricity to consumers of different income groups. The analytic approach was preferred because of the fact that the study made use of low and higher-order inferential techniques on testing correlation and hypotheses for predictions (Lusambo, 2009); for example, Poisson regression was used to find out predictors for ICT adoption while Point-Biserial Correlation (PBC) was used for correlating expenditure on backup fuels and levels of electricity reliability.

1.8.4 Sampling procedure and respondents' selection

To obtain the desired sample, the sampling frame which was an updated list of households (customers) connected to electricity from TANESCO was considered. The distribution engineers and technicians filtered the list of live account for residential customers. The updated list was checked to realise if the household connected fits to be included in the study. The key criteria were, first, a household should be connected to electricity supplied by the state utility company for not less than 24 months (2 years). Second, the household should actively be using electricity by having a live account for two years. The qualified customers in Uyui were 2 585 households while Kasulu had 3 475 households that totalled to 6 060 households. After that, the sample size was calculated, 374 households were obtained after applying Taro Yamane's (1967) sample size formula (equation 1). Then, a stratified proportionate sampling procedure was undertaken to obtain the sample representative from each district and villages as well (equation 2 and 3)

(a) Taro Yamane's sample size formula

$n = \frac{N}{1+N*(e)^2}$ ……………………………………………………………...............(1)

n= Sample size

N= Total population of the connected households qualifying to participate in the study

e= ±0.05 precision

1= Constant

Note: The household population in Uyui district was 2585 while Kasulu district had 3475 households. Thus, the total household population for two strata was 6060

Therefore, $n = \frac{6\ 060}{1+6060*(0.05)^2}$ =374

Sample size (n) = 374

(b) Proportionate sampling procedures from two districts of Uyui and Kasulu

$$\boxed{\text{Sample size} * \text{Uor K} = \frac{\text{Total sample size}}{\text{Total population of stratum}} \text{xTotal Population U or K}}$$

**U=Uyui, K=Kasulu*

$\text{Sample size for Uyui} = \frac{374}{6060} x\ 2585 = 160$……………………………………(2)

$\text{Sample size for Kasulu} = \frac{374}{6060} x\ 3475 = 214$…………………………………(3)

(c) Stratified proportionated sampling for a representative sample from the villages and sub-station. The common formula devised was;

Representative sample (RS) for each village or sub-station =Sample for District (SD) divide to the Total sample for two Districts (TSfD) multiplying by the population of the sub-station or village (PSS) [RS=SD/TSfD*PSS]

Table 1. 3 : Stratified proportionate sampling

District	Village/sub-station	Qualifying households	Representative sample RS=SD/TSfD*PSS	sample size
Uyui	Isikizya sub-station	91	38	**160**
	Magiri substation	87	36	
	Uyui HQ substation*	84	35	
	Ilalwansimba substation	75	31	
	Igoko substation	48	20	
Kasulu	Kabanga substation	175	72	**214**
	Herujuu substation	98	40	
	Kidyama substation	106	44	
	Nyansha substation	141	58	
	Total sample size			**374**

* *Is not a village but a substation in Ilalwansimba village*

After identifying the sample representative as shown in Table 1.3, the next step was to select the respondents. In that, the first step was identifying streets which have customers who share the same feeder or substation. Second, selecting randomly the streets to be included in the study. For that, a rotary strategy under probability method was used, where streets were given names which were written on a piece of paper marked as “participant” and “not a participant”. Third, the meeting with street leaders was convened specifically for familiarization with enumerators who were moved around the areas a day before data collection. Fourth, probability methods through random technique were used to select the households. The households were coded by being numbered from 1 to 374 which is the sample size. Then, a random number Table which was constructed before fieldwork was applied to select the household whose respondent was the household head. On that, the household head was obtained by asking a question of “who is a head of the household” after giving the prime clarity on the meaning and attribute of the household head. On the use of the random technique in selecting respondent, Marczyk *et al*.(2005) explained that the technique provides an equal chance in determining who should participate in the study; thus, removing any possibility of selection bias. The random technique ensures that the findings obtained are generalizable (Teddlie & Yu, 2007). Moreover, technically, the random technique offers a high external validity of the results (Beins, 2004)

1.8.5 Data collection methods and tools

A questionnaire was a tool used during survey methods of data collection. Crewell (2014) explains that the survey method is based on questioning individuals on a series of topics and finally make a thorough interpretation of the given response. Survey method is used to gather both qualitative and quantitative data. Crewell (2014) narrates that survey can pursue and serve mainly two purposes; first, description of aspects or attributes of a population and second testing of the hypotheses based on relationships and prediction of phenomena of interest. Concerning the current study and its suggested design, there is compatibility based on the fact that the study tested hypotheses and conducted correlations analyses on variables of investigations.

Data collection tools under survey method included questionnaire. This technique was used to collect quantitative primary data from the field. The tool comprised of, mostly open-ended and less open structured items. The nature of data collected through questionnaire was on: costs incurred on electricity connection, reliability and affordability of electricity based on outage frequencies and duration and the income accrued for household sustenance as the result of reduced expenditures due to electricity services. The questionnaire for depicting household income was based on a bipolar scale which is good and works well for predicting positive and negative recommendations. The questionnaire was a key tool because, with it, adequate information was collected easily while maintaining the anonymity of the respondents. Before the actual data collection, five male graduate (Teachers) enumerators were recruited from Idete Secondary School in Uyui. Then they were exposed and trained for two days on how to use the tool. Later, they were given a room to practice the tool in a real environment by filling the questionnaire up to five respondents each. The purpose was to ensure reliability and consistency in posing questions while checking the pace for recording answers.

The key informant interview guide composed of open-ended items was also used to gather qualitative data based on affordability of electricity and the key causes of power outage. The interview was conducted on the face-to-face basis. This was important due to the sensitivity of information based on system outages. The key informants whom the interview guide was administered to were TANESCO’s Regional and district managers, distribution and transmission engineers, complaints and emergency departments. The criteria for selecting these key informants were based on the fact that they had rich and relevant information in relation to study objectives. The interview was recorded on the voice recorder and through text on the notebook. In administering the interview, enumerators did not participate, only the author scheduled the interview after the consent of the interviewees. The interview guide was preferred because it is flexible and provides a room for collecting a wider and specific type of information, it reflects emotions and explores issues with deeper focus.

The documentary review was also used in collecting information. Bowen (2009) informed that this technique involves skimming or quick examination of the document, reading thoroughly and interpreting the text. For that, the documentary review was used to obtain information that has been developed and recorded in the past (Silverman, 2000). The documents which were reviewed were, REA annual reports of 2014 -2018, Energy and Water Utility Regulatory Authority (EWURA) performance report on electricity Sub-Sector for 2018 and 2020, and Tanzania Development Vision 2015. Others were Tanzania Investment Prospectus 2030, the Tanzania Power System Master Plan (PSMP) 2035. Finally, the Tanzania Human Development Report 2017, Report on Global Electricity Status 2017 and World Energy Outlook report of 2015 were also reviewed. In purporting documentary review, Angrosino and Mays de Pérez (2000) argued that documentary review serves a great course because they can be analysed to verify the findings even though they are also used as a stand-alone technique.

Finally, the Focus Group Discussion (FGD) was used to collect extra and worth data based on affordability and how electricity was being used in improving social and economic aspects. Hayward, Simpson and Wood (2004) argued that a focus group is important because it brings together the researcher and group of individuals for the aim of having discussion on a specific topic. FGD helps to draw personal experience, perceptions and attitude of participants. Further, the authors commented that FGD is principally built on moderation of interactions. This is important because the moderator has to direct the discussion while keeping the opinions of participants in line with the topic. Out of many types of FGDs, the study followed Nyumba *et al*. (2017) who suggested a Single Focus Group Discussion (SFGD) as the most classical type. It has a high level of interactions which involves moderators and a team of participants in one place. Thus, the study borrowed guidance of Nyumba *et al*. (2017); van Eeuwijk and Angehrn (2017) who had the opinion that the number of participants should be minimal to manage (7-10 members); Gibson (2012) time of discussion be between 1-2 hours to avoid fatigue. In the selection of the respondents or participants of the FGD, Research and Marketing Strategies (RMS) (2016) postulated that one knowledgeable person can be purposively selected and then become a lead to obtain other members from the community. Indeed, this approach by RMS (2016) was borrowed in selecting the participants purposively based on being knowledgeable about information need.The voice recorder as well as paper and pencil were used to record information during FGD which were conducted under a tree near the village offices in quest of shadow during suny times.

1.8.6 Reliability and validity of data collection tools

1.8.6.1 Reliability of data collection tool

Reliability refers to the internal consistency of the results obtained from the same tool and persons when administered at different times by a different or similar administrator. Sarmah and Hazarika (2012) reliability is interpreted as the measurement tool being accurate and efficiently free from all sorts of impeding errors. Further, Sarmah and Hazarika (2012) explained that the more the measurement errors, the less the reliability. For that, this study delved into a series of reliability checkers; first, by training enumerators and carry out practices in the actual field where at least five questionnaires were filled. The purpose was to check consistency in posing the questions and recording results to reduce errors. Second, reliability was ensured by pilot testing the tool. Pilot testing was also proposed by Saturno-Hernández *et al*. (2019) who pilot tested for checking the reliability of indicators for safe childbirth. The Authors used 47 and 30 respondents at different hospitals and time. The authors were confident of truth worth of the results which were > 0.6, thus, giving them assured reliability.

Thus, this study borrowed the approach by Saturno-Hernández *et al*. (2019) where 40 respondents were picked randomly for pilot testing in Uyui district. Speaking of reliability, it can be based on different types: Inter-rater, test re-test, and internal consistency reliability. Thus, two types were chosen because not all items of the questionnaire can be checked by a single type. Test re-test method (stability) was chosen to gauge reliability for items based on continuous data such as household income. The continuous data cannot easily be extrapolated by Cronbach’s Alpha. Therefore, technically speaking, an instrument was administered to the same group of participants in Uyui district at 14 days interval and then the results of the scores on two occasions were compared through Pearson's *r* (Sarmah & Hazarika, 2012). The intraclass correlation coefficient results ranged from 0.843 to 0.998 indicating the high reliability of the instrument.

Internal consistency reliability was also chosen and the Cronbach's Alpha with values ranging from 0-1 was used to depict the values for reliability prevalence. In fact, values of 0.7 and above was acceptable. Not all items in the instruments were subjected to reliability, only those measured on scale level were. The Cronbach's Alpha score for included items was between 0.69 - 0.83 and thus indicating the best internal reliability which is acceptable especially in social sciences (Lusambo, 2009). Normally, the prevalence of reliability was sufficiently ensured.

1.8.6.2 Validity of data collection tool

Validity refers to the ability of the research instrument to measure that which it was intended to measure (Sarmah & Hazarika, 2012); equally, is the extent to which a concept is accurately measured in quantitative studies (Heale & Twycross, 2015). Validity is therefore based on the purpose of generating fidelity of the results. Sufficient validity needs a clear cut of establishment otherwise it can jeopardise the results. There is a myriad type of validity, such as concurrent validity, predictive validity and congruent validity. These depend on statistical operations in reporting validity. However, Heale and Twycross (2015) reported content validity as one of the most important tests: Indeed, it was used in this study.

The content validity is explained by Creswell (2005) as the extent to which the question and its score represent all possible questions that could be asked about the content. The content validity was ensured by sharing the tool with experts in the field of rural energy from TANESCO, the sole state energy utility. Items were reviewed because the experts were asked to indicate whether or not they found items well matched with the content of the study. As the matter of fact, opinions were given; some items were removed while the rest were restated. Finally, face validity was ensured because it is based on the outer look of the items. It is facially based, individuals, including social science scholars in the faculty at the University were asked to comment on the tool if it looked valid and especially in relation to the study objectives.

1.8.7 Data analysis

Analyses of qualitative data were done by transcribing the recorded data and decode them. Then, they were grouped according to themes and study objectives. The themes included reliability of electricity, causes of electricity outages, planned and unplanned outages. Others were, electricity and income of the household, electricity and micro business. Interpretation was done with direct quotes being picked along inferentially analysed data. Data from documentary review were assessed and analysed to depict relevant issues which were taken verbatim to support the results of the present study. To measure affordability of electricity connection and consumption, different approaches were adopted. First, Conventional Affordability Ratio (CAR) (Price Income Ratio) at 10% threshold was used to measure affordability of connection.

Affordability of electricity consumption based on the first objective was measured through PIR at 5%. This threshold was assessed along with the basic need electricity of 30 kWh/month. At the same, to depict the influence of electricity on electrical appliance ownership; assessment was done descriptively and then a paired sample t-test was used to apprehend the difference in ownership before and after electricity connection. Finally, a Multiple Regression Model was used to depict the determinants of electrical appliance ownership. The thinking was, electricity could not be the only determinant in this milieu and that its predictive power was important to reveal.

Reliability of electricity system in the second objective was analysed through a step-wise approach. This was to ensure the robustness of the results and that any volatile measure is complemented. Generally, a five-point scale was used, the assessment of the time of the day outages commonly occurs was done descriptively. The trend analysis was also used to depict the annual SAIF and SAID which was important in indicating the reliability of electricity for a long time. Finally, a General Electric System Index (GESRI), a simple index was developed by summing up the score from eleven item scale measures. The general index had 1. Low-Reliability [Score 0-29], 2. Moderate Reliability [Score of 30], 3. High-Reliability [Score 31-51]. The mean score of the indices was compared through One-Way ANOVA followed by a post-hoc test. Further, Ordered Logistic Regression Model was used to analyse predictors of power system reliability. The model was preferred because the dependent variable was ordinal categorical as depicted from reliability index. On the same, Logistic Model was used to apprehend determinant of reliability at the domestic level. It was based on whether consumers had experienced reliability problems emanating from indoor or otherwise.

To analyse the influence of electricity on ICT adoption in objective three, descriptive statistics was computed using Pivot Table Data analysis. Radios, TVs, Mobile phone and Computers were the devices of interest because they easily carry the meaning of rural ICT. Seven hypotheses were tested by using various inferential techniques. Mann-Whitney *U* inferential statistics (Non-parametric alternative to independent sample T-Test) was used to analyse differences in ICT devices preference by gender of the household head. The *U* test deals with independent groups in terms of the median for continuous variables (and ranked data due to serious violations of parametric assumptions) by converting them into the ranks (Pallant, 2007). The Poisson Regression Model (PRM) was used to determine factors for ICT adoption at the household. The model fits well when the dependant variable (Y) is an observable count with a Poisson distribution.

Similarly, for the third objective, the Wilcoxon Signed-Rank *(W)* test was used to analyse the differences in TV access by gender of household members before and after electricity connection. The test fit for a binomial independent variable with one continuous dependent variable (Field, 2009). The *W* is based on the sum of the positive ranks (T_{+}) and the negative ones(T_{-}). Notwithstanding the use of ICT in accessing different types of information against the gender of household head, the Chi-square test of independence (x^2) was employed. Field (2009) and Lusambo (2009) explained it as an elegant statistic based on comparing frequencies observed in given categories to the frequencies expected by chance in those categories.

Finally, to analyse the differences between age of household head (continuous) and the type of ICT devices used (Radio, TV and Mobile phones) a non-parametric Kruskal-Wallis *H* Test which is analogous to One-way Analysis of Variance (ANOVA) was adopted. The test compare scores on continuous dependant variable and categorical independent variable by converting a score into ranks for each group and compare them after computing the sum of each group. Lastly, to analyse the influence of quality electricity on household income, a Partial Least Square Structural Model (PLS-SEM) was used. The conceptual model was formulated with

13 alternative hypotheses as depicted from the literature. The model has household strength as a mediator and three moderators; age, education and gender. Electricity was modeled along with other constructs; development assets and individual motivation. The reality is, in models with latent variables and complex interrelationships PLS-SEM is "virtually without competition" (Wold, 2006). PLS-SEM algorithm supports advanced analysis techniques. For that, "Importance - Performance Map Analysis (IPMA)" was conducted for expanded results. IPMA can undeniably compare the most important antecedent on a target construct (Hair *et al*., 2017).

1.8.8 Ethical considerations in social sciences research

Ethics refer to a set of moral principles of conduct used to govern the decision-making behaviour and procedure of undertaking an activity (Agwor & Adesina, 2018). It is the general rule on how to behave. Ethical consideration is the heart of social and behavioural science researches. It provides the basis of deciding and judging if a certain act is correct or wrong in the given context. In this study, several aspects of ethics were considered at different phases of undertaking.

1.8.8.1 Problem identification and literature review

The problem identified should be meaningful and should have benefits not only to the researcher, but also those individuals being studied (Agwor & Adesina, 2018). This is further supported by Creswell (2007) that the researcher should not disempower those being studied and that there should be fairness in reporting the problem in its reality. In this study, the problem was carefully identified with extracts from the literature, it was not individualized. It has benefits to the individual being studied upon working on a recommendation based on electricity price. In the literature review, key ethical aspects were observed coherently. The reviewed materials, both published and unpublished were used and well acknowledged. Nonetheless, the study refrained itself from word to word submission of the previous works. Finally, self and all other kinds of plagiarism were subjected under strict check.

1.8.8.2 Ethical issues during fieldwork

Before fieldwork, an ethical clearance letter was obtained from Moshi Co-operative University. This was used to introduce the researcher to the Regional Administrative

Secretaries (RAS) in Tabora and Kigoma. The Regional authorities provided the legal permits for data collection in Kasulu and Uyui District, where research permits were provided as directions to the local leaders. Before fieldwork, enumerators were trained for two days, one of the aspects covered was basic ethical issues in data collection, obtaining the participants voluntarily, use of descent language and dress well. During the actual fieldwork, the objectives of the study were well explained, then the consent statement was disclosed. It informed that participation is free, no compensation of time, a participant is free to drop from the study anytime she or he wanted to. Confidentiality and anonymity were ensured. There was no data manufacturing because the questionnaire was inspected the same day, where defaults occurred the responsible participant was referred for corrections. The key informants declined from being recorded through the voice recorder during the interview, thus, information was recorded in the form of text in the notebook as part of ethical consideration. Only enumerators were paid as per the agreement, and street leaders who guided the researcher and enumerators were also paid in compensation for their time.

1.8.8.3 Ethical issues during data analysis and interpretation

The collected data were entered into the computer software and then carefully analysed. Jenn (2016) explained that inappropriate data analysis does not necessarily amount to misconduct and ethical violation, except for intentional misinterpretation and the omission of some data. Thus, in this study there was no data omission, except computer as ICT gadgets did not feature in the analysis because it lacked analytical fits, the omission did not affect the results anyhow. The technique and tools used in data analysis are disclosed and appropriate procedures of interpretation were assured. Analysis and interpretation were done according to rigorous literature guidance. There were no fabrication and falsification of data, no exaggeration in reporting the results, neither the author did influence the results. As part of ethical consideration, the author went back to the field to collect information that fits the specific analytical model for objective four.

1.8.8.4 Report writing and conflict of interest

During report writing, the researcher made substantial efforts to ensure that the scientific procedures of writing are in place as per prescribed guidelines. The key findings were all reported, according to the objectives of the study, no results were excluded except where it deemed so and was not with the intention of redirecting the results, hiding or influencing the results. Neither, the researcher had conflicts of interest, thus for any results, no direct or indirect benefits are accrued.

1.8.9 Organisation of the thesis

The thesis is in the format of publishable manuscripts which form an independent chapter. The thesis is organized in six chapters, where chapter one is about an introduction. It carries an overview on the background of the problem. Equally, it covers the statement of the problem, objectives of the study and justification of the study, conceptual framework and the general methodology. Chapter two presents the first manuscript, titled, affordability of electricity to rural consumers. The manuscript delved into measuring the affordability of electricity to consumers of different income levels. It also presents issues related to the influence of electricity on domestic electrical appliance ownership. Chapter three is based on the second manuscript which is about rural electric system reliability for households' lighting fuels. The manuscript assessed reliability of electric system through an index. It is followed by chapter four which presents the third manuscript based on electricity for information and communication technology adoption. The fourth manuscript is about quality rural electricity and household income nexus, it is presented in chapter five. Lastly, chapter six is about a summary of the findings, conclusions and recommendations.

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CHAPTER TWO

2.0 Affordability of Electricity to Rural Consumers in Kasulu and Uyui Districts, Tanzania

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2.1 Abstract

Affordability of electricity in rural areas has received diminutive attention, thus, equivocally reported. From that backdrop, the paper ventured into affordability assessment on two aspects, connection and consumption. Further, it examined the influence of electricity on domestic appliance ownership (electrical asset). It is extrapolated that through Price Income Ratio at 10% threshold, electricity connection was not affordable to consumers of the lowest income quintile. This is because, on aggregate they spent 33% of household income on electricity connection. On consumption, the paper argues that electricity was affordable because respondents had spent no more than 5% share of household monthly income on it. Second, about 41kWh was consumed per month. This is above 30 kWh per month as stated in Multi-tier Framework. Additionally, through multiple regression model, the paper expounds that electricity affordability and desire for well-being motivate consumers to avail with domestic electrical appliances. It is explicated that to ease affordability of connection, the government needs to subsidise electrical materials for rural consumers while devising instalment payment modality for electricity connection.

Keywords: Affordability, consumers, rural electricity, electricity connection, appliances

2.2 Introduction

Affordability of electricity which is on top of the energy ladder has been and remain fundamental in development for decades. Electricity being affordable is not the same as being low-cost or cheaper rather, the ability to pay for necessary levels of consumption or connection within normal spending patterns (Kayode *et al.*, 2015; Westskog & Winther, 2014). At the household, electricity demand is growing due to its importance (Platchkov & Pollitt, 2011), but affordable electricity has the potential to transform rural lives and livelihoods through the use of a variety of electrical appliances (Richmond & Urpelainen, 2019). For that, through sustainable energy for all initiatives (SE4ALL) electricity became a global agenda in 2011 (United Republic of Tanzania, 2015).

In 2012, affordability was also recognised through Sustainable Development Goal number seven (SDG7) which calls to ensure access to affordable, reliable and sustainable modern energy for all (United Nations, 2016). Fueyo *et al*. (2014) enumerated that, affordability of electricity is a challenge to most developing nations. For instance, from Asia, in 2004 the Lao People's Democratic Republic had 20%−40% of households which could not afford a connection charge of US $100. Thus, affordability is arguably a prime concern if universal access to electricity is sought (Riley, 2014).With increasing rural electrification to boost access to clear energy (Odarno, Sawe, Swai, & Maneno, 2017); people remain in need to be unlocked from electricity fuel poverty by making it accessible and affordable (Heindl and Schüssler, 2015).

The strategy to unlock people from electricity poverty requires a quantum leap of efforts because there are about 1.3 billion people who lack electricity in the world (International Enegy Agency, 2013). Sub-Saharan Africa alone has 573 million people without access to electricity (International Energy Agency, 2019). In Sub-Saharan Africa most people are poorer and health constrained due to vulnerability (World Health Organization, 2015); further, they could remain poor in socio-economics if affordable and reliable electricity is not enhanced (Taneja, 2018). Winkler *et al.* (2011) argued that affordability of electricity determines access and consumption rates. This was supported by Winkler *et al*. (2011) that affordable energy makes it accessible for both upper-and lower-income earners. The world's urban electrification rate is 90% by 2013, while rural stands at 70 % (WB, 2013). This disparity is the result of generation, transmission and income inequality (Kojima, *et al*., 2016). In urban areas, people can pay connection and consumption demands (Deller & Waddams, 2015) but rural consumers struggle to connect even at very lower costs (Kojima & Trimble, 2016). While rural areas in Rwanda, South Sudan and Malawi had low generation leading to 12% access to electricity (Fabin, Taneja and Barido, 2014), affordability of connection and consumption is considered critically challenging. On similar theme, Golumbeanu and Barnes (2013) explicated that in rural areas consumers can only afford monthly bill of US $3-7. Thus, failure to afford electricity consumption can cause economic pressure (Bezerra, *et al*., 2017), while livelihoods through electrical appliances like TV and cook stoves could be abandoned (Batteiger & Rotter, 2018). All these pose can pose dampening effects of the general livelihood of the people.

International Energy Agency (IEA) (2016) and Lusambo (2009) stipulate that lack of connection and or consuming less than 250 kWh and 500 kWh per year for rural and urban customers is considered as electricity poverty. Hence, consuming less could affect education and limits electrical assets ownerships at the household for improved well-being (Narasimha & Pachuri, 2017; Lee, Miguel, & Wolfram, 2016). Additionally, the connection cost in some poor countries is extra high; for example, in Kenya it was US $400, Tanzania US $ 297, Central Africa Republic US $ 283 and Burkina Faso US $ 264 (WB, 2013). These are the highest connection costs than in any other region. This is cultivated by a high cost of power production and distribution. However, through REA programs cost situation has recently been rectified in some countries including Tanzania.

In rural areas, high connection cost orchestrates meter sharing among consumers in Africa (Kojima, *et al*., 2016) and illegal connections (Azimoh, 2016). Further, on affordability issue, Mainuddin (2006) elucidated that in South Africa some consumers disconnect from the grid; Winkler *et al*. (2010) equates the disconnection as related to “unaffordability”. For similar substance, in Bangladesh, about 13% of rural power consumers were disconnected in 2005 while in some more poor regions the disconnection rate stood at 20% (Bangladesh Bureau of Statistics, 2007). Those who lack access to electricity due to unaffordability of connection and consumption lack a typical ingredient of socio-economic development (Groh, Pachauri, & Narasi, 2016). This was supported by Azimoh (2016) who argued that rural people cannot avail themselves with development opportunities without access to electricity; in that manner, appliances can be part of the development opportunities (van deWalle *et al*., 2017).

Affordability of public utilities is an issue to consumers and suppliers (Miniaci *et al.*, 2008). The term is closely related to poverty (Fankhauser and Tepic, 2005, Milne, 2014); Niëns and Brouwer (2013) it involves Out of Pocket (OP), hence, raising more concern. Electricity consumers can be affected if the price goes untamed (Sari *et al.*, 2017). Nonetheless, electricity being affordable does not mean cheaper rather spending within a normal pattern (Kayode *et al*., 2015). Various index measures of affordability exist; Haurin (2016), Milne (2014), Renne *et al*. (2016), Sautenkova (2012), Deller (2016), Ranasinghe (2011), Betraud (2016) and Stone, Burke, & Ralston (2011) suggested residual income-ratio of an index utility price to household disposable income. Rademaekers *et al.* (2014) suggested income expenditure and consensual approach while Niëns and Brouwer (2013) are of catastrophic and impoverishment measures. Catastrophic is based on the index of Price Income Ratio (PIR) (Gawel *et al*. 2011 and The Brookings Institution , 2006). Thus, this paper uses PIR at 10% threshold as suggested by WB (2002) and (Lusambo, 2009) to measure affordability of connection; while 5% threshold coupled with basic need electricity of 30kWh as adopted from the WB (2016) was used to measure affordability of electricity consumption

To endure affordability, efforts are made by different countries; for example, Senegal has lowered connection and upstream network costs from US $ 725 to US $ 99 and provide customers with electrical materials to cut installation costs (de Gouvello and Kumar 2007). Liberia reduced the US $ 950 connection and upstream network cost while Kenya has subsidy to lower US $300 upfront cost for rural connections. Ethiopian Electric Power Corporation (EEPCo) finances up to 80% of connection costs and offers installation materials. More importantly, Tanzania has reduced upfront cost from US $ 270-1957 in 2012 to US $80 for single-phase rural customers, though the cost varies with distance from distribution lines (de Gouvello and Kumar 2007). EWURA (2018) indicated that residential meter rental charges and connection application fees were ceased as part of the efforts of ensuring affordability of connection and consumption. On top of that, the lifeline tariffs were increased from 50 to 75 kWh for lower tariffs electricity consumers in rural areas including Kasulu and Uyui (Peng & Poudineh, 2016).

Despite electricity connection and cost adjustments, the clarity on affordability remains scant due to methodological scratches and variables selected. For example, Golumbeanu and Barnes (2013) used PIR to assess upfront cost and consumption, but technical costs as an important predictor were considered less; hence inferences remained shaky. Kimambo (2012) substantiated that power was not affordable based on upfront charges only. Nonetheless, Ranasinghe (2011); Winkler *et al*. (2010); Fankhauser and Tepic (2005) observed affordability of consumption while reporting less on upfront costs and how power can influence domestic appliance purchase. While there are still equivocal inferences about affordability; Richmond and Urpelainen (2019) enumerates, empirical evidence on how rural electrification translates into appliance ownership and usage remains understudied across contexts. Thus, this paper was enticed by the view that affordability of electricity should be measured on key components of connection and consumption. For that, the paper:- (i) assessed affordability of electricity on aggregated components of connection and consumption (ii) examined the effect of electricity affordability on purchase of domestic appliances.

2.3 Theoretical framework

2.3.1 Energy Justice Theory and the Multi-Tier Framework

The paper was underpinned by Energy Justice Theory (EJuT) and MTF for assessment affordability (price justice) and consumption. The EJuT was propounded by John Rawls in the 1970s. It draws its ideas from different social theories and instigates them in the energy context (Sari *et al*., 2017). EJuT advocates sharing equitably benefits and burdens of energy service, provision of safe, affordable and sustainable energy. Simcock (2016) asserted that in energy service there is an injustice of price, access and consumption costs. Jenkins *et al*. (2013) says, the assumptions of EJuT is built on its three tenets, namely (i) procedural justice: this encompasses the decision-making framework with eight principles: availability, affordability, transparency and accountability, sustainability, intra-generational, inter-generational, equity and responsibility.

In light of this study, the tenets are the result of legal frameworks and policy output. Electricity has to be “available”; price of access be “affordable” to all groups of consumers to eliminate injustice. (ii) Distributional justice: electricity needs to be accessible to consumers of different capacities. (iii) Recognition justice: it is based on the view that social inequalities exist, therefore the rural communities should be provided with electricity for their economic context. EJuT does not reveal consumption level, thus needs MTF for clarity (Table 2.1)

Table 2. 1: The Multi-Tier Framework for affordability of electricity

Attribute of access	Tier 0	Tier1	Tier2	Tier3	Tier4	Tier5
Capacity		Capacity from (3W to above 2kWh) and ability to power appliance (off-grid)				
Duration of supply	NA	> 4 hrs	> 4 hrs	> 8 hrs	> 16 hrs	> 22 hrs
Duration-evening		**> 2 hrs**	**> 2 hrs**	**> 4 hrs**	**> 4 hrs**	**> 5 hrs**
Reliability					**Number of the duration of outages**	
Number of Disruption					Max 14/Week	Max 3/ week, duration of < 2 hours Agg*.
Annual SAIFI* and SAIDI*					< 730	< 156 < 6 240 mins
Quality	**NA**				**Voltage problems do not affect the use of desired appliances**	
Affordability				Basic service less than five 5% of a household income for 30 kWh		
Legality	**NA**				**Service provided legally**	
Health and safety					**Absence of accidents**	

Source: Kojima (2016) **NA=Not Available, and mostly lack access to electricity fuel*

The MTF (Table 2.1) was developed by the World Bank in the role of sustainable energy for all (SE4ALL) in 2011. The framework advocates that consumers of different levels (Tiers) require a different amount of electricity coupled with respective appliances. It divides consumers into Tier 0-Tier 5. The framework advocates that rural consumers should not spend more than 5% share of household income to consume 30 kWh of electricity per month. It further indicates the usability of electricity in the household. The types of appliances to be used at different Tiers are also indicated. For example, TV, radio, fridge and metal iron. EJuT and MTF provide clear guidelines on the assessment of energy affordability and consumption level. EJuT and MTF draws relevant variable of the study such as connection and consumption costs to be just to consumers of all categories and the amount of power to be consumed for sustenance (WB and Energy Sector Management Assistance Program-ESMAP, 2015).

2.4 Methodology

The study was conducted in eight villages from Kasulu and Uyui Districts of Kigoma and Tabora respectively. Kasulu is served with Mini-grid electricity while Uyui district is connected to National grid. The areas being of low socio-economic status (Kilama, 2016), has made it a research priority for assessing affordability of electricity connection and how appliance ownership have been influenced. The study employed a cross-sectional research design which fits when variables are about ratios and exhibit relationship (Graziano and Raulin, 2004). The unit of analysis was rural households connected to the utility at least for two years because affordability of electricity is best assessed through connected households using a retrospective approach than the willingness to pay (Thom, 2000). From two districts, the total sample size for the study was 374 household computed using a formula by Yamane (1967). Further, proportionate stratified sampling technique was applied to obtain the sample representative from districts and eight villages. Respondents were selected proportionately depending on the number of consumers connected to a specific feeder transformer in the villages. Simple random sampling technique was used to select respondents.

The method for this study was survey because it helps to obtain data from a wider range of topics (Graziano and Raulin, 2004). A questionnaire was used to gather data on households' annual and monthly income as well as expenditure. The method of focus groups discussion (three FGD) of seven participants in a mix of male and female were conducted to obtain qualitative information (Nyumba *et al*., 2018). Likewise, an interview was conducted to five key informants from TANESCO including managers and distribution engineers. Qualitative data were transcribed, analysed and decoded according to objective and themes. Descriptive (mean, mode, median and percentages) and inferential statistics were computed using SPSS.

In measuring affordability of electricity connection, a catastrophic approach through the index of utility Price Income Ratio (PIR) at a threshold of 10% was adopted (Lusambo, 2009). The PIR components were added to include the technical and material cost to capture an adequate level of affordability. Consumption affordability was determined through PIR at 5% share of income threshold coupled with an assessment of basic electricity consumption at 30 kWh/per month/households of different income quintiles (World Bank, 2016). Thus, respondents were divided into five income quintiles; this approach was adopted from Adam, Brew-Hammond and Essandoh (2013). The equations for affordability are given in 2.1 and 2.2

$$\text{Affordability of Electricity Connection Cost (AECC)} = \frac{\text{UPC+MTC}}{\text{ANHAI}} \text{x100} \ldots\ldots\ldots(2.1)$$

Where;

UPC=Upfront cost payable directly to the utility

MTC=Total material and Technical Cost

ANHAI=Aggregate Net Household Annual Income from various sources

Decisive threshold =10%

Affordability of Electricity Consumption (AEC) $= \frac{\text{UP}}{\text{ANHIM}} x100$……..……(2.2)

Where;

UP=Utility price for the reference month

ANHIM=Aggregate Net Household Income for the reference month

Decisive threshold 5% and 30 kWh as basic need electricity

Further, to assess the effect of electricity on domestic electrical appliance, three stages were employed; first, descriptive statistics were used to capture the number of appliances owned by the household before and after electricity connection from the utility. Second, a paired samples t-test was used to find the difference between domestic appliances owned before and after electricity connection. Richmond and Urpelainen (2019) used Ordinal Least Squares (OLS) with binary measures of the appliance (dummy) in India. Thus, to assess whether electricity and allied factors (Table 2.2) have a predictive effect on domestic appliances this paper used a multiple regression model (Field, 2009) (equation 2. 3) where appliances were treated as count variables.

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i$ ………………………..........................…… (2.3)

Where: $Y =$ Number of domestic electrical appliances

β_0 = A constant term

β_{1-k} = Partial coefficients

X_{1-k} = Predictor variable

ε_i = Random error term

Table 2. 2: Explanation of variables used in the multiple regressions model

Variable symbolic	Names of variables	Measurement
Y/ Outcome	Domestic electrical appliances	Number of appliances purchased
X_1-X_{13}= Regressor		
X_1	Duration since power connection	Years since power connection
X_2	Knowledge on how to use the appliance	1= decisive factor, 2=Not a decisive factor
X_3	Electricity connection	1=Yes, 2=No
X_4	Loan ability of the appliance	1=Loan able, 2=Not loanable
X_5.	Wattage capacity of appliance	1=Considered, 2=Not considered
X_6.	Appliance as an asset	1= decisive factor, 2=Not a factor
X_7.	Attainment of social wellbeing	1= for happiness, 2=not for happiness
X_8.	Gender of household head	1=Female, 2=Male
X_9.	Age of household head	Years of the household head
X_{10}.	Level of education of household head	1=literate, 2=Illiterate
X_{11}.	Affordability of consumption	1=Affordable, 2=Not affordable
X_{12}.	Marital status of head of the household	1=Married, 2=Never married
X_{13}.	Economic status of household head	Income from householders aged 18+

Regarding content and face validity of data collection tools, was ensured by pre-testing and scrutinizing contents against the intended information obtained through the tool. Nonetheless, reliability of the tool for variables-based on household income and expenditure on electricity was ensured through the intraclass correlation coefficient (ICC) which was conducted using Test re-test reliability coefficient. ICC fits for continuous variables which can hardly be extrapolated at best by Cronbach's Alpha. Therefore, test one and test two (T1 and T2) were administered to 40 respondents at 14 days interval which is ideal (Landers, 2011). The results were then correlated. ICC indicates the degree of correlation and agreeability of results consistency. ICC takes a scale of 0 and 1, where 1= perfect reliability, $\geq$ 0.9= excellent reliability, $\geq 0.8 < 0.9$= good reliability, $\geq 0.7 < 0.8$=acceptable reliability, $\geq 0.6 < 0.7$=questionable reliability, $\geq 0.5 < 0.6$=poor reliability, < 0.5 = unacceptable reliability, 0 = no reliability (Landers, 2015). The results provided in Table 2.3, shows ICC of 0.8 to 0.9 reliability coefficients which are excellent and good for average measures score on a two-way mixed-effects model where people effects are random and measures effects are fixed.

Table 2. 3: Intraclass correlation coefficient (ICC)

At the Confidence of 95%				
Parameters/Variables tested	**Tests**	**Mean**	**ICC**	**ICC value**
The net annual income of the household head	T^1	2192333.33	0.729	0.843
The net annual income of the household head	T^2	1839666.67	0.843	
The net annual income of subsequent HHM	T^1	758000.00	0.764	0.866
The net annual income of subsequent HHM	T^2	708000.00	0.866	
Annual expenditure on education	T^1	103000.00	0.996	0.998
Annual expenditure on education	T^2	107666.67	0.998	
Total material and technical costs	T^1	410583.33	0.862	0.926
Total material and technical costs	T^2	408216.67	0.926	
Freq. Power purchase failure for the last two months	T^1	0.30	0.926	0.962
Freq. Power purchase failure for the last two months	T^2	0.20	0.962	

**Two-way mixed-effects model where household effects are random and measures effects are fixed T1=Test one, T2=Test Two, Freq=Frequency, HHM=Household Members*

2.5 Results and Discussion

2.5.1 Respondents' characteristics

The study sought to find out the socio-economic and demographic characteristics of 374 households' respondents. Status about the age of the household head, economic activities, household size and the number of houses in the compound are some of the key parameters associated with income and expenditure of the households. This, in turn, can be used to predict the ability of the household to afford electricity connection and consumption. The result on characteristics of the respondents is presented in Table 2.4

Table 2. 4: Characteristics of the respondents

Variables	Minimum	Maximum	Median	Mode
Age of household head	29	65	49.0	
Household size	2	13		7
Houses in the compound	1	6		2
Number of houses electrified	1	5		2
Size of the main house in term of rooms	2	6		4
Duration since power connection	2	6	4.0	
Members who contribute income	1	6		3

In Table 2.4 it is enumerated that the median age for household heads was 49. This is an indication that most household heads are still energetic and can work to accumulate wealth. The household size in the study areas being 7 was also reported by the United Republic of Tanzania (2012). The household size has a significant effect on electricity consumption for connected households if members can or cannot contribute income. Moreover, the household has 2 houses electrified in the compound while the size of the main house in terms of bedrooms stood at 4. The size of the house and the number of houses in the compound can affect the cost of power installation and consumption as well. The duration since household connected electricity from the utility supplier was 4 years; this was enough to reflect the effect on domestic appliances among consumers. Moreover, the household had 3 members who contribute, for that, consumption and connection affordability can be predicted by looking at the net income of the household.

Apart from the results in Table 2.4, the paper assessed the gender of household heads. It was found that 19.3% of the surveyed households were headed by females while 80.7% were males. The attributes of culture in the surveyed areas recognise males as principal household head regardless of their contribution to household sustenance. The current study considered the head of household as a person who is responsible for making decision and provides mostly for household sustenance (Kleinjans, 2013). Thus, it was evident that women play part in household maintenance including access to clean energy sources like electricity. Likewise, about 90.9% of the surveyed respondents were married with farming being a primary economic activity by 60.7%. This was common because statistics indicate that about 75% of the rural population had farming as focal economic activity (URT, 2015). Likewise, private sector employee, peasant, livestock keeping and business comprised of 61.5% as secondary economic activities among the respondents. Multiple economic activities have increasingly become a feature of rural and urban economies aiming at reducing intensifying volatile income.

2.5.2 Affordability of electricity connection at the household

To assess affordability of electricity among the rural consumers, a catastrophic approached (CA) using PIR (index) at the 10% threshold was used. Affordability was assessed stepwise; first, basing on utility upfront costs; second, material and technical cost and finally on the aggregate costs of electricity connection. Respondents were categorised into different income quintiles because assessment affordability of electricity requires precise articulation. Affordability should be reported with reference to the specific group of consumers to be able to answer the question “affordable or not affordable to who?”. This is to say, inferences on affordability sound best when equated with income group of consumers (Table 2.5)

Table 2. 5: Households share of expenditure on electricity connection

Income Quintiles (TZS) AHNI		HHMCI	TEEC	Share on UCEC	Share on MTC	ASEC	% of N(374)
	Median TZS	Mode	Median TZS	% of mean			
Lowest	1,940,000	2	627,000	13	20	33	61.76
Min	1,000,000	1	327,000	.89	9	13	
Max	3,600,000	4	1,152,000	51	33	64	
Lower	5,080,000	3	797,000	6	9	15	28.07
Min	3,620,000	1	407,000	.44	5	7	
Max	6,200,000	6	1,132,000	11	15	25	
Medium	6,940,000	2	915,000	6	6	12	7.75
Min	6,250,000	1	367,000	.34	5	5	
Max	8,600,000	5	1,452,000	14	9	12	
High	10,150,000	2	720,500	3	5	7	1.06
Min	9,060,000	2	627,000	2	4	6	
Max	11,300,000	4	878,000	4	6	9	
Highest	13,100,000	3	768,000	2	3	6	1.33
Min	12,400,000	2	625,000	1	3	5	
Max	13,400,000	4	885,000	3	4	7	Total.100

Notes: AHNI=Annual household net income, HHMCI=Household members contributing income, TEEC=Total expenditure on electricity connection, UCEC=Upfront cost on electricity connection, MTC=Material and technical costs, ASEC=Aggregate share on electricity connection

The summary of the results in Table 2.5 show that the share of household income spent on the upfront cost by consumers in the lowest income quintile was 13% while material and technical cost drew 20%. On aggregate, the share of expenditure stood at 33%. The lower, medium to higher income quintile respondents spent less than 10% share of household income on upfront, material and technical cost. Thus, the paper infers that to the lowest income quintile consumers (61.8%) electricity was not affordable at both levels because they were burdened with high connection cost (33 % share of income). In that line, 33% of income is catastrophic (Niëns *et al.*, 2010). Spending 33% of annual income has a detrimental effect for household to flourish because some consumers had to sell assets like land while others had been dragged into debts at high-interest rates. These results are supported by the Bangladesh Bureau of Statistics (2007) which indicated that electricity consumers had spent 23% of income on connections while in Brazil 30% share was used. In the study area, to secure fund for electricity connection, about 42.2% of the respondents took loans from Village Community Bank (VICOBA), Savings and Credit Co-operative

Societies (SACCOS), relatives and friends. Those who paid loans timely were 56%, while 36.6% failed to pay in time, 5.4% failed to pay. This is a clear indicator of unaffordability of electricity connection.

More than 75% of Tanzania population lives in rural areas, most of them being poor. For example, in Kasulu the per capita income in 2015 was estimated to be TZS 650 000/= (URT, 2015). In 2016 and 2017 Kasulu and Uyui had TZS. 1 075 268 /= GDP per capita URT, 2017). With reference to the GDP per capita it was evident that electricity consumers in the study areas could hardly afford connection costs. Information from EWURA (2018) indicated that the subsidised connection fee for consumers within 30 Meters from distribution lines were TZS 180 000/= while for unsubsidised was TZS.385 682/=. These are cost payable to the utility company. In fact, some other costs such as materials and technical costs when added on that the prices hike to the level that raises affordability concern. It is important to understand that the rural people are vulnerable to economic shocks, meaning that any increase of cost could push then into troubles. Furthermore, electricity consumers with little earnings are still burdened with more costs on household sustenance such as food, communication, transport, health, education and clothing.

Regarding Energy Justice Theory, it sees to it that electricity should be affordable to all consumers of different capacities, therefore, social inequalities in the society should not limit an individual to access clean energy service. The connection costs which exert a huge burden of expenditure share is considered "unjust price" in the view of energy justice theory. The rural population depends on agriculture with unpredictable access to market, shaky weather, poor transport system which aggravate sporadic economies while the cost of electrical materials stand high. Thus, the high cost of electricity connection is viewed as the vicarious source of transient poverty among rural people. For instance, concerning connection costs, FGD participants claimed that:

> "*There are so many costs for connecting electricity, and you have to pay them once. The inspection and upfront costs have no excuse and it worsens as you stay beyond 30 metres from power line" (FGD, Uyui District, 14 February, 2018)*

This statement indicates that upfront cost changed with distance from power lines, although being closer doesn't imply affordability but it gets worse as a consumer stay away from the power line. Cost variations indicated that a single-phase customer within 60 metres TZS, 337.740/=, within 90 metres, TZS 454, 654/= (TANESCO, 2016). These costs are challenging to be borne by the poor income earners. However, the key informants (Transmission engineers) indicated that some consumers were within 30 metres of power line but failed to pay the amount of TZS.27, 000/= connection cost (Usually paid while distribution engineers are on-site). However, little connection upfront cost cannot be inferred as affordable because electricity connection does not end at paying the upfront cost. The paper analysed affordability for the population as a clarity-based analysis. The findings in Table 2.6 indicate the inferential statistic for the pooled sample and population statistic on affordability. This is important because it offers the valid precision for policy and price recommendation

Table 2. 6: Inferential statistic for affordability on pooled and population

Income Quintiles	**Sample statistic**				**Inferential statistic for the population (95% CI)**			
	N=374	**Share on UCEC**	**Share on MTC**	**ASEC**	**Share on UCEC**	**Share on MTC**	**ASEC**	**% of N**
			Mean of %			**Mean of %**		
Lowest	231	13	20	33	12-14	19-20.7	31.7-34.4	61.76
Lower	105	6	9	15	5.5-6.5	9.4-9.8	14.7-16.1	28.07
Medium	29	6	6	12	4.9-6.8	5.9-7.1	11.1-13.8	7.75
High	4	3	5	7	0.79-4.5	3.3-6.2	4.5-10.7	1.06
Highest	5	2	3	6	1.2-3.7	2.9-3.7	4.8-6.7	1.33

UCEC=Upfront cost on electricity connection, MTC=Material and technical costs, ASEC=Aggregate share on electricity connection

Table 2.6 enumerates that, using the PIR at 10%, aggregated connection cost for the population in the lowest quintile was found to be between 31.7-34.4% at a 95% confidence interval. This is surely acute and catastrophic spending which indicates huge burden ratio of expenditure on electricity connection. The population in the lower and medium income quintile was burdened to spare power cost on aggregate between 14.7-16.1% and 11.1-13.8% respectively (95%, CI); it still denotes affordability problem given the 10% rule. The high- and highest-income earners though constitute 2.36 % of the total population had a favourable affordability status of which rarely exceed 10% of the household income. Nonetheless, the paper explicated affordability analysis for stratum coupled with inferential checks for robust inference (Table 2.7)

Table 2. 7: Sample and population affordability in the stratum

Income Quintiles	Sample statistic				Inferential statistic (95% CI)			
	District	**Share on UCEC**	**Share on MTC**	**ASEC**	**Share on UCEC**	**Share on MTC**	**ASEC**	**N**
mean of percentage								
Lowest	Uyui	13.7	20.3	34.0	12.2-15.3	19.1-21.6	31.8-36.4	94
	Kasulu	12.5	19.8	32.3	11.4-13.6	18.9-20.7	30.7-34.0	137
Lower	Uyui	6.1	9.3	15.7	5.3-6.9	8.7-9.9	14.3-16.5	51
	Kasulu	5.9	9.5	15.4	5.2-6.7	8.9-10.1	14.5-16.4	54
Medium	Uyui	5.7	5.9	11.6	4.9-6.6	4.9-6.9	10.0-13.3	11
	Kasulu	6.0	6.9	12.9	4.6-7.5	6.1-7.7	10.9-15.0	18
High	Uyui	1.6	4.1	5.7	N.A	N.A	N.A	1*
	Kasulu	2.9	5.0	7.9	-.060-6.0	2.6-7.4	2.6-13.3	3
Highest	Uyui	2.7	3.2	5.9	-.14-5.7	2.1-4.3	3.8-8.1	3
	Kasulu	1.9	3.3	5.3	-.5.7-9.7	2.1-4.7	-10.0-11.7	2

*NA=Not applicable, * The strata of the Quintile has one respondent, inferential cannot be computed UCEC=Upfront cost on electricity connection, MTC=Material and technical costs, ASEC=Aggregate share on electricity connection.*

The results in Table 2.7 suggest that the stratum have marginal differences in expenditure on electricity, be on sample statistic or inferential statistic. In Uyui district for example, the lowest income quintile on sample had a PIR of 34% and on inferential statistic 31.8-36.4% (95% CI) less than the counterparts in Kasulu who spent on aggregate a share of 30.7-34.0. There is a similarity of affordability problem which is cultivated by the fact that most rural areas share cultural and economic realms as they all depend on agriculture with unpredictable markets with poorly developed transport infrastructures.

2.5.2.1 Affordability of electricity consumption at the household

Affordability of electricity does not end at the connection. In fact, connection and consumption are two different phenomena; therefore, consumers can remain in dark if they fail to afford consumption cost despite being connected. Thus, Table 2.8 shows the results on affordability of electricity consumption using the Price Income Ratio (PIR) based index at a threshold of 5% and 30 kWh basic need electricity.

Table 2. 8: Affordability of electricity consumption to residential customers

Income Quintiles	Sample statistic (median)			Mode	The inferential statistic at 95% CI			% of N
	Median expenses	Share on electricity/ month	kWh	Consumer Category	Median expenses	Share on electricity	kWh/month	
Lowest	9150	4.8	40.9	T1*	8842-9719	4.7-5.4	41.6-45.9	61.76
Lower	15000	3.17	56.3	T1	13654-16541	3.0-3.7	50.0-57.2	28.07
Medium	20000	3.13	56.3	T1	15485-21146	2.8-3.6	44.3-75.1	7.75
High	12500	2.17	48.7	T4*	-3712-32712	-0.04-5.2	25.7-82.8	1.06
Highest	8500	0.93	57.3	T4	6877-10322	-1.1-5.4	24.8-73.2	1.33

T1=Tariff One, T4=Tariff Four/Zero (Highly subsidised power consumers)

Interestingly, from Table 2.8 it is explicated that respondents in the lowest income quintile (61.8%) were middle power tariffs (T1) consumers and had spent 4.8 % share of monthly income on electricity fuel. Moreover, it is very surprising that information from the key informant indicated that consumers in rural areas are not aware of tariff or consumption categories. Therefore, most of the lowest income earners are in T1 which is partially subsidized. The lower and medium income quintiles spent 3.1% shares on electricity while high- and higher-income quintile consumers had 2.2% and 0.9 % share on electricity. They enjoyed being in the highly subsidized category of power consumers. Interestingly, on the inferential statistics, the population in all quintile had spent the acceptable and tolerable share of income on electricity. Though lowest, high and higher quintile consumers spent up to 5.4% share of income on electricity consumption, it was within the tolerable range despite a partial hike, therefore, inference about affordability prevalence remains valid.

Moreover, affordability of consumption was assessed along the amount of electricity consumed for household sustenance. In Table 2.8, respondents in all income quintiles consumed more than basic need electricity 30kWh as indicated in the Multi-tier framework. Basing on these findings, it is inferred that electricity consumption was affordable to all consumers of all categories and income quintiles. Although Winkler *et al*. (2011) expounded that spending very little share on electricity could signify unaffordability and economic stress, yet, according to the findings, the amount of share could suffice to meet the basic need electricity. The theory of energy justice calls for affordability of power consumption as well. Therefore, it applies maximally to that effect. The amount of kWh consumed (40-57) was enough to run domestic appliances like TV/VIDEO, Radio and provide sufficient lighting for the household

(Coelho & Goldemberg, 2013). This is similar to Carranza and Meeks (2016) who found that a reasonable amount of kWh can operate several Compact Fluorescent Lamps for efficient lighting. Further, the current results corroborate the findings by Maliti and Mnenwa (2011) who reported that poor urban households on average use 51 kWh per month or 620.4 kWh per year regardless of whether they are in Dar es Salaam or in other regions.

Additionally, inferential statistic (95% C.I) in Table 2.6 indicates that respondents in the lowest income quintile consumed between 41.6 to 45.6 kWh. These results are supported by Bast and Krishinaswamy (2011) who found that in India consumption of electricity was 10-50 kWh on average of 30 kWh per month with an ensured power supply of 6-10 hours per day. In rural Brazil share spent on electricity consumption was 3.2%, South Africa 5.9% and Bangladesh was 5% (Winkler *et al*., 2011). In Togo, the share was 4.1%, Uganda 3.1%, Angola 4.2%, Rwanda 3.3 while Sierra Leone had 13.2% (Barnes *et al*.,2013). Although the amount of power consumed was not revealed, the share spent was affordable. Expenditure on electricity among the rural consumers is aggravated by the high demand for domestic electrical appliances, school children who spent some hours for private night studies. Likewise, the availability of small business at home premises and low cost of electricity per kWh makes power consumption viable; for example, one key informant explained that 1 kWh for lower tariff (D1/T4) consumers was TZS.122/= while the middle tariff (T1) consumers paid TZS 356/ kWh tax inclusive. Consumption affordability to residential customers indicates that electricity fuel poverty is on the verge of an end as agreed during the FGD:

> *"The price of electricity is cheaper; nobody can sleep in darkness for failure to buy power units; for example, TZS.1000 can buy 8 units of electricity" (FGD, Kasulu District, February 19, 2018)*

This statement simply indicates how far better electricity consumption is affordable whereby TZS.1000/= can earn up to 8 kWh which can sustain the household for several days in running a few available appliances.

2.6 The influence of Electricity Connection on the Domestic Electrical Appliance

Electricity connection at the household is assumed to render multiple effects, electrical appliances for well-being is among the assumed effects. To that end, the paper was enticed to assess how utility connection coupled with affordability brought the desired effects. The key purpose in this milieu was, first to assess the accrued appliances before and after electricity connection, second, to examine if there was a difference in appliances ownership with electricity connection scenario and finally to find out determinants for appliance ownership at the household (Table 2.9).

Table 2. 9: Electrical appliance ownership among residential consumers

Pre-electrification domestic electrical appliances			**Usability status %**		**Post electrification electrical appliances**		**Usability status %**	
Name of appliance	**Frequency**	**% of purchase**	**FR**	**OCC**	**Frequency**	**% of purchase**	**FR**	**OCC**
Radio	292	78.1	60	40	145	38.8	75	25
Solar lamp	158	42.2	90	10	142	37.8	30	70
Mobile Phone	318	85.0	95	5	275	68.7	100	0
TV/VIDEO	31	8.2	65	35	224	59.8	70	30
Iron metal	13	3.5	15	85	185	49.5	40	60
Electrical fan	12	3.2	20	80	113	30.2	15	85
Drycell lamp/Torch	183	48.9	56	44	85	14.0	45	55
Rechargeable lamp	10	2.7	30	70	94	25.1	26	74
Water heater	0	0	0	0	10	2.6	5	95
Electrical jug	0	0	0	0	44	11.7	20	80
Fridge	0	0	0	0	38	10.0	70	30
Blender	0	0	0	0	85	14.0	15	85
DVD/CD player	15	4	0	0	189	50.5	72	28
Home theatre	16	4.2	0	0	151	40.4	85	15
Electric cookstove	0	0	0	0	33	8.8	40	60
Rice cooker	0	0	0	0	31	8.2	30	70
Computer	3	0.8	100	0	10	2.6	100	0
Oven	1	0.3	100	100	5	1.3	55	45

**FR=Frequently, OCC=Occasionally*

The results summarized in Table 2.9 enlightens that post utility connection went together with domestic appliance increases. There was a notable improvement in TV/VIDEO ownership from 9% to 59.8% while 68.7% of the respondents bought new mobile phones. This doesn't mean that the ownership decreased, except some respondent continued to use the same mobile phones even after electricity connection. The type and quality of mobile phones owned after electricity connection had internet supporting feature (Smartphones). A shift to the smartphone was cultivated by ensured supply and efficient electricity because it was challenging to maintain smartphone in the absence of reliable electricity. Some appliances were occasionally used by the household in the fear of bursting power bills and consume above the required cap of 75 kWh. Appliances like electrical metal iron were under the care of the adult members of the household. This was because if it goes on uncontrolled use it could excavate high power consumption. Several members of household owned mobile phones as opposed to pre-electrification era because the source of power to run it was ensured. The results indicate that there was a difference of appliance ownership, but to understand if the difference was statistically supported, the appliances were summed, then a paired sample t-test conducted for apprehension (Table 2.10)

Table 2. 10: Paired sample T-Test for differences in domestic electrical appliances

Appliance owned on time scenarios	Mean	N	St. Deviation	Std. Error Mean
Electrical appliances before utility connection at the household	15.26	374	.968	.050
Electrical appliances after utility connection at the household	24.24	374	3.170	.164

Paired Differences

	Mean	Std. Deviation	Std. Error Mean	95% CI of Difference Lower	Upper	t	Df	Sig. (2-tailed)
PPE domestic appliance pairing	-8.981	3.088	.160	-9.295	-8.667	-56.246	373	.0001**

PPE=Pre and Post Electrification ***Significant at p <0 .05*

In the determination of the effect size of the paired samples t-test from Table 2.8. The Cohen's d Eta squared was used as suggested by Pallant (2007)

$$Eta\ squared = \frac{t^2}{t^2 + N - 1} = \frac{-56.246^2}{-56.246^2 + 374 - 1} = \frac{3163.6123}{3536.6123} = 0.8945$$

notes: t= t-statistics, N=sample size

Results from Table 2. 10 indicate that there was a statistically significant difference (increase) between domestic electrical appliances owned before electricity connection (M=15.26, SD 0.968), after electricity connection (M=24.24, SD 3.17, t (374)=-56.246, $p < 0.05$ (The Eta 0.8945 indicated the large effect size). Thus, about 89.5% of the variance in domestic electrical appliance was explained by electricity.

Generally, mobile phones and Radio were found common because they play a significant role in accesses to news and communication. Private generators, solar power and dry cells were sources of energy to operate appliances before utility connection which have had cost implications to consumers. Those who owned mobile phones incurred between TZS. 300-500 out of pocket payment (OP) at the phone charging centres. Nevertheless, the appliances purchased after electricity connection are based on capability segregation. For example, the government employees and businessmen and women had heavy electrical appliances than the counterpart. These included rice cooker (8.2%), electric cook stove, fridge and electric iron 49.5%. The results on increased electrical appliance ownership are supported by Debnatha, Moursheda and Chewa (2015) who reported on increased TV/VIDEO ownership in rural Bangladesh from 24% to 48/%, electrical fan 45.1% to 56.92%. In rural Kenya Lee *et al.* (2016) found 82 % TV increase; electric iron metal 34% while DVD/CD player increased to 38%. TV/VIDEO was the precious electrical appliance most households struggled to purchase. An assured supply of efficient energy from the utility company, the feeling of social well-being, access to information by watching TV news, education as indicated by Kanagawa and Nakata (2008), but more importantly entertaining programmes exacerbated the need for appliance. Nonetheless, these cannot be ruled to be the concrete causes for appliance purchase because there are myriad factors for this occurrence; and any inference would warrant statistical backing (section 2.6.1 in Table 2.11).

2.6.1 Determinants of domestic electrical appliance purchase

In spite of electrical appliance increase after electricity connection at the household, this cannot be inferred as the end or the only cause. To that end, the multiple regression model was used to ascertain statistically the factors for appliance increase. The results are presented in Table 2.11

Table 2. 11: Multiple regression results for appliance ownership

Regressed variables	*B*	St. Error	*β*	Sig.	Tolerance	VIF
(Constant)	**35.657**	**1.605**		**.0001**		
X_1. Year of power connection	.306	.157	.085	.0520	.865	1.156
X_2. Knowledge on the use	1.894	.291	.293	.0001	.808	1.238
X_3. Power connection	.483	.099	.215	.0001	.844	1.185
X_4. Loan ability	.005	.115	.002	.9620	.687	1.455
X_5. Wattage capacity	.089	.104	.039	.3930	.775	1.291
X_6. Appliance being an asset	-.165	.098	.079	.0920	.744	1.344
X_7. Social wellbeing	.550	.135	.201	.0001	.666	1.502
X_8. Gender	.844	.346	.105	.0150	.882	1.134
X_9. Age of household head	-.055	.017	.144	.0010	.854	1.172
X_{10}.Level of education	.503	.149	.148	.0010	.850	1.176
X_{11}.Affordability of cons	.174	.064	.137	.0060	.657	1.521
X_{12}.Marital status	-.502	.355	.062	.1570	.862	1.161
X_{13}.Economic status	.243	.000	.170	.0010	.661	1.513

Durbin -Watson 1.387, R^2 = 0.410, $R^2_{Adjusted}$ = 0.389, ANOVA model significant $p < 0.01$

On the assumptions of the model (Table 2.11) multicollinearity (< 0.6) and collinearity diagnostics indicated tolerance value of variables were > 0.10, while VIF for variables were < 10. The goodness fit of the model indicated acceptability as ANOVA (*$p < 0.01$)* and Durbin-Watson value >1 but < 2. The R^2 was 0.410, meaning that the model explained 41% of the variance.

The results in Table 2.11 with considerations of *β* values indicate that predictors have had a contribution to domestic electrical appliances ownership except some (x_4, x_5, x_6 and x_{12}). However, x_5 has had practical significant because the consumption capacity of the appliances counts maximally for the uptake. Electrical appliances that can accentuate electric bills at the household are preferred less. Moreover, knowledge on how to use appliance and attainment of social well-being were significant at (*$p < 0.01$)*. In rural areas, people are interested in appliances which are simple to use and or easily learn to use because dangers of electricity are high; for example, 58% of respondents fear cooking on electrical stove due to dangers of shocks. This is supported by Winther (2012) who illuminated that some rural people in Zanzibar expressed a deep fear of electric stoves due to shocks that may be caused by misuse. The results contradict Ganesan and Vishnu (2014) who reported religion as affiliated with appliances. Nevertheless, well-being predictor was significant ($p <$ 0.01). This was due to that, happiness and the state of feeling successful through electricity connection and its associated appliances took chance. People's subjective wellbeing is mostly fuelled by materials success, whether domestic and or non-domestic which are arguably enticed by the capability approach as explicated by Sen (2009).

Efficient power supply from the utility ($p < 0.01$) had also induced appliance increase. Tiresome expenditures on charging mobile phones, running private generators made it unreliable for purchasing hard and sophisticated appliances. Energy efficiency from the utility increased the degree of freedom on appliance purchase. Some household started to buy electrical appliances like TV and home theatre even before completing the installation of electricity in the household. The reason for this is that TV was a precious and mostly aspired appliance (Lee *et al*., 2016). Appliances like TV, Radio and Fridges are directly associated with happiness and life comfortability. Entertainment and educating programme on TV do set up a ladder for well-being at the household level. Further, household cohesion through time together on TV made it with imperative demand. Affordability of electricity consumption ($p < 0.01$) and economic status of the household ($p < 0.01$) have had unique contribution on dependent variable. The affordable power consumption the more it exerts effects on appliance purchase. The amount of appliance purchased is predicted by “just price” which is also sensitive to an annual or monthly income of the household. Tanzania like many other countries is increasingly becoming characterized by counter urbanization. Some economically endowed persons coupled with government workers are taking their life in the countryside; hence there is a growing mix of people with different economic capabilities.

Higher consumption costs can lead to disconnection and refrain from using some appliances by the householders. The 75kWh lifeline tariff for lower power users in Tanzania makes it easier for them to gauge appliances which fit their ability to purchase power units. More importantly, the gender of the household head being significant ($p < 0.05$) elucidate that male headed households can be flooded with male-controlled appliances and vice versa. This argument is supported by Winther (2012) that electric iron metal, fridges, home theatres, rice cooker, water heaters and electric cookstoves and TVs are gender and education sensitive. Male are dominant heads of households who mostly influence the type and nature of the appliance to purchase. Therefore, domestic appliances are important as some can still be used in running some small enterprises like kiosk at home premises.

2.7 Conclusions and Recommendations

The study expounds that affordability of electricity connection to rural consumers was hardly enhanced. The share of household income spent on electricity connection indicates catastrophic expenditure which makes a household dwindle in some other basic needs like food, communication costs, thus, forced into selling off assets. For that, in turn, it creates a vicious cycle of poverty. Upfront cost coupled with material and technical costs remains a challenge towards electricity connection in rural areas where sporadic income sound to be one of the common features. The lower price of electricity per kWh makes it affordable on consumption and more relevant to MTF. This is important in reducing electricity fuel poverty and relieving people from unsafe and health-hazardous sources of domestic energy. In fact, electricity connection costs should get better first before it gets best on consumption. Electricity connection entangled with affordability of consumption has a functional effect on domestic electrical appliance purchase. The appliances are important in enduring well-being of the consumers. The well-being is accentuated through household cohesion during the shared use of the appliance like TV and mobile phones. The paper argues to the energy utility regulator that upfront charges for electricity connection be reconsidered to ensure affordability. On top of that, due to the sporadic income of consumers, instalment mode of payment has to be devised because the current lump-sum payment exerts a huge burden and sound unbearable to the most. In sum, electricity is increasingly becoming a basic need for socio-economic development and well-being. Making power connection affordable is making appliances and well-being viable.

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CHAPTER THREE

3.0 Rural Electric System Reliability for Households Lighting Fuels in Kasulu and Uyui Districts, Tanzania

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3.1 Abstract

An increasing supply of rural electricity has always received negligible deliberation on reliability which is an indicator of electricity quality. This paper was set to examine the reliability of rural electric system based on consumers; determine the factors influencing system reliability, and finally examine the effects of outages on households' expenditure on backup fuels. Reliability was assessed through a stepwise approach. A five-point scale, a general system reliability index and trend analysis for unplanned outages were used to measure reliability. The results showed that electricity was reliable on all measures. Voltage fluctuation, time of the day outages occurred did not affect consumers. Moreover, electricity system was available most of the time consumers wanted to use it. The index also confirmed the prevalence of system reliability while on trend analysis consumers spent between 6 to 15 days per year without electricity due to unplanned outages. The paper indicates that weather, fire, lightning and vegetation determined system reliability. Further, it was found that cost on household fuels did not hike due to outages. The amount spent on backup cost was minimal due to reliability. The state energy utility is recommended to inspect electric system on regular basis to keep unplanned outages low while advocating the use of concrete and metal poles in areas prone to wind, fire and termites.

Keywords: System reliability, domestic expenditure, lighting fuels, rural, electric system

3.2 Introduction

Reliability of electricity has emerged as a global challenge in modern development; it has attracted attention of development planners, utility companies and consumers (Kojima & Trimble, 2016; Nikzad & Mozafari, 2014). Both poorly and highly electrified countries suffer from reliability problems (Gertler *et al*., 2017), though at different levels. To reap benefits from electricity, its reliability must be assured. Indeed, a reliable electric system has to be available mostly to satisfy consumers (Marvin & Hoyland, 2004). Additionally, Bhatia, and Angelou (2015) argue that reliable power has to be adequate in quantity, available when needed, of good quality, convenient, affordable, of health and safety standards.

Access to reliable electricity is more than being connected (Chakravorty *et al*., 2012), because, in the end, consumers do not want just electricity but an affordable and reliable one (URT, 2015). Different reliability thresholds exist. In Europe, a system interruption not greater than three (3) minutes is considered reliable (Campbell, 2012); while in the USA, it should not exceed five (5) minutes. ESKOM- South Africa's considers interruption less than one (1) minute as reliable for High Voltage (HV) networks and less than five (5) minutes for Medium Voltage (MV) (Chatterton, 2014). Moreover, Australian Energy Market Commission (2014) report thresholds for Sustained Interruption (SI) as having two or more minutes (2+) while Momentary Interruptions (MI) has less than two (2) minutes.

Kaufmann (2013) and Gertler *et al.* (2017) inferred electric system reliability as measured by System Average Interruption Frequency Index (SAIFI) based on an average number of times per year the supply to a customer is interrupted while System Average Interruption Duration Index (SAIDI) represents the average amount of time (seconds) per year that power supply to a customer is interrupted (Gertler *et al*., 2017). The metrics are data sensitive as described by Chatterton (2014) that they depend on precise data from Supervisory Control and Data Acquisition (SCADA) or the annual validation and auditing of the paper operation log. The different electric systems have varying SAIDI and SAIFI values, the lowest values indicate high reliability (Kaufmann, 2013). This was confirmed by Taneja (2016) through values of the electric system in Nairobi having SAIFI of 23 and SAIDI 216.3 hours. For these values, it can be viewed as standard reliability. However, SAIDI and SAIFI measures are criticised for taking into account every outages incidence (Shivakumar *et al*., 2014).

In furtherance, electricity system in countries like the USA had SAIDI eight (8) hours (480 minutes) in 2017 indicating a high degree of reliability (U.S Energy Information Adminstration, 2018). In Pakistan SAIFI was 232 and SAIDI 8, 149 minutes per year (Ali, 2016); in urban areas, the outage was 6-8 hours while rural areas had 10-12, this means, reliability in rural areas remains a challenge. Reliability in Africa lags; for example, in 2014 Nigeria had 32.8 outage hours per month, while Burundi had 16.6 hours, the Central Africa Republic 29 and Egypt 16.3 hours (Energy and Environmental Service , 2015). Further, Tanzania had a load shedding of up to 20.3 hours in 2012-2016 (Msyani, 2016). Additionally, for a month (June 2018) Tanzania had an unplanned outage of 1,044 hours, outage frequencies 1,640 (Energy and Water Regulatory Authority , 2018). Indeed, “reliability” is a key question in electricity consumption for domestic and productivity use (Rud, 2012). Reliable power can improve public safety (Dinkelman, 2011), education and health services (Savacool, 2014; Ramachandran, Shah and Moss, 2018), increases opportunities for jobs (Küfeoğlu, 2015), and reduce dependence on unclean energy for backup lighting sources.

Indeed, the efforts for rural electrification in Africa have to go *inter alia* with system reliability. For that, Panos *et al*. (2016) reported that despite poor access to electricity (12-18%) in most rural and urban areas of Sub-Saharan Africa, the question of reliability remains a serious concern. Moreover, Keneth, Miguel and Wolfram (2017) also reported survey results for 21 Sub-Saharan countries where capital cities had a power connection of more than 75% (except Lilongwe). The authors further explain that less than 20% of the connected especially in Lagos reported electric system working most of the time. This unreliability might increase expenditure on household fuels and enterprises operations (Abotsi, 2016). On top of that the key question could be, what is the status of reliability in rural areas if urban areas had less than 20% of consumers who report having power system working most time, and what is the cost of unreliable power for domestic lighting fuels.

According to Scott *et al.* (2014) in developing countries in Africa, on average electricity was cut 6.3 times with 4.7 hours while South Asia outage had 25 times with 5.3 hours of the typical outage in a month (Min *et al*., 2017). The outages could exacerbate expenditure on backup fuels for school kids at home and domestic activities. Studies (Allcott *et al*., 2016; Fisher-Vanden *et al*., 2015; Abeberese, 2013) have been conducted to assess the effects of unreliable power on business (manufacturing and processing firms) than on households. On business, Allcott *et al*. (2016) concluded that unreliable power affects enterprise's operations. Additionally, Shivakumar *et al.* (2014) claimed that unreliable power had led to a self-backup generation of which 43.6% of firms own a generator in Sub-Saharan Africa (SSA). This is led by Senegal (90.7%) and Nigeria (85.7%) while the world's figure stood at 31.6%.

Tanzania, due to unreliable electricity lost 10% of GDP in 2010 with 7,341 people losing jobs in six regions only (Confederation of Tanzania Industries, 2011). In fact, due to complex economic and social activities, reliability of electricity is seemingly a major concern in urban as opposed to rural areas (Mwakapugi, Samji , & Smith, 2010). However, scrutinizing reliability in rural areas carries an important meaning because domestic consumption of energy accounts for 75% while 14% is for industry (URT, 2015). Unreliable electricity does not only affect enterprises but also education for night studies, food processing and storage (Herman, 2014). It can lead to energy switch, thus, extra expenses become obvious to consumers in rural areas where Lusambo (2016a) referred to as having high-income inequality. Energy switch to sources like candles, kerosene and biomass has environmental problems (Lusambo, 2016b). It increases Indoor Air Pollution (IAP) which is a serious health hazardous (Chen & Modrek, 2018). Likewise, it has been reported that in Tanzania , about 20,353 people died due to houseshold air pollution in 2012 (Stiles and Murove, 2015).

Moreover, in Tanzania, measures to provide reliable power became central in 2000s after establishing legal and institutional frameworks such as Rural Energy Agency (REA). In collaboration with Tanzania National Electric Company (TANESCO) REA has facilitated increased rural access to electricity from 2% in 2003 to 49% in 2017 (Rural Energy Agency , 2017). This was due to the extension of national grid and establishment of mini-grid. For instance, Odarno *et al.* (2018) reported that about 109 mini-grids located in 21 regions supplied power to at least 183,705 customers. The mini-grids were established to ensure that rural people are relieved from time consuming and health dangerous sources of energy. It also aimed at ensuring reliability of electricity supply.

Reliability threshold in Tanzania requires annual SAIFI to be less than 3 interruptions per customer per year, SAIDI less than 650 minutes per customer per year and Customer Interruption Duration index (CAIDI) of less than 4 minutes (0.01hours) per customer per interruption event per year (Energy and Water Regulatory Authority, 2018). Despite the reliability threshold and the hitherto efforts of electricity supply; rural electric system reliability is shakily assessed and reported due to its fragile economies (Mensa, 2016; Oseni and Pollit, 2015; Abeberese *et al.* ,2017; Moyo, 2012; and Arlet, 2017). Thus, this paper assessed reliability of the rural electric system, determined the factors for reliability of electric system and finally examined the effects of outages incidences on expenditure for backup fuels at the household.

3.3 Theoretical Framework

3.3.1 The Multi-Tier Framework (MTF) for electric system reliability

The MTF was developed in 2013 by the World Bank in the role of Sustainable Energy for All (SE4ALL). It redefines energy access to fill the gaps in the Global Tracking Framework (GTF) binary access measurement metrics such as whether a household has or no access to electricity and cook or non-solid fuel. MTF provides power quality descriptions for different tiers of users (Bhatia, and Angelou, 2015). MTF (Table 3.1) offers relief in measuring various aspects of power quality (reliability, safety, affordability) because access to energy is vital to economic, social and human development. The MTF is one of the most recently used frameworks in energy studies; for example, Kojima and Trimble (2016) used the framework in assessing power quality.

Table 3. 1 : Multi-Tier Framework for electric system reliability

Attribute of access	Tier 0	Tier1	Tier2	Tier3	Tier4	Tier5
Capacity		Capacity from (3W to above 2kWh) and ability to power appliance (off-grid)				
Duration of supply	NA	> 4 hrs	> 4 hrs	> 8 hrs	> 16 hrs	> 22 hrs
Duration-evening		**> 2 hrs**	**> 2 hrs**	**> 4 hrs**	**> 4 hrs**	**> 5 hrs**
Reliability					**Number of the duration of outages**	
Number of Disruption					Max 14/Week	Max 3/ week, duration of < 2 hours Agg*.
Annual SAIFI* and SAIDI*					< 730	< 156 < 6 240 mins
Quality	**NA**				**Voltage problems do not affect the use of desired appliances**	
Affordability				Basic service less than five 5% of a household income for 30kWh		
Legality	**NA**				**Service provided legally**	
Health and safety					**Absence of accidents**	

Source: Bhatia and Angelo (2015)

The MTF in this study guided the assessment of electric system reliability based on important metrics and indicators encompassing: duration of supply, which has to be between 8 and 22 hours for consumers in Tier 3, 4 and 5. The electric system has to provide at least 4- 5 hours of evening supply while maximum disruptions for unplanned incidences be 14 and 3 per week for Tier 4 and 5 coupled with annual SAIFI less than 730 and 156 respectively.

3.4 Methodology

The study was conducted in Kasulu and Uyui districts which are electrified through Rural Energy Agency (REA) and Tanzania National Electric Supply Company (TANESCO). The areas are the first beneficiaries of rural energy through mini-grids and grid extension. A cross-sectional survey was used as it fits better in multiple variable studies and in studying prevailing characteristics in a population (Hemed, 2015). The unit of analysis was households connected to electricity for at least two years. The sample size was 374 households arrived at by using Yamane’s (1967) sample size formula. The sample size was drawn from eight villages purposively selected. For a fair representation, a proportionate stratified sampling technique was used to obtain sample representative from each district and village. Finally, a random number table was used to select respondents (heads of households) from an updated list of electricity customers.

The questionnaire was used to collect quantitative data on reliability, the income of the household and expenditure on backup fuels. Three (3) Key Informant Interview

(KII) were conducted to gather data on reliability and its determinants. The key informants included Transmission and Distribution Engineers (TaDE), Regional and District Managers for TANESCO. Four (4) gender-sensitive focus group discussions (FGD) with eight (8) members as suggested by Van Eeuwijk & Angehrn (2017) were conducted to collect data on the perception of respondents on system reliability. Content validity and reliability of data collection tools were ensured through pre-testing and pilot testing. Some questions were rephrased and deleted due to ambiguity and redundancy. Nonetheless, internal consistency reliability was ensured through Cronbach's Alpha where, 11 items were tested and scored 0.68 to 0.83, which are acceptable values (Field, 2009).

General system reliability was assessed through descriptive and inferential (ANOVA) statistics where mean; frequency and percentages were computed. Moreover, a five-point scale and trend analysis for annual power outages in two feeders of Kasulu and Uyui was conducted. Furthermore, the General Electric System Index (GESRI) was developed from the summed score of 11 items scale measures. GESRI mean score was 30, minimum 29 and maximum score was (51). Therefore, the index score was 1. Low reliability [score 0-29], 2. Moderate reliability [score of 30], 3: High reliability [score 31-51]. Although SAIDI and SAIFI are common indices for electric system reliability, they are criticized for taking into account all incidences of outages regardless time of the day and do not reflect perceptions of customers (Herman, Gaunt, & Tait, 2014). Thus, typical SAIDI and SAIFI were not used rather System Average Interruption Frequency (SAIF) and System Average Interruption Duration were used (SAID).

Furthermore, One-Way ANOVA and Tukey Honesty Significant Difference (HSD) post-hoc I-J test of means difference was used to analyse the variability of means scores between power reliability thresholds. Ordered Logistic Regression Model (OLRM) was used to analyse predictors of power system reliability based on direct control by the utility supplier. The OLRM formula as suggested by Hosmer and Lemeshow (2000) was given in equation 3.1

$$log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \cdots \beta_m X_m + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

$log\ \left(\frac{p}{1-p}\right)$= the odds (logit) of being in lower against higher reliability of electricity

$\beta_1 \ldots \beta_m$ are the coefficients of independent variables influencing reliability of electricity, $X_1 \ldots\ldots X_m,$ are the vector of predictor variables,

β_0 =is the intercepts which vary from one level of power reliability to another and Ɛ is an error term.

Moreover, electric outages at the household levels among the respondents were determined using the logistic regression model. The fact is, power system might be available, yet, some consumers at the household might experience blackout resulting from domestic incidences. The logistic regression model the probability that the binary response is a function of a set of predictor variables and regression coefficients as given in equation 3.2

$$logit(Y) = \log\left(\frac{p}{1-p}\right) = \beta_o + \beta_1 \mathrm{X}_1 + \beta_2 \mathrm{X}_2 + \cdots + \beta_m \mathrm{X}_m + \cdots \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

$\log\left(\frac{p}{1-p}\right)$=logarithm of the odds where p is the probability

β_o Intercept

$\beta_1 \ldots \beta_m$ = regression coefficients of independent variables

$\mathrm{X}_1 \ldots \mathrm{X}_m$= predictor variable

$\varepsilon =$ an error term

Furthermore, descriptive statistic (median) was used to assess the effect of outages on household expenditure on lighting fuels while paired samples T-test was used to determine if statistical differences existed between household expenditure on lighting before and after electricity connection. Nonetheless, the three levels of reliability were collapsed into a dummy variable (1=reliable and 0=unreliable) by recoding the levels into different variables in SPSS. This was important in order to fit assumptions of point -biserial correlation coefficient ($\boldsymbol{r_{pb}}$) in investigating the correlation between expenditure on backup fuels and reliability. The $\boldsymbol{r_{pb}}$ was preferred because it is a special case of Pearson's ***r*** which can estimate categorical variables (Sheskin, 2011), it provides the best results than Kendall's Tau non-parametric. The $\boldsymbol{r_{pb}}$ coefficient is given in equation (3.3)

$$r_{pb} = \frac{M_1 - M_0}{S_n}\sqrt{pq} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

M_1= mean (for the entire test) of the group that received reliable electricity

M_0 =mean (for the entire test) of the group that received unreliable electricity

S_n=Standard deviation for the entire test, $p =$ Proportion of cases on reliable electricity, $q =$ Proportion of cases on unreliable electricity

3.5 Results and Discussion

3.5.1 Respondents' characteristics

The respondents' characteristics were based on prime aspects which are interlinked with expenditure on backup fuels and can influence domestic outages (Table 3.2). These included age of respondents, size of the household, size of the main house in term of rooms and number of school children were recorded.

Table 3.2 : Respondents' characteristics

Variables	Mode
Age of household head	55
Household size	7
Electrified houses in the compound	2
The main house in terms of rooms	4
Members who contribute income	3
Secondary school children at the household	2
Primary school children at the household	1

The results in Table 3.2 indicates that the age of the respondents was 55. This means that respondents were still capable to work and meet household needs including expenditure on lighting fuels. The household size in the study areas was 7. This was also indicated by URT (2012) that Uyui and Kasulu districts have similar household sizes. Given that, the household size can affect expenditure on backup fuels and influence domestic outages. Further, respondents had two living houses in the compound with the main house having four rooms. This was important due to large household size characterised by polygamy and extended families which is a common phenomenon in rural areas of Tanzania; Kasulu and Uyui in particular. The number of electrified houses in the compound can also be linked to domestic outages and backup cost for lighting fuels especially in large outages scenarios which could persist in most rural areas as Ali (2016) substantiated. The household's members with income contribution ability were 3 while the schooling children were 3 as well. The income contributors can share the burden of cost on lighting fuels, while the schooling kids can be assumed to exacerbate backup fuel consumption due to private studies at night.

3.5.2 Determinants of electricity system reliability

The study assessed the general reliability of the electric system (GRES) using a bipolar scale, trend analysis and indexed measures. A five-point scale was used to grasp information based on voltage stability, duration and frequency of outages and common time of the day power outage occurs. The purpose was to obtain aggregated inferences on the reliability of electricity. Therefore, consumers were asked to rate reliability of electricity for the past three months an approach which is commonly used especially if instrumental measures of reliability are not used (Electricity Supply Monitoring Initiative (ESMI), 2017). Analysis and discussion of the results presented in Table 3.3 was limited to perception's percentages, because any extension to mean perception of each statement could results into shaky results because the numbers on the scales are considered to be nominal, thus they have no numerical values since they can be
substituted with letters.

Table 3. 3 : Consumers' perception on reliability of electricity

Perception statement	1=SA	2=Ag	3=Un	4=DA	5=SD	Total frequency	Percentage
Generally, the reliability of the electric system in the past three months satisfied me	156 41.7	112 29.9	4 1.1	74 19.8	28 7.5	374	100 100
In the past three months outage frequencies were intolerable	57 15.2	76 20.3	15 4.0	109 29.1	127 33.9	374	100 100
The outages duration was not tolerable in the past three months	85 22.7	64 17.1	17 4.5	125 33.4	83 22.2	374	100 100
Voltage fluctuation does not affect appliance use	125 33.4	119 31.8	21 5.6	49 13.1	60 16.0	374	100 100
In the case of an unplanned outage, there is the fast restoration	45 12.0	91 24.3	150 40.1	56 14.9	32 8.5	374	100 100
There is prior information for planned major outages	74 19.8	119 31.8	23 6.1	87 23.3	71 18.9	374	100 100
Electricity is available most of the time is needed	82 21.9	146 39.0	30 8.0	73 19.5	43 11.5	374	100 100

Key: SA= Strongly Agree, Ag =Agree, Un = Undecided, DA = Disagree, SA = Strongly Disagree

The results in Table 3.3 show that the respondents have the general feelings of electricity being reliable under the period of study because the positive perception on the general view was summed to 71.6%. This perception is contributed to by many aspects, for example 63% of consumers disagree on frequency of electricity outage being intolerable with reference to the past three months (Table 3.3). Likewise, it was found that domestic consumers had disagreed that duration of outage was not tolerable (55.6%). Moreover, reliability was favoured due to that consumers did not fail to use their domestic appliances due to voltage instability. In fact, these results, although indicates slight confidence of electricity reliability, yet, it can be deduced that outages incidences were severe. This is indicated by poor response on electricity restoration after unplanned outages. However, in response to this claim, Herman *et al*. (2014) explained that despite outages and voltage instability incidences consumers could still infer electricity as being reliable only if the incidences do not affect them. Thus, if electricity is available most of the time consumers needed, then a positive perception on reliability is always guaranteed. Likewise, the decisions to perceive electricity as being reliable can be linked to the day (work days or weekend) and time of the day outage incidences occur; for example, outage incidences during the midnight could have little effects than during the day. Therefore, a further scrutiny was extended to obtain key information on time of the day outage incidences occurs. Consumers were asked to state the common time of electricity interruptions, the results are presented in Table 3.4.

Table 3. 4 : Time of the day power outage commonly occurs

Time of a day power outage mostly occurs	Stratum				Aggregated	
	Uyui District		Kasulu District		Kasulu and Uyui	
	Freq	**Per**	**Freq**	**Per**	**Freq**	**Per**
Morning [06-11 am]	84	52.5	97	45.3	181	48.4
Afternoon [12-03pm]	38	23.8	58	27.1	96	25.7
Evening [04-06 pm]	7	4.4	23	10.7	30	8.0
Night [07pm-05am]	31	19.4	36	16.8	67	17.9
Total	**160**	**100.0**	**214**	**100.0**	**374**	**100.0**

Notes: Freq=Frequency, Per=Percentage

The results in Table 3.4 show that consumers in Uyui and Kasulu had 76 .3% and 73.4 % reporting outages during morning and afternoon. The high percentages were exacerbated by planned outages due to power rationing resulting from maintenance and extension of services. On aggregate outages were common in the morning and afternoon (74.1%) while evening and night times were reported by 25.9%. On a technical basis, planned outage for utility is commonly done in the morning or on weekends for the assumption that electricity use and demand is at minimal, thus the outage has less effect on domestic consumptions.

A part from the results in Table 3.4, consumers were also asked to state the time they wanted electricity outages not to occur. The result was that 90% of respondents acknowledged evening and night as the time outage should not occur. This was based on the view that electricity had significant role in enabling night studies for schooling children and the news on TV. Respondents were not bothered by morning and afternoon outages because in rural areas householders have to leave home for farm works. For that, electricity use was kept at minimal demands. However, those who owned refrigerators had to bear the cost of food storages and cost to replace it as argued by Herman *et al*. (2014) that electricity outages could spur cost to replace the rotten food. In fact, consumers reported to have more than 5 hours for evening supply. This is relevant to MTF benchmarking which state that 4-5 hours of evening supply of electricity is enough for household sustenance. Thus, despite outages, consumers were not adversely affected; hence, electricity was reported to be reliable

3.5.2.1 Trend analysis for electric system reliability

Moreover, using secondary data, a confirmatory trend analysis (Figure 3.1 and 3.2) was carried out on unplanned System Average Interruption Duration (SAID) and System Average Interruption Frequency (SAIF). Using auto recorded secondary data from TANESCO district office, the results showed that the system was reliable based on the duration and frequency of outages (Figure 3.1 and 3.2). Likewise, the evening supply of electricity was 5 hours a satisfactory duration for carrying all domestic activities in the evening.

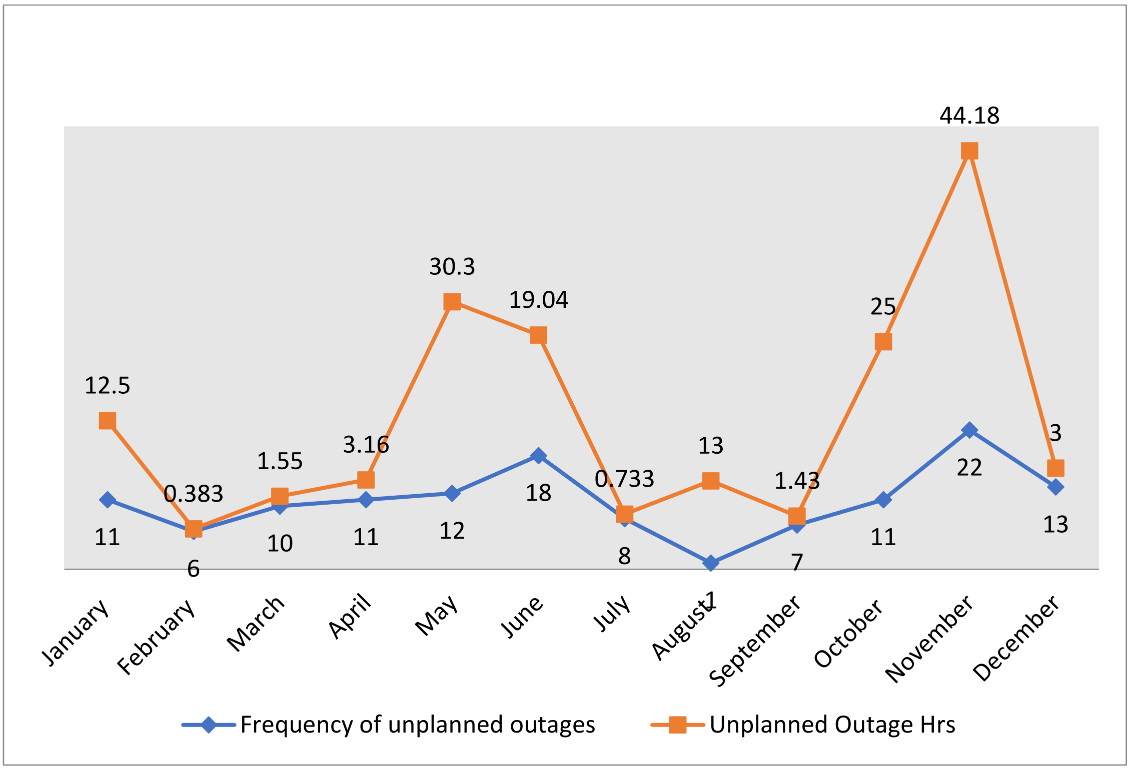

Figure 3. 1 : Unplanned SAIF and SAID in Kasulu District, 2018

Source: Kasulu TANESCO (2018)

The result in Figure 3.1 shows that the trend for unplanned outage incidences was all-weather. The analysis confirms that unplanned System Average Interruption Duration (SAID) was 154.27 hours (9 256.2 minutes) while System Average Interruption Frequency (SAIF) had 130 incidences. The SAID value means that consumers had outages equivalent to 6 days for the year 2 018. The minutes of the outage are above standards in MTF for consumers in Tier-5 which state outage minutes of 6 240 for reliability. The marginal difference in minutes of outages was tolerable and infers that the system was reliable to consumers. According to MTF, a reliable system should have SAIF incidences less than 730 (Tier 4) and 156 (Tier 5). The standard relevance of the values shown in Figure 3.1 and the MTF conveys a favourable inference on the reliability of the system in Kasulu district.

Regarding Uyui district, the finding (Figure 3.2) shows that unplanned SAID was 361 hours (21 660 minutes equivalent to 15 days while the SAIF incidences were 260 per year. Then, consumers in Uyui District had more dark days than those in Kasulu for the year 2018. The disparity could be due to difficulties in managing complex national grid faults as it can be triggered by outer region factors to cause outages. The better reliability in Kasulu was due to dependence on modern

Independent Power Plants (IPPs) operating on auto-shift and self-servicing mode. Also, the small coverage areas made it simple to manage the distribution and transmission systems. Speaking on the results on hours of evening supply, it is similar to that of Electricity Supply Monitoring Initiative (ESMI), (2017) where Kinondoni and Ilala districts though are in a big city where electricity is assured had five (5) hours of evening supply. This is to indicate the tolerable range of reliability among electricity customers in rural areas.

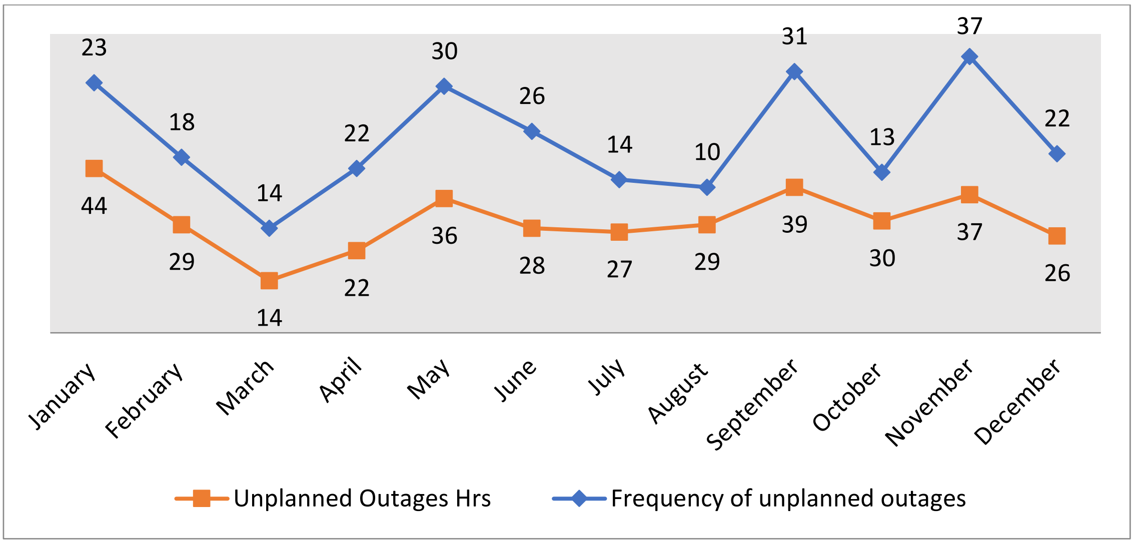

Figure 3.2 : Unplanned SAIF and SAID in Uyui District, 2018

Source: Uyui TANESCO (2018)

The results in Figure 3.1 and 3.2, when reflected against the Multi-Tire Framework (MTF) indicates that some components of reliability were met while the rest were not. However, that cannot infer electricity as unreliable given that the consumers are less affected. For instance, MTF indicates that the maximum disruption is 14/week; the system disruptions is less than 14 per week as indicated in the trend analyses. Further, when asked if electricity system ever caused any accidents related to electric shocks, the results showed that only 10% of the respondents had an accident (meter defectiveness and shocks on the domestic appliance) resulting from system disruptions. This indicates the minimal presence of accidents cannot qualify the system as unreliable. Yet, for domestic consumption, there were no voltage fluctuations, because when asked, 95% of the respondents reported all domestic appliances working properly. All these indicate that despite some minor deviation of the results from the MTF standards the system is viewed as reliable.

3.5.2.2 General Electric System Reliability Index (GESRI)

Utility supplier can hardly reveal the general index of system reliability rather those based on specifiers like SAIFI, CAIDI and SAIDI which do not capture the perception of consumers. Therefore, further assessment of electricity reliability was conducted using GESRI developed from summed scores of 11 Likert scale items. GESRI was based on; Score of 1-29=Low reliability, 30=Moderate reliability, 31=51 High reliability (Table 3.5).

Table 3. 5 : General index of electric system reliability

Reliability Levels			Stratum statistics				Aggregated statistics	
			Uyui District		Kasulu District		Kasulu and Uyui	
	N	Mean	Freq	Per cent	Freq	Per cent	Freq	Per cent
Low reliability	176	26.642	89	55.6	87	40.7	176	47.1
Moderate reliability	16	30.000	8	5.0	8	3.7	16	4.3
High reliability	182	37.022	63	39.4	119	55.6	182	48.7
Total	374		160	100.0	214	100.0	374	100.0

**Freq=Frequency, Standard Deviation for Low Reliability =2.688, Moderate Reliability=0.000, High Reliability =5.509*

The result shows Kasulu district having a 55.6% score on high reliability while Uyui District had 39.4%. The high reliability in Kasulu was due to dependence of new IPPs which were rarely hit by external forces to cause outages. The low reliability (but acceptable to consumers) in Uyui was viewed as caused by lack of self-dependence on generation. The complex network of the national grid had ups and downs, thus, some faults in one region or district could necessitate outage in other regions connected to the same feeders or Transmissions lines. On aggregate, electric system had high reliability by 48.7% (mean score=37.022) compared to low 47.1% (mean score=26.642) and moderate reliability 4.3% (mean score=30.00). Consumers were not affected by morning and midnight outages. This had led to higher ratings in favour of reliability. Although the means score between reliability thresholds (Table 3.5) could be seen as different, yet it has no honestly statistical proof for precise judgment. To depict any statistical differences between reliability thresholds, a One - Way ANOVA with a post-hoc test was conducted (Table 3.6)

Table 3. 6 : One-Way ANOVA for reliability thresholds

One-Way ANOVA	Sum of squares	Df	Mean Square	F	P-value
Between groups	86.828	2	43.414	3.981	.0001
Within Groups	261.709	371	0.705		
Total	348.537	373			

Tukey HSD Post Hoc I-J Test of Mean Difference

(I) Reliability Index	Mean	SD	(J) Reliability Index	Mean Difference (I-J)	Std. Error
Low Reliability	26.642	2.688	Moderate reliability	-3.35795*	1.11447**
			High reliability	-10.37993*	.45121**
Moderate Reliability	30	0.000	Low reliability	3.35795*	1.11447**
			High reliability	-7.02198*	1.11294**
High Reliability	37.022	5.509	Low reliability	10.37993*	.45121**
			Moderate reliability	7.02198*	1.11294**

******The mean difference is significant at the 0.05 level. For One -Way ANOVA, the Leven's test of homogeneity of variance was significant at $p < 0.05$

The results for One -Way ANOVA (Table 3.6) show that there was a statistically significant difference at $p < 0.05$ between groups, [F (2, 371) =3.981, $p < 0.05$]. Nonetheless, the honest difference between reliability threshold was not shown. Therefore, Tukey HSD post-hoc I-J Test of means difference was run to determine which index threshold differs and at what statistical level. The results show that low reliability (M=26.642, SD =2.688), $p < 0.05$, was significantly different from moderate reliability (M=30.0, SD=0.000) at $p < 0.05$ and high reliability (M=37.022, SD=5.509), $p < 0.05$. These results indicate that the reliability index has different means each, therefore it confirms and waxes the findings in Table 3.5 that electricity was reliable, and that the percentage score for high-reliability index 48.7% was different from the low score of 47.1% given the means consideration.

3.4 Determinants of Electric System Reliability

Reliability of the electric system is determined by multiple factors; it was important to depict them. An ordered logistic regression analysis was used. The dependant variables were levels of system reliability index (1=Low reliability, 2=Moderate Reliability and 3=High reliability). The results of analysis are presented in Table 3.7

Table 3. 7 : Ordered logistics regression for determinants of reliability

Predictors	Estimate	Std. Error	Wald X^2	Df	p-value
Reliability = 1]	-0.847	0.251	11.426	1	0.001
Reliability = 2]	-0.615	0.248	6.130	1	0.013
Pole decay	-0.909	0.272	11.184	1	0.001
Weather	0.989	0.274	15.112	1	0.000
Fire	-1.970	0.355	30.750	1	0.000
Vegetation contact	-0.775	0.337	5.276	1	0.022
Transmission breakdown	0.610	0.407	2.245	1	0.134
Lightning	4.048	1.370	8.728	1	0.003
Accidents on pole	-0.904	1.272	0.505	1	0.477

Model fit summary: Null model, 2LL = 294.131; Final model, 2LL=180.297(Chi-square, 113.204, $p < 0.01$). Model goodness-of-fit: Pearson's Chi-square= 244.648, Deviance 148.246 ($p > 0.05$); Pseudo R-square, *Cox and Snell= 0.541, Nagelkerke=0.621, McFadden= 0.518*

The full model (2LL =294.131) shows a significant improvement of the baseline intercept model against the model with predictors (2LL=180.297) and that it gave a better prediction of 51.8% (McFadden Pseudo R-square,) of all the determinants. The statistically significant predictors were; weather and fire ($p < 0.01$). The result implies that bad weather as associated with heavy rain and wind increases the probability of affecting electric system reliability by 0.9. This was confirmed by consensus from the FGD

> *"Electric system in most cases is affected by weather coupled with heavy and long periods of rain and winds, it breaks down power infrastructures including poles supporting transformers" .....(FGD Kasulu, 23 February 2018)*

This statement means that electric system infrastructure in Kasulu and Uyui is vulnerable to adverse weather shocks and that, it had caused nightmare to customers. Bad weather spurs crackdown of power infrastructure as of current, ESKOM South Africa is shedding 6 000MW from national grid due to weather (Conversation, 2020). Although fire indicates a strong predicting power ($p < 0.01$), its effect was not adverse in the study area. This is because of the fact that the transmission and distribution networks did not cut across the fire prone environment rather the settlement areas where fire could erupt. However, bush fire resulting from farm preparations spread destroyed transmission cables and poles leading to unplanned outages. The lightning predictor was significant ($p < 0.01$). This could be common phenomena because the study areas are prone to lightning, thus the scale of effects on the electric system escalated despite overhead earth wires and lightning arresters. Statistics indicated that high lightning intensity had set on fire eight (8) transformers in 2017 (Uyui District) while Kasulu had five (5) in 2016. This poses reciprocating effects especially on associated cost to replace the damaged apparatus. In similar strain, to minimize risks, electricity was cut-off by utility supplier during and sometimes before it sprinkled. This was revealed through FGD consensus that:

> "*TANESCO (utility supplier) usually cut off power supply especially when it rains with heavy lightning and thunders" … …..(FGD Kasulu, 23 February 2018)*

The statement signifies that the system is vulnerable to lightning which causes loose connections, transformer failure, high-tension cables break down; it also caused disarray at the household due to meter defectiveness. The effect of lightning is confirmed by Edson Electric Institute (2019) that in the USA it caused 70% of all outages leading to economic loss in enterprises and domestic harmony. On the same, Minnar *et al.* (2012) reported outages as caused by lightning, fire, pollution, bird streamers and windstorms in most parts of South Africa especially in rural areas. Likewise, decay of electric pole was a significant predictor of reliability ($p < 0.01$), this was due to termites which caused clutters in Kasulu and Uyui. This was also explained by the Key Informants that in Kasulu 175 poles were replaced in 2017. In reality, this phenomenon causes planned and unplanned outages to replace poles; yet, it affects the utility supplier on the cost incurred to replace the poles. These findings contradict the results by Schoeman and Saunders (2018) who reported cable theft and ageing infrastructures as major causes of interruptions in South Africa. This is because of the fact that reliability determinants differ due to various reasons including geographical locations and system stability.

Moreover, apart from system reliability, information regarding outages emanating from the household were examined. Thus, on binary response, 75% of the respondents reported on having experienced domestic induced outages for the past three months. In fact, the outages emanating from the households for various reasons are accounted in the system reliability although the utility is not directly involved in tracking unless it is reported by the consumers. Therefore, logistic regression model (Table 3. 8) was used to appraise the determinants of domestic induced outages.

Table 3. 8 : Logistic regression results for domestic outages determinants

Predictor	β	S.E.	Wald X^2	Df	P-value	Exp (β)
Age of household head	-0.003	0.015	0.042	1	0.838	0.997
Number of houses electrified	-0.124	0.190	0.427	1	0.514	0.883
Gender of household head	-0.308	0.295	1.089	1	0.297	0.735
Education level of the household head	0.659	0.483	1.865	1	0.172	1.933
Controlled use of electricity	-0.570	0.299	3.619	1	0.057	0.566
Wiring by a registered technician	1.138	0.284	16.069	1	0.000	3.120
Total schooling children	-0.409	0.133	9.475	1	0.002	0.665
Household size	0.232	0.095	6.019	1	0.014	1.262
Constant	-0.584	0.949	0.379	1	0.538	0.557

Fit Summary: Percentage Accuracy in Classification (PAC): Model with constant =59.9%, with -2LL=503.738; Model with predictors= 67.4 %, with -2LL= 474.617, Omnibus test of model coefficient (Chi-Square=29.118; $p < 0.01$); Cox & Snell R^2 : 0. 635, Nagelkerke R^2 = 0. 731; n=374, H-L statistic GoF=31.265, p value= 0.231

The result in Table 3.8 shows that the statistically significant predictors were; wiring by a registered technician ($p < 0.01$), it determines the reliability of power at the household than the rest in reference to the odds values. Although the utility inspects wiring system before connection of electricity, issues of forgery still existed. Indeed, forgery was caused by bureaucracy and the high cost charged by certified technicians. Poor quality wiring installation could lead to power outages as high sensitivity meter flip off even on minor shocks caused by technical errors.

The number of school children in the household was statistically significant ($p < 0.01$). The school children have had an interest in using electrical equipment so does influence outages due to poor knowledge on the use; for example, improper use of unfitting plugs generates shock which leads to stripping off. Another predictor was household size ($p < 0.1$) which indicated that large household induces outages due to irregular use of appliances which increases the risk. Nonetheless, another statistically significant predictor of outage was controlled use of electricity ($p < 0.1$). At the household adults' members had to control or restrict the use of electricity. This was done by fuse removal something which left the house unpowered. It has practical applicability to most of consumers because it reduces outage probability as electricity is only used when adult members of the household are present. The key informants also reported some other factors for outages include quality of domestic appliances, wiring cables and vegetation contact. Some domestic appliances lack quality. This has been a long-time challenge due to free trade where a check on the quality of appliance and cables is seemingly hard and challenging to control.

3.5 Effects of outage incidences on household expenditure for backup fuel

In spite of the electric system being reliable as per consumers (Table 3.3; Figure 3.1 and 3.2 and Table 3.5), several incidences of outages were reported. These could necessitate unplanned expenditure on backup fuels for household sustenance. The effects of outage incidences on backup expenditures were examined respective of outage scenarios versus expenses before electricity connection (Table 3.9)

Table 3. 9 : Average monthly cost on lighting fuels at the household (TZS)

District and on aggregate	Monthly Expenditure – electricity	Lighting costs before power connection	Monthly Cost on backup lighting	Current total lighting cost including backup
Uyui District	9 325.00	12 000.00	1 450.00	11 150.00
Kasulu District	10 000.00	10 500.00	800.00	10 800.00
Kasulu and Uyui District	10 000.00	12 000.00	1 100.00	10 850.00

The results in Table 3.9 revealed that the average expenditure was estimated using median. The cost differed. For Kasulu, the median cost was TZS 10 000/= while TZS 9 325/= was for Uyui District. On aggregate sample, the cost was TSZ 10 000/=. All expenses were based on the refence month. The marginal differences in districts could be due to that Uyui district had more outages and so does expenditure on backup fuels. This study argues that expenditure on sources like candles, torches, kerosene and petrol before electricity connection was higher (TZS 12 000/=) as compared to electricity (TZS 10 000/=). Rural Energy Agency (2017) reported electricity as the most expensive fuel for lighting in Kasulu TZS 13, 183 while Uyui was 12, 590. The decline in the cost of electricity (TZS, 10 000/=) might be orchestrated by the shift in tariffs by consumers. The current results reveal electricity a least expensive, yet it provides high utilitarian through efficient light for comfortability in performing some domestic activities like cooking and night studies for children.

Moreover, outages incidences have led to extra-unforeseen expenditure on backups; Uyui, TZS 1 450/= and Kasulu, TZS 800/= while TZS 1 100/= was on aggregate. The disparity on backup cost can be attributed to levels of reliability among strata, household size, nature and price of backup fuels (kerosene, mobile solar lamps, private generators and candles). On the same, Ebitoye (2013) explained other factors like the number of devices used at the household, hours used per day and consumption capacity. In fact, the results in Table 3.9 portray marginal visual differences, but to depict the honest statistical differences, a paired samples t-test was performed. The paired statistics showed the varying means score on lighting expenses before electrification TZS 13 829.95/= (SD=*9 633.388),* current expenditure on electricity fuel TZS, 11 660.96/= (SD= *6 187.468),* expenditure on electricity plus backup TZS, 13 230.05/= (*SD=6 804.329).* More, the results for paired differences of the t-test are presented in Table 3.10

Table 3. 10 : Paired samples T-Test on household lighting expenditure

Paired Differences							
Paired parameters	**Mean**	**Sd**	**SEM**	**T**	**Df**	**P**	**Eta Value**
Lighting cost before electricity - on electricity	2168.984	8482.057	438.597	4.945	373	0.000**	**6**
Current electricity and backup cost- Cost on electricity	1604.178	1480.135	76.845	20.876	373	0.000**	**54**
Current electricity and backup- Lighting the cost before electricity connection	-574.259	8205.862	426.027	-1.348	373	0.179	**0.5**

** *Significant at p < 0.05*

From Table 3.10, the results indicate that the difference between domestic expenditure on lighting fuels before electricity connection and after electricity connection had statistically significant difference at $p < 0.05$ with 6% magnitude of the effect. Also, a statistically significant difference existed between expenditure on electricity plus backup fuels combined and expenditure on electricity alone at $p < 0.05$ with 54% magnitude of effect indicating that the large effect was due to expenditure on electricity and backup cost. Expenditure on electricity plus backup fuels combined had no statistically significant difference to expenditure on lighting fuels before electricity connection $p < 0.05$. The result informs that expenditure on lighting through electricity fuel was cheaper among respondents, but outages and the *tertium quid* had dragged respondents for expenses on backup fuels.

In fact, expenditure on electricity combined with backup fuel are similar to expenditure incurred on lighting fuels before electricity connection. It is important to note that electricity is efficient and can provide perceptible benefits for other uses such as extension of business hours for small shops at home premises. The amount incurred on backup fuels was significant but was not directly proportional to the outage rates because factors like household size, duration of lighting and presence of schooling children could count too in orchestrating high expenditure. However, expenses on backup fuels due to outages can be linked to the levels of reliability (Low, Moderate and High reliability). Thus, for valid inference on interrelatedness, a Point-Biserial Correlation Coefficient ***(r_{pb})*** was used. The coefficient here three levels of reliability (Low, Moderate and High Reliability) were collapsed into dichotomy variable (1=Reliable, 0=Unreliable) to fit ***r_{pb}*** assumptions (Table 3.11)

Table 3. 11 : Point-Biserial Correlation for backup cost and reliability

		Reliability of electricity	Expenditure on backup fuels.
Reliability of electricity	Pearson Correlation	1	0.302*
	Sig. (2-tailed)		0.049
	N	374	374
Expenditure on backup fuels.	Pearson Correlation	0.302*	1
	Sig. (2-tailed)	0.049	
	N	374	374

The normality assumption was ensured for the continuous variable (Kolmogorov-Smirnov and Shapiro test) whose probability value was not significant at $p < 0.05$. After using log_{10} for data transformation a Point-Biserial Correlation ***(r_{pb})*** was run to investigate if domestic expenditure on backup fuels has a correlation with electricity reliability. In Table 3.11 the result show that there was a moderate positive correlation, ***r_{pb}*** = 0.302, $p < 0.05$. It is an indication that unreliability has had low (eta value 9.120%) magnitude of effect on expenditure for backup fuels among respondents. The weak correlation is further posing and indication that, exposure on lighting fuels is not only linked to backup cost but also to other factors like nature of appliance used for backup, price of the energy sources and lastly the of fuels used.

3.6 Conclusion

The rural electric system was reliable from all sorts of assessment. Although incidents of outage existed, they were within absorbable range by the customers. It was reliable because it did not shy away from their daily dependence by being available most of the time, especially evening and night. Hence, reduced the use of and expenditure on health-hazardous backup lighting fuels. Moreover, lightning had adverse predictive to determine system reliability as it causes significant damages of transformers on feeders. Weather (wind and heavy rainfall), fire outbreak in bushes and vegetation cover determines the reliability of a system. Likewise, termites also determine electric system reliability in rural areas. The nature of electric wiring installation at the household, controlled use of electricity and household size on the other hand influences system interruptions at the household level. The outage incidences, despite reliability, has visible effects on domestic expenditure for backup lighting at the household. On the MTF, it was viable that the framework is valuable in assessing the reliability of the system. Although some parameters deviated negatively, it was still enough to infer power system reliability.

3.7 Recommendations

The state energy utility is argued to keep outages incidences checked because despite reliability prevalence these incidences pose economic effects due to unforeseen expenditure on backup fuels. To deal with electric system faults, the energy utility and Rural Energy Agency should use metal and concrete poles especially in areas prone to termites and fire. Moreover, to ensure all-weather reliable system there should be a continuous inspection of the system itself and make use of Supervisory Control and Data Acquisition Device (SCADA) on distribution lines. Standby transformers in the inventory should be established to save time on logistics after incidences. To reduce costs on backup fuel, consumers are argued to adopt mobile solar lamps which can provide efficient light even for night studies at home.

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CHAPTER FOUR

4.0 Electricity for Information and Communication Technology Adoption in Rural Areas, Tanzania

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4.1 Abstract

Improving access to electricity in rural areas has diverse effects. Nonetheless, with such phenomenon there remains a sluggish clarity on how it has inclined adoption of Information and Communication Technologies (ICT) which is a social and economic need of the rural communities. Thus, to shed light, the study assessed ICT adoption status among rural households; determined the influence of electricity and allied factors on ICT adoption and finally examined the practical use of ICT gadgets in accessing plausible information. The Mann-Whitney U test, Poisson regression and Wilcoxon-Signed Rank (*W*) were used to analyse data. The result uncovered that adoption of ICT gadgets such as Television (TV) and mobile phone had encouraging records in the presence of electricity than to the contrary. On a similar vein, adoption was propelled, *inter alia*, electricity connection, information and communication need and affordability of electricity consumption. The paper argues that, with such adoption, the preference on ICT devices like TV and mobile phone did not differ by gender of the household head. The adopted ICT was used to access political, economic, weather and social information. Along the same line, gender of the household head correlated to information preference while across ages, differences on types of information accessed lacked evidence. The paper argues the state energy utility (TANESCO) to close electricity poverty gap through diverse approaches to harness ICT adverse growth in typical rural areas. The adopted ICT should be used by rural people to keep income and information poverty at bay for well-being improvement.

Keywords: Rural Electricity, Communication, Information access, ICT adoption

4.2 Introduction

Globally, electricity is considered as an important ingredient of development; it influences ICT adoption in rural areas and thus, requires indispensable attention in this digital era. This is because information is in fact a currency of the 21st century, that is why people have immersed themselves in information. Thus, people cannot live without information because they are information themselves. The developed world (for example, Europe and America) has 99% Television (TV) and mobile phone adoption (Nielsen, 2015). Similarly, Africa has 75% radio adoption; on the mobile phone, South Africa, Botswana, Gabon and Seychelles have 74-89% adoption (Asenso-Okyere *et al*., 2012).

The reality is, ICT adoption and use is important because it can increase employment to youth at the prima facie (Mohammed, Haroun, & Sadiq, 2018).This is through small business based on material and mobile money transfer which accounts about 81% in Sub-Saharan Africa than in any other region of the world (Katakam, Frydrych, Murphy , & Naghavi, 2014). Despite the improvements in ICT adoption and applications in developed countries; Mengiste (2013) and Tripathi *et al.* (2012) report that it remains a challenge especially in rural areas of the global south. Inadequate driving forces like reliable and affordable electricity, poor infrastructure, affordability of devices, technological literacy and appropriateness are some of ICT adoption challenges (Jere *et al*., 2013).

Furthermore, although electricity is considered a quantum driver for ICT adoption, Ahlborg and Hammar (2017) argue that it is not a sole factor for manifestation; factors like technology literacy, age, education level and techno-culture could have a role to play (Philip *et al*., 2017; Hodge *et al*.,2016). ICT is useful in many ways, for example in Tanzania, Kenya, Malawi and Zimbabwe, it is used in accessing weather information for agriculture (Asenso-Okyere & Mekonnen, 2012); poverty reduction and livelihood improvement (Sife, Kiondo, & Macha, 2010); it also improves access to health services (Asongu & Odhiambo, 2017). Additionally, Khaliq *et al*. (2016) actuated that ICT is used to reduce information access gap between men and women especially in rural areas.

The use of ICT is indispensable for improving education by enhancing access to useful materials among the schooling persons in urban and rural areas. ICT have multi-facets of use leading to the booming increase in adoption that is why devices like Fax, Computer, TV and mobile phones have increasingly doubled in Sub-Sahara Africa (Asongu & Odhiambo, 2017). For example, in 2013 about 81% of Tanzanians had been listening from the radio, 54% watched TV programmes of interest (Mwantimwa, 2018). Additionally, 8 in 10 households (78%) owned a mobile phone in 2017 compared to 46% in 2010 (URT & UNDP, 2018). This increased adoption is reported by Khaliq *et al*. (2016) as propelled by education level. Myriad factors can influence ICT adoption but this paper hypothesises that at the household, ICT adoption in Tanzania is factored by electricity connection and affordability of consumption. Equally, information needs about politics, economic and agriculture, age and gender of the household head could also entice people to avail themselves with ICT (TV, radio, feature phone, smartphones, personal computers and tablets).

The use of printed newspapers and public dissemination at large are replaced by digital communications and information like internet, TV, radio and mobile phones (Ramirez, 2014). This is due to the shift of paradigm from print to online newspapers (Amadu *et al*., 2018). In Japan, for example, newspapers readers in 2018 plunged by 2 million (5%), in USA weekday print media decreased by 12% while 13% was for Sunday print media (Mediatique, 2018). The decline is also prevalent in Tanzania (Media Council of Tanzania , 2019) because of the booming online TV and information sharing through mobile phones. Until late 1990s, in rural areas of Tanzania, Rwanda, Kenya and Africa in general, people had to gather at or outside home for communal radio listening and TV watching (Murthy , 2014).

In Tanzania, men dominated communal TV watching outside home by 44% compared to women (33%) (Murthy , 2014). Communal access is orchestrated by slow ICT diffusions since 2005 (Stern, Adams, & Elsasser, 2009) and the shared interest like football for men and plays for women; this is an evidence that information access is also gender sensitive. In Kigoma and Tabora regions, TV, radio and computers adoption lagged for decades especially in rural areas due to lack of infrastructure and technical human resources. This has affected women who were not able to access information using a few ICT facilities available (The Carter Center, 2016).

The well-being of urban people is frolicked among other factors, ICT use and ensured access to information (Khaliq *et al*., 2016) due to availability of electricity. This is an indication that ICT adoption and usage in accessing plausible information is indispensable (Asenso-Okyere & Mekonnen, 2012). There is a growing culture of ICT adoption "techno-culture" in urban than in rural areas due to the desire of seeking knowledge and skill through e-learning in various institutions and information access among the people especially the youth (Philip *et al*., 2017). Furthermore, less censored information, affordable ICT devices have shuttered ICT gap in urban areas while rural Africa, especially in Kigoma and Tabora regions, continues to experience digital and ICT divide with urban settings (Bornman, 2015). The use of ICT in urban areas is no longer a luxury but a necessity. For that, urban has well-informed individuals than in rural areas (Mtanga *et al*., 2012). ICT adoption in rural areas seems to be of interest among the people but reliable electricity as one of the driving forces has always been reported to be the greatest challenge (Jere *et al*., 2013).

Inequality of electricity connection leads to digital, ICT divide and exclusion (Varallyai, Herdon, & Botos, 2015), which exist in forms like TV and internet access level and proficiency resulting into economic and information access gaps (Warren, 2007). People in developing countries are still offline in terms of internet use. For instance, Tanzania has 25% internet use, South Africa 59%, Kenya and Ghana 39%, Nigeria 42% and Senegal 46% (Global Attitude and Trend , 2017). On mobile phone adoption, Tanzania has 62% feature phone and 13% smartphone while Kenya has 50 % and 30% on the same (Silver & Johnson, 2018). However, in 2018 Tanzania had improved general ICT adoption. For instance, mobile phone rose to 72% (43.46 million) while internet rose to 38%, (East Africa Horizon, 2019).

ICT adoptions require a clear analysis especially in rural areas to find out if they emanate from the countryside electrification. On ICT usage, plethora findings infer with mixed results. Food and Agricultural Organization (2016) reported that ICT is useful in accessing agricultural information. Mwantimwa (2018) and Karlsson *et al*. (2017) infer that electricity, income and gender predict radio and TV ownership and listening among agro-pastoralist while Sife *et al*. (2010), Aker & Mbiti (2015) provide that ICT have roles for livelihood and economic improvement in rural areas through TV show business and mobile money transfer.

The literature centres on ICT usage with unclear clarity on its adoption in rural areas which have been marginalised in terms of electricity for decades. Therefore, with considerable efforts of rural electrification, the paper set to (i) assess ICT adoption

(TV, radio, mobile phones and computers) among the rural households, (ii) determine the influence of electricity and allied factors on ICT adoption and (iii) examine the practical use of ICT in accessing plausible information. Generally, from empirical literature review, the paper hypothesised that:

(i) **H_0**: The supply of electricity in rural areas does not influence ICT adoption
(ii) **H_0**: Affordability of electricity consumption does not influence ICT adoption
(iii) **H_0**: The need for information and communication does not influence ICT adoption
(iv) **H_0**: Females and males' TV access hours did not change after electricity Connection
(v) **H_0**: There is no correlation between information preference by gender of the household head
(vi) **H_0**: The use of ICT in accessing socio-economic information cannot be differentiated by age

4.3 Theoretical Model

4.3.1 Technology Acceptance Model (TAM)

The study is centred on Technology Acceptance Model (TAM) as first proposed by Fred Davis in 1985. It is an information system theory that models how individuals come to accept and use the technology (ICT) (Davis, 1989). Indeed, a plethora of models exist to explain technology acceptance. For example, Theory of Reasoned Action (TRA), Theory of Planned Behaviours (TPB) and Decomposed Theory of Planned Behaviour (DTPB) and influencing motives, TAM and the versions there-of has remained prolific (Scherer, Siddiq, & Tondeur, 2018).

Venkatesh and Davis (2000) explained that the information system community still consider TAM as a parsimonious and powerful theory due to its wide use in word processor, e-mail and hospital information system. This was supported by Lee *et al*. (2003) who confirmed that of all the theories, TAM is considered the most influential and commonly employed theory for describing individual's acceptance of information system than Wilson's model of information behaviour (Wilson, 1999). TAM is preferred due to its flexibility of fitting a range of external variables. Therefore, TAM (Figure 4.1) assume that ICT acceptance is determined by two foremost user motivation variables; Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) aligned with Attituded Toward Using (ATU).

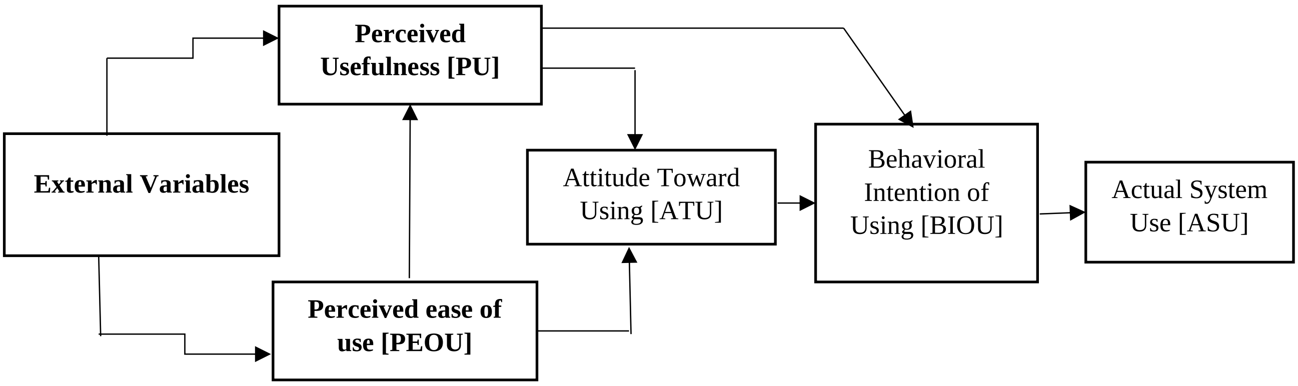

Figure 4. 1 : Technology Acceptance Model (TAM)

Source: Lee *et al.* (2003) and Scherer *et al.* (2018)

Marangunić and Granić (2015) proposed that PU and PEOU can explain directly and indirectly the outcome variables (behavioural intentions tied with technology use). PU is the subjective probability that using a specific technology will increase life efficiency or performance while PEOU is the degree to which the user expects the technology to be free of efforts (Islam, 2011). PU and PEOU are accompanied by external variables which are conceptualized depending on the environment and personal capabilities (Abdullah & Ward, 2016). The variables could include, education, age, marital status and operation incentives like electricity. In this paper electricity is viewed as an external variable which in its presence, PU, PEOU and ATU of ICT users (Mobile phones, TV, computer and Radio) can be positive and hence build a sense of BIOU and develop actual use behaviour. Contrary to electricity availability, the study assumes that ICT users in rural areas are deemed to lugubrious state due to lack of driving force in information access.

4.4 Methodology

The study was conducted in eight villages of two regions of Tabora (Uyui District) and Kigoma (Kasulu District) in Western Tanzania. Since 1961, rural people in the region had been without access to electricity until the intervention by Rural Energy Agency in the 2000s. This has led to the selection of the areas to find out if the efforts had repercussion on ICT adoption. The study employed mixed design as Malina *et al.* (2011) argued that it allows exploration of complex issues such as personal views on a phenomenon. On sample size, Yamane's (1967) sample size formula was used to arrive at a sample of 374 households connected to electricity. Additionally, the proportionate sampling techniques was used to determine representatives' sample from the sampled villages. Then, a simple random sampling technique was carried out to select respondents from each village based on the specific feeder. A questionnaire was used to collect quantitative data about ICT adoption at the household. Focus Group Discussions (Six FGDs) were conducted to obtain qualitative data based on preference on ICT devices based on gender. The FGDs had between 8-10 people, the group size is proper for harnessing information, it is also manageable (van Eeuwijk & Angehrn, 2017). The FGD was composed of members with and without communication devices, this was to understand the views of the have and have not in parallel. Further, the FGDs were gender blended and segregated as well to capture information in varied scenarios.

Descriptive statistics was used to analyse respondents' characteristics, ICT adoption at the household, female and male hours for TV access. It was done by using Pivot Data Table. Mobile phone access was analysed qualitatively by drawing themes from Focus Group Discussion while the Mann-Whitney *U* test was used to compare ICT preference by gender of the household head. The *U* test deals with independent groups in terms of the median for continuous variables by converging them into ranks and evaluate if the ranks differ (Pallant, 2007). The Mann and Whitney Test is given by equation 4.1

$$Ui = n_1 n_2 + \frac{n_i(n_i+1)}{2} - \sum R_i \quad \ldots \ldots \quad (4.1)$$

Where, U =Mann-Whitney U Test Statistics, n_i= Sample size of the group (gender of household heads, n_1= Female 72, n_2= Males 302), R_i=The sum ranks for group

The households have different numbers and types of ICT devices in their locality, hence, a Generalised Linear Model; Poisson Regression Model (PRM) was used to analyse determinants for ICT adoption. In this, electricity was a variable of interest in understanding it prediction power in influencing ICT adoption. This fits best when dependent variable (Y) is an observed count that follows the Poisson distribution. PRM assumes that the possible Y values are nonnegative integers as 0,1,2,3…., and that large counts for some *Ys* are rare, hence requires the count to be less than 10 (Table 4.1)

Table 4. 1: Variable measurement for Poison regression model

Sn	Independent variable	Description
1	Information need	Dummy, 0=No, 1=Yes
2	Perceived ease of using	Dummy, 0=No, 1=Yes
3	Economic activities	Dummy, 0=No, 1=Yes
4	Reliability of power supply	Dummy, 0=No, 1=Yes
5	Gender of the household head	Categorical,1= Female, 2=Male
6	Consumption affordability	Percent of expenditure on electricity
7	Education level	Categorical,0=Illiterate, 1=Literate
8	Income of household	Continuous, Aggregated income of the household
9	Age of household head	Age from birth
10	Household size	People residing in the household for more than 4 weeks
11	Electricity connection	Dummy, 0=No, 1=Yes

The Y variable was measured on count as the number of ICT devices adopted by the household

In PRM the Poisson distribution has the property that its mean and variance are equal. In PRM, it is supposed that the Poisson incidence rate μ is predicted by a true set of the k regressor variables (commonly the X's). Its expression as adopted from Parodi & Bottarelli (2007) is given in equation 4.2

$$\mu = t \exp\ \beta_0(\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$

Where ; β_0 is called intercept, the regression coefficients $\beta_1, \beta_2 \ldots\ldots\ldots \beta_k$ are unknown parameters that are estimated from a set of data. The $X_1 \ldots\ldots X_k$ are predictor variables for counts Y or the Poisson incidence rate μ. The t is exposure which in most cases is time, in case no exposure value, 1 become a value for the parameter. The Poisson incidence μ may be interpreted as the risk of a new occurrence of the event during a specified exposure period, t.

The differences in TV access by gender of household members before and after electricity connection was analysed through Wilcoxon Signed-Rank *(W)*. The test fits for a binomial independent variable with one continuous dependent variable (Field, 2009). The W is based on sum of the positive ranks (T_+) and the negative ones (T_-), but to be able to find the significance of the test statistic(T), it is important to find the mean (T_) and its standard error (SE) which is the function of sample size n; given in this case there was only one sample size as the same participants were used. The expression in equation (4.3) is for the mean of negative sums $\bar{T}$ and in (4) is for Standard Error of $\bar{T}$

$$\bar{T} = \frac{n(n+1)}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.3)$$

$\bar{T} = Mean\ for\ negative\ sums$

n

$= Sample\ size\ , one\ sample\ only\ was\ used\ at\ time\ t, of\ power\ connection\ scenario$

$SE_{\bar{T}} =$

$$\sqrt{\frac{n(n+1)(2n+1)}{24}} \qquad (4.3.1)$$

More importantly, to analyse the correlation between information search (Politics, Agriculture, Economic and Social) and gender of a household head, the Chi-Square (x^2) test of independence was employed. Field (2009) explained it as extremely elegant statistic based on comparing frequencies observed in given categories to the frequencies expected by chance in those categories. Basically, x^2 compares if two categorical variables are related, of which each of the variables can have two or more categories given the 5 cells principle has been met (Pallant, 2007). The test is expressed as in equation (4.4)

$$x^2 = \sum \left(\frac{Observedij - Expectedij}{Expectedij}\right)^2 \qquad (4.4)$$

Then; ***i*** represents rows in the contingency table while ***j*** represents columns on the same. The model works with the frequencies (observed and expected) and not the means when there are only categorical variables. It also requires to establish the expected frequencies by taking n/NC (n is observation while NC =Number of Categories) as used in Lusambo (2009). A non-parametric Kruskal-Wallis *H* Test which is analogous to One-way independent (ANOVA) was applied to analyse differences between several independent age and types of ICT devise used. Fir clarity, the *H* Test compares score on continuous dependant variable (age) and categorical independent variable (Radio, TV and Mobile phones) by converting score into ranks for each group and compare them once the sum ranks of each group has been computed. The *H* Test is denoted as in equation (4.5)

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1) \qquad (4.5)$$

H is a test statistic for Kruskal-Wallis**,** N is the total sample size ($n_1 + n_2 + \ldots\ldots n_k$), n_i is the sample size for a specific group ($n_1\ \ n_2\ and\ \ n_3$), R_i is the sum of ranks for every group (say R_1, R_2 and R_3), k is the degree of freedom (given by, $k-1=2$)

Validity and Reliability are considered one of the most important parts of quantitative studies (Heale & Twycross, 2015); and that they determine the value of the findings. In this study, face, construct and content validity were ensured by pre-testing, sharing and reviewing data instruments with experts. Reliability as a measure of internal consistency of instrument results was ensured through pre-testing and pilot testing. The instrument was rectified by removing 8 redundant items while 12 items were re-stated to depict the clear meaning and ensure that they are free from the sort of errors. Internal consistency for 8 items through Cronbach's Alpha (α) had between 0.75 - 0.79 value which are acceptable in social sciences (Field, 2009)

4.5 Results and Discussion

4.5.1Characteristics of respondents

The study examined characteristics of respondents apart from age, household size and income of the household. Some characteristics can be directly and indirectly linked to ICT gadgets ownership, preference and use in accessing information. The results are presented in Table 4.2

Table 4. 2: Characteristics of respondents

Variables	Median	Std	Minimum	Maximum
Age of household head	49.00	8.225	29	65
Household size	7	1.746	2	13
Female household members	3.00	1.197	1	8
Male household members	3.00	1.067	1	7
Secondary school children	1.00	0.968	0	4
Duration since power connection (Years)	4.00	0.879	2	6
Aggregated net annual household income (TZS)	2 900 000.00	2 219 477.32	1 000 000.00	13 400 000.00

Notes: TZS=Tanzanian Shillings

Table 4.2 quite reveals that the median age of the respondents was 49, portraying that they can still be ICT active users because the lesser the age the more a person avails technology (Philip *et al*., 2017). The respondents are still energetic to work (far from retirement age for a public servant) to meet the cost for ICT devices in terms a person want to purchase avail with any. Gender of household members tied to 3 for males and females. Nonetheless, respondents have 4 years since they connected electricity, this can be linked with ICT adoption rate. Moreover, the income of the household which was TZS 2 900 000/= can influence ICT adoption by increasing purchasing power as confirmed by Mwantimwa (2018).

The household size in the study areas was 7. It might have implications on the income of the household given that the working members are above 18 years of age. However, it can also determine the number of ICT adopted in the household. Additionally, apart from the information presented in Table 4.1, the study also surveyed the sex composition of household head as well as level of education. It was found that males dominated as household heads by 80.7% while the female had 19.3%. For that, households may prefer different ICT adoption depending on the gender of the head. Further, the study noted that 93% of the respondents had attended formal education something which could spur ICT adoption and use as confirmed by Khaliq *et al*. (2016) that educated people have high chance of adopting ICT than the counterparts.

4.5.2 Adoption of ICT devices by the households with electricity

Adoption of ICT devices is a paramount aspect if the household at all devotes to ease information access and communication. Therefore, respondents were asked to state ICT devices adopted before and after electricity connection from the utility company in their localities. This was important as a prime stage in creating the baseline for gauging electricity effects on ICT. The results are presented in Table 4.3

Table 4. 3: ICT adoption scenarios at the household

ICT adopted before utility connection			Internet feature		Post utility ICT devices adopted		Internet feature	
ICT devices	**Frequency**	**% of adoption**	**%Yes**	**% No**	**Frequency**	**% of adoption**	**%Yes**	**%No**
Radio	292	78.1	-	-	145	38.8	-	-
Mobile phone	318	85.0	22	78	275	68.7	82	18
TV	31	8.2	-	-	224	59.8	-	-
Computer	3	0.8	-	-	10	2.6	-	-

From Table 4.3 it is apparent that mobile phone as owned by 85.0% of respondents dominated rural communications even in the absence of electricity from the state utility. Equally, before electricity connection, smartphones were less preferred (20%) due to high bills accentuated by irregular battery charging of between 5-6 times per week and internet bundles. Information from the FGD indicated that Mobile phones were charged through photovoltaic (PV) power and private generators for TZS 400-500/= per typical plugging; thus, feature phones were preferred due to longer battery life. After electricity connection, 68.7% of respondents adopted new mobile phones of which 82% supported internet whose charges seems to be affordable due to stiff competition among communication companies. Further, it was easy to maintain it due to guaranteed electricity which also helped reduce battery charging cost. From Table 4.3, there is an indication that internet supporting phones technology was accepted due to electricity which is a background factor in TAM.

Moreover, in the absence of electricity from the utility, radio was also one of the ICT devices adopted (78%.1) and commonly used in rural areas. However, 38% of the respondents adopted radio after electricity connection, this was a shift towards electricity operated radio. The low rates of radio adoption after electricity connection could be due to the fact that some mobile phones had radio features (FM radios), TV and the Internet might have led to low interest as well. For TV, its adoption increased from 8.2 % to 59.8% after electricity connection (Table 4.3). This outstanding increase was due to reliable and efficient electricity for running the device though factors like price and income of the household cannot be overlooked.

TV operation through PV and or private generator is "either way" expensive given the wobbly economy and unstable fuel price could side-line consumers. Meanwhile, Personal Computer (PC) had little attention to rural communities despite some counter urbanization. The device is not a rural feature, rather an elite tool with a huge gap due to price and complications of use. Generally, it is inferred that adoption of ICT devices were calculated over perceived ease of use (emanating from driving forces like electricity which when not available limits adoption and use as well) as described in the TAM. The current results corroborate the findings by Lee *et al*. (2016) that in Kenya TV adoption increased by 82% while in rural Bangladesh adoption increased from 24% to 48%. All these confirm that electricity is a driver of ICT adoption in rural areas.

Despite the considerable rate of adoption of ICT; an analysis of preference on those adoptions by gender of household head required strong attention (Table 4. 4). This is because, communication and information-seeking behaviours differ between female and male leading to contradicting preference on ICT and nature of information accessed. Thus, respondents were asked to rank most to least preferred ICT devices (From 1- 4).

Table 4. 4: Preferences of ICT adoption by gender of the household head

ICT Devices	Sex of household Head	Mean Rank	Sum of Ranks
Mobile phone	Female	205.21	14775.00
	Male	183.28	55350.00
Television	Female	178.04	12819.00
	Male	189.75	57306.00
Radio	Female	165.90	11945.00
	Male	192.65	58180.00
Computer	Female	203.99	14687.00
	Male	183.57	55438.00

Notes: Female, headed households (n)=72; Male, headed households (n)=302

Table 4.4 indicates that female and male headed households have ranked mobile phone as the most preferred ICT with mean rank 205.21 and 183.28. This might be due to perceived ease of using the gadgets caused by electricity, functional simplicity like sending messages, beep and portability. Its role as a transaction device for Mobile Money Transfer (MMT) and the ability to serve a shared use makes it more preferred. It can also be used by non-household members especially neighbours who can request to call, send and receive messages from their brethren in urban areas. In the second place, TV had a mean rank 178.04 for females and 189.75 for males, radio was third with 165.90 for the female while the male had 192.65.

The high male's preference on TV was linked with the fact that the device is controlled by them especially during the world cup football tournament which coincided with the time of the survey. TV and radio are a round table food waiting (conversation) point at and outside the home where men gather to pass time on news and entertainment sessions; hence, TV, radio and mobile phones serve a great course in communication and are highly adopted technologies than PC. Although the differences in preferences on ICT existed basing on ranked data as in Table 4.4, indeed, the honest difference is difficult to tell. This necessitated for a free assumptions Mann-Whitney U Test (Table 4.5) to reveal any statistical differences.

Table 4. 5: The differences on ICT adoption by gender

	Mobile phone	Television	Radio	Computer
Mann-Whitney U	9597.000	10191.000	9317.000	9685.000
Wilcoxon W	55350.000	12819.000	11945.000	55438.000
Z	-1.800	-.933	-2.009	-2.273
Asymp. Sig. (2-tailed)	.072	.351	.045	.023
Effect size $(\boldsymbol{r}) = \frac{\boldsymbol{z}}{\sqrt{\boldsymbol{n}}}$	0.093	0.048	0.104	0.118

A close look in Table 4.5 provides no statistically significant differences on mobile phones adoption preference between male and female headed households; mobile phones, U = 9597.000, z= -1.800, $p > 0.05$, r = 0.093, the null hypothesis was accepted. TV, U= 10191.000, z = -0.933, $p > 0.05$, r = 0.048: Thus, the null hypothesis was accepted. Further, adoption preference on radio and PC differed significantly, radio, U = 9317.000, z= -2.009, $p < 0.05$, r = 0.104; Personal Computer, U = 9685.000, z = -2.273, $p < 0.05$, r= 0.118. Thus, the null hypotheses cannot be rejected.

The results in Table 4.5 mean that mobile phone and TV serve a great purpose to both male and female headed households. They provide high utilitarian, for example; they increase cohesion through communication and communal watching at home while mobile phone breaks distance as a barrier of communication and serve mobile money transfer. The African figures support these findings by indicating that the deviation of preference is minimal, for the male at 45 % while the female is at 37% (International Telecommunication Union, ITU, 2016). Radio is a male-controlled ICT as female sporadically listen from it due to household duties congestion, thus, as well, Farm Radio International (2011) found a difference on access, male 80% and female 60% in Tanzania while in Kenya it was 86% versus 62%. Females employees with high education level preferred computer compared to males. Regarding TAM, it reveals that the computer is a poorly adopted ICT due to high knowledge demand for application (Mtanga *et al*., 2012). Business and high elite members of the community adopt it because it is perceived as useful and easy to use. This reason will continue creating PC divide among community despite the availability of electricity.

4.5.3 Electricity and allied factors in ICT adoption by the household

Electricity as a factor of interest was modelled along with other allied factors (Table 4.6). In this quest, Poisson Regression Model was applied having met the assumptions; dependent variable was measured on count (number of ITC devices), non-zero and nonnegative integer less than 10. Independence of observations was assured while the mean and variance of the model were identical [$(SD)^2$ divide by mean of count variables].

Table 4. 6: Poisson regression results on factors for ICT adoption

Parameters	β	Std. Error	Hypotheses Test			Exp(B)	95% Wald CI for Exp(B)	
			Wald x^2	Df	Sig.		Lower	Upper
(Intercept)	0.043	0.419	0.011	1	0.918	1.044	0.458	2.378
Information need	-0.460	0.190	5.848	1	0.016	0.631	0.435	0.916
Perceived ease of using	-0.053	0.141	0.139	1	0.709	0.949	0.720	1.251
Economic activities	0.057	0.115	0.246	1	0.620	1.059	0.845	1.326
Reliability of power supply	0.025	0.061	0.170	1	0.680	1.025	0.911	1.155
Gender of household head	0.063	0.074	0.737	1	0.391	1.065	0.922	1.230
Consumption affordability	0.015	0.005	8.429	1	0.004	1.016	1.005	1.026
Education level	0.174	0.122	2.025	1	0.155	1.190	0.937	1.511
Income of household	0.278	0.137	4.129	1	0.042	1.000	1.000	1.000
Age of household head	0.012	0.004	10.194	1	0.001	1.012	1.005	1.020
Household size	0.036	0.034	1.161	1	0.281	1.037	0.971	1.108
Electricity connection	0.146	0.041	12.531	1	0.000	1.158	1.068	1.255

Goodness-of-fit. Deviance value 100.076, df 362, value/df 0.277, Pearson Chi-Square 97.935, df 362, value/df 0. 271, Log likelihood 623.023. Akaike's Information Criterion (AIC) 1272.065. **Omnibus test**; Likelihood ratio Chi-square 57.485, df=11, Sig <0.01

The Model Goodness-of-Fit provides a measure to assess how well fits the variables. An important measure here is the Pearson Chi-Square 97.935 and the value/df which is 0.271. The value of 1 indicates equidipersion, value >1 is overdispersion and < 1 is underdispersion. The value of 0.271 saves useful because the serious violation is overdispersion. The Omnibus test for the model fit indicates all the independent variables jointly improves the model over the intercept model only. The model explained 57.5% *(*Likelihood ratio Chi-square) of all the variables which were significant at $p < 0.01$. This indicates that the addition of independent variable will generate a statistically significant model.

The results shown in Table 4.6 establish that electricity connection had a statistically significant influence on the number of ICT adopted at the household ($p < 0.01$) and that ICT adopted will increase by 1.158 times for every unit of electricity connection. This is because electricity ease ICT operations, thus, creates well-perceived ease of using. Hinging on TAM's assumption, the study elucidates that ICT devices like TV can be adopted only if efficient electric energy is enhanced first. TAM's components will only surface if the background factors like electricity are well enhanced. Although people adopted TV (8%) and mobile phones (85%) before electricity, only those with good economies were capable, because private generators and Photovoltaic (PV) for running TV and other ICT devices were deemed expensive compared to when electricity supply was enhanced. The price of PV was based on the initial cost for installation while the use of private generators was hampered by unstable fuel prices and the maintenance costs.

On the other hand, age of household head and income of the household had significant predictive power; age (p < 0.01) with income (p < 0.05). The result means that age is linked to ICT adoption, the moderate the age the more ICT avails and vice versa. Youths lead in ICT adoption especially smart mobile phones and a computer coupled with the internet for social media like WhatsApp, Instagram and Twitter while elders lead in feature phone adoption. However, it is argued that due to techno-culture growth there is a little demarcation of age limiting individual from ICT adoption though usage can differ as well. Moreover, electricity connection is entangled with income and that respondents who can connect electricity can avail themselves with ICT. This is because household sustenance and materials ownership are decided by income level. Although more than 75% of respondents were peasants, TV and Mobile phones adoption were on high records because they are considered as a basic need in this world of information business and sharing. Partly, the results of the present study are supported by Mwantimwa (2018) and Philip *et al.* (2017) who reported age and income as drivers of ICT adoption and use.

Affordability of electricity consumption was significant (p < 0.01) while information and communication need were also significant (p < 0.05). Although mobile phones, TV and Radio are not high-power consumers, this cannot be neglected because any overuse of TV could escalate power bills. Thus, due to sporadic income of the rural people, the first question before the adoption of ICT device is its consumption capacity, hence, undeniably some household reported to have set a specific time for TV watching in fear of escalating bills. Alternatively, the need for communication and information access was a significant and important predictor (p < 0.05). The rural people have been side-lined in ICT for decades and hence develop the need for political information, especially during general elections. Also, the need for information sharing and transfer has a rudimentary influence on ICT adoption.

In spite of the fact that perceived ease of use and education lacked significant predictive power ($p < 0.1$), the paper argues that they count maximally in decision making about ICT adoption. Depending on the level of education one could use programmes in ICT devices to ensure that hidden information is well taped and shared. This goes together with the fact that in TAM, the perceived ease of use of technology is a manifestation of the function of enabling variables. Further, household size was not statistically significant at ($p < 0.10$) but is assumed to have practical significance on the adoption of ICT. This is because some household had more than three mobile phones to its members, while some individuals at the household also had owned multiple phones. In this aspect, it is argued that the larger the household size the more the likelihood of having more mobile phones while on TV multiple ownerships rarely existed except to those who have established TV show centres.

4.5.4 Practical use of ICT in accessing information

4.5.4.1 Intra-household TV access by gender of household members

The use of ICT in accessing plausible information is preceded by access to available technologies. The ICT adoption does not guarantee practical use in access to information. Considering the gender of household members, it is indicated that males and females differ in the access to ICT devices. Male were dominant on TV access through communal watching outside home by 44% compared to women at 33% (Murthy , 2014). Thus, access to TV by gender of the householders was assessed at the prima facie on time scenario (before and after electricity connection). Adult male and female household members represented their gender during data collection. The results of the scrutiny are presented in Table 4. 7

Table 4. 7: Median hours for TV access by gender

TV access by gender of household members	Std. Deviation	Minimum	Maximum	Median
Females' TV access hours before electricity connection	3.287	0	14	.00
Males' TV access hours before electricity connection	4.232	0	24	4.00
Females' TV access hours after electricity connection	7.923	0	35	14.00
Males' TV access hours after electricity connection	7.458	0	42	14.00

Notes: Female =374, Males=374 all from the household representing access to TV

Table 4. 7 provides a summary showing that the median hours for females' TV access before electricity connection was zero while males had 4 (four) per week. This was caused by poor TV penetration. Nevertheless, TV running cost was ever-increasing causing few hours to watch for specific programmes such as news, football and plays. Moreover, females had low access hours due to domestic activities constraints because in Uyui and Kasulu women are primary family caretakers while their male counterparts had a room to stay outdoor for communal watching at their neighbours and or TV show centres. However, TV technology adoption had led to increased access hours (14) between males and females. This was also orchestrated by smartphones, as some had access to online TVs.

Moreover, for females, TV access hours in the study areas might have been affected by popular plays which was aired on TV; possibly it might have affected the results to both. Similarly, survey was done few months before the World cup Football Tournaments, this might have affected the results for male's TV access. In fact, the TV access hours by gender usually differ between urban and rural areas; Bhatt and Singh (2017) reported that women in urban areas have more time on TV for various reasons including lifestyle learning while women in rural areas mostly watch TV for entertainment though do not outshine men who control TV mostly. Thus, electricity accentuates ICT which have a role in empowering women on information access as well (Winther, Matinga, & Ulsrud, 2017). Further, the results on increasing information access by women are similar to Neuman (2018) who reported that, with increasing ICT adopting about 80% of women in local communities can access information as men do. The results in Table 4.6 cannot indicate ties and statistics of difference for TV access among the pairs. Therefore, to be able to capture and understand the positive and negative ties as well as statistical differences between the groups, the free assumptions Wilcoxon Signed Rank test was conducted with results presented in Table 4.8. It was found that some females had TV access hours unchanged (26[c]) in both scenarios. This is denoted as ties which might have been caused by TV ownership by some household before electricity connection.

Table 4. 8: Wilcoxon Signed-Rank results on TV access

Descriptive				
		N	**Mean Rank**	**Sum of Ranks**
Female's TV hours after electricity – TV hours before electricity connection	Negative Ranks	4[a]	72.75	291.00
	Positive Ranks	344[b]	175.68	60435.00
	Ties	26[c]		
	Total	**374**		
Male' TV hours after electricity – TV hours before electricity connection	Negative Ranks	3[d]	89.00	267.00
	Positive Ranks	363[e]	184.28	66894.00
	Ties	8[f]		
	Total	**374**		

Test Statistics [a]		
	Female Weekly Hrs on TV after Utility Service - Female weekly Hrs on TV B4 Utility service	Male Weekly Hrs on TV after Utility Services - Male weekly Hrs on TV B4 Utility Service
Z	-16.029[b]	-16.455[b]
Asymp. Sig. (2-tailed)	0.000	0.000
Effect size (r) =$\boldsymbol{Z/nx2}$	0.586	0.586

Notes: Test statistics, **a**. Wilcoxon Singed rank test, **b**. Based on negative ranks. To obtain an accurate effect size, n is multiplied by 2 because of the number of observations over the two-time spots and not the number of cases

Table 4.8 provides that females had 344 positive ranks with a mean rank of 175.68. This indicates that the majority of them have greater TV access after electricity connection just like males with 363 positive ranks and 184 mean ranks. The test statistics indicates that, females' access to TV before electricity connection (Mdn = 0.00) was statistically significant different after electricity connection (Mdn = 14.00), z = -16.029, p < 0.01, r = 59% (large effect size). Moreover, a statistically significant difference existed between males' TV access hours before electricity connection (Mdn = 4), after electricity connection (Mdn =14), z=-16.455, p < 0.01, r = 59% (large effect size*).* Therefore, the null hypotheses are all rejected. The differences in TV access hours is cemented by the fact that before electricity connection, technology acceptance was not enhanced as compared to the period after access to electricity.

On the mobile phone, respondents were asked to state who control and own a mobile phone. The results showed that gender of household members improved in favour of females. Males owned mobile phones by 95% while females had 65%. There was multiple ownership of mobile phones among male household members while other household members depended on a shared mobile phone. Explorations revealed that sharing a mobile phone is wearisome especially when one member of the household moves with the phone. Due to electricity availability, it was imperative for (principal) male and female at the household to possess a mobile phone to ease communication. It was also imperative for mobile money transfer, internet use and information sharing. The increased mobile phone adoption is cemented by Information from the literature which show that mobile phone is the fastest-growing ICT in Africa and that there is more mobile phone than adults in developing countries (Melia, 2019). Elsewhere Ghana and Kenya have 80% mobile penetration while Tanzania has 75% (Global Attitude and Trend , 2017)

4.5 The practical ICT use in accessing information by the households

The adopted ICT determines the nature of information searched and accessed by respondents, thus, assessing the practical use of ICT was imperative because adoption does not necessarily mean usability. Analysis of information searched and accessed were grouped into five dimensions: politics, economy, weather, social and entertainment. Respondents were asked to state common information accessed using various adopted ICT (Table 4. 9)

Table 4. 9: The use of ICT in information access at the household

Information Behaviour	Aggregated sample		Stratum			
			Kasulu District		Uyui District	
	Freq	Perc	Freq	Per	Freq	Perc
Politics	105	28.1	66	30.8	51	31.9
Market/economy	102	27.3	45	21.0	39	24.4
Weather/Agriculture	101	27.0	50	23.4	42	26.3
Social	39	10.4	44	20.6	12	7.5
Entertainment	27	7.2	9	4.2	16	10.0
Total	**374**	**100.0**	**214**	**100.0**	**160**	**100.0**

Notes: Freq= Frequency, Perc=Percentage

Aggregated results in Table 4.9 show that information seeking behaviour about politics, market and weather differ less. However, politics took a higher echelon on aggregate (28.1%) while on stratum 30.8% was for Kasulu and 31.9% for Uyui. This was because respondents were moved to know political decisions that affect their lives given the trend of televised politics and government operations. Interest in politics varies from time to time, as during general elections there is a high need for polity information for voting decisions. Access to economic information (Market and prices of farm produce) varied on stratum because Kasulu had no cash crops compared to Uyui which has tobacco. Respondents wanted to know price stand even for other crops like cashew nuts and cotton that had a price conflict at the time. However, on ICT usability in agriculture the results are similar to Bukenya (2015) that, mobile phone ease access and sharing of information among the farmers.

On stratum, there was high demands of weather (rain forecast) information in Uyui (26.3%) and low in Kasulu (23.4%). Despite the shared geographical zone (Western Tanzania), weather status differs because Kasulu (Kigoma) has a predictable calendar contrary to Uyui (Tabora) which has experienced devastating droughts for several years in recent. Generally, information access behaviour at the household can be linked to the gender of household head, age, economic activity, nature of ICT adopted and education. The alarming factor is gender because females and males have varying interest in the information. This was important to execute because it can be useful in policy and development actions. Then, a Chi-square test of independence (χ^2) was used to depict any relations between gender of household head and preference on a type of information. The five-cell principle was observed while expected frequencies were also established given the number of cases (374) for Five (5) Parameters of Reference (5PR) based on information searched. Consequently, the expected frequencies used in χ^2 were calculated as Pallant (2007) proposed.

$$f_e = \frac{n}{NPR} \quad \text{...} (4.6)$$

Where, f_e *is expected frequencies,* n *is number of cases,* NPR *is the number of parameters of references;* Then, $fe = {}^{374}/_{5} = 74.8$. Therefore, the expected frequencies for parameters of references (Politics, Market, Agriculture, Social and entertainment) or test were: -

- 74.8 (20%) of female and male headed households would search and access politics, market, agriculture, social and entertainment-based information. Hence, the χ^2 was run to depict gender relations and information search, the results are presented in Table 4.10

Table 4. 10: Chi-square results for information access by gender

GoH		Descriptive for observed frequency on Information need behaviour by gender					
		Politics	**Market**	**Weather**	**Social**	**Entertainment**	**Total**
Female	Count	16	13	29	9	5	72
	%within GoHH	22.2%	18.1%	40.3%	12.5%	6.9%	100.0%
	% within ISoS	15.2%	12.7%	28.7%	23.1%	18.5%	19.3%
	% of Total	4.3%	3.5%	7.8%	2.4%	1.3%	19.3%
Male	Count	89	89	72	30	22	302
	%within GoHH	29.5%	29.5%	23.8%	9.9%	7.3%	100.0%
	% within ISoS	84.8%	87.3%	71.3%	76.9%	81.5%	80.7%
	% of Total	23.8%	23.8%	19.3%	8.0%	5.9%	80.7%
Total	Count	105	102	101	39	27	374
	%within GoHH	28.1%	27.3%	27.0%	10.4%	7.2%	100.0%
	% within ISoS	100.0 %	100.0%	100.0%	100.0 %	100.0%	100.0%
	% of Total	28.1%	27.3%	27.0%	10.4%	7.2%	100.0%

Chi-Square Statistic			
	Value	**Df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	10.058[a]	4	0.039
Likelihood Ratio	9.823	4	0.044
Linear-by-Linear Association	3.098	1	0.078
Valid cases N	374		

Notes: GoHH=Gender of Household Head, ISoS=Information Searched on Specific. **For Chi-Square Statistic:** Symmetric Measures, Phi=0.164, p < 0.05; Cramer's V=0.164, p < 0.05; Contingency Coefficient=0.162, p < 0.05

The Chi-Square Statistic, *Cramer's V* and *Phi statistic* have a value of 0.164 (p < 0.05), which is an acceptable range of 0-1. Thus, *Cramer's V* and *Phi statistic* values indicate that there was a minimal association between the two groups. The effect size was calculated through *Cramer's V,* given by the formula as used in Lusambo (2009), especially when one variable has more than two categories

$$v = \sqrt{\frac{x^2}{n(df)*}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.7)}$$

Where, v is the effect size, x^2 is Chi-squared, df is the value of R-1 or C-1, where R and C represent Row and Column, n is the sample size or the number of cases.

Then, $v = \sqrt{\frac{10.058^2}{374(4)*}} = 0.067$

Therefore, the results indicate that there was a statistically significant correlation between information search behaviour (preference) by gender of household head, Pearson Chi-square (χ^2) (4) =10.058, p < 0.05, Cramer's V 0.067 small effect size of the preference. The null hypotheses thereafter cannot be accepted. Correlation is based on the view that females are household primary caretakers through production and sustenance activities, hence sparing little on information, however, the current improvement in information access is commendable. Males have high mobility and may stay outdoor for communal TV watching, their supremacy as first mobile phone owners at the household gives them an early exposure on information search and access. Despite the correlation, age also has raised a concern, its debate is substantial in as to whether it is decisive in ICT use. This made it imperious to analyse the differences in using ICT devices for information access by age of respondents. The Kruskal-Wallis H test was used (Table 4.11)

Table 4. 11: Kruskal-Wallis results on ICT use by age of household head

Ranks			
	Technology use		**Mean Rank**
Age of household head	TV		203.02
	Mobile phone		171.25
	Radio		190.91
Kruskal-Wallis H Test Statistics			
Age of household head			
Chi-square (H)		5.825	
Df		2	
Asymp. Sig.		0.054	
Monte Carlo Sig.		0.058	
	95% Confidence Interval	Lower bound	0.052
		Upper bound	0.064

Notes: Grouping variable; Technology used in accessing information and entertainment sessions

The result in Table 4.11 reveals that the use of ICT devices (TV = 122, mobile phones = 140 and radio = 112) in accessing political, economic, agriculture, social and entertainment-based information has no statistically significant difference, H (2) =5.083, $p < 0.05$ (of the Monte Carlo estimate of significance) across the ages of household heads, hence, the null hypothesis lacks rejection. The results mean that rural communities are homogenous especially in most socio-economic dimensions, there is an indication that levels of education and economic status have not yet divided people. Nonetheless, the hyper of less censored information on social media, radio and TV has bridged the gap for information access, sharing and search behaviour among individuals of different ages.

4.6 Conclusion

The supply of electricity in rural areas is decisive and adorns in the adoption of ICTs like Radio, TV, feature phones and smartphones which are useful in communication and information access among the connected households. Electricity makes it easier to operate internet supporting mobile phones and TV as well while preference on ICT devices become feasible due to perceiving ease of using associated with reduced running cost among the household. ICT is a social and economic need which requires a careful and strategic expansion among the people by making electricity facility reliable and affordable. However, electricity is not the lone driver of ICT adoption and use rather education level and economic status have a share of influence on the later. ICT adoption leverage females to access information and thus reducing the gap with their counterparts. The lucrative effect of ICT is viewed in the dimensions to enabling individual connected to electricity easily access political information like elections campaign, weather, health and education as well. ICT adoption is not accidental rather affirmative upon electricity and allied factors. However, regarding TAM, it is evident that, the background factor can best be defined to suit the need of the current study. It is enumerated that, intention to use and perceived ease of using any ICT is built on the enabling prime variable at the background. Thus, TAM remains valid model for explaining ICTs adoption.

4.7 Recommendations

The state energy utility should guarantee a wider supply of electricity to stimulate ICT adoption which in turn becomes useful in information access, sharing and bridge ICT gap between urban and rural people. It also improves access to financial services through mobile money transfers which increases employment and livelihood strategies among the people. Furthermore, the telecom companies like TIGO, VODACOM, HALLOTEL and AIRTEL better plan strategically to improve and stabilize communication infrastructure in peripheral areas by extending communication signals. Additionally, the Tanzania Communication Regulatory Authority (TCRA) should continue with education programs on the proper use of ICT in accessing useful information for individual and development of the society at large.

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CHAPTER FIVE

5.0 Quality Rural Electricity and Household Income Nexus in Kasulu and Uyui Districts, Tanzania

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5.1 Abstract

The persisting household income poverty and increased investment in electricity supply in rural areas have sparked unresolved debate regarding "energy household income nexus". To address this paradox, the paper examines the influence of quality electricity on household income along with supplementary development assets. It evaluates the mediating effects of household strength and moderating roles of age, education and gender on constructs. The paper is built on Resource-Based View (RBV) for a hypothetical model. Nevertheless, to cast light on the shadow, exclusive Partial Least Structural Equation Model (PLS-SEM) was used to analyse the complex interrelations of variables. The paper argues that quality electricity is superior to other resources as it plays an important role in predicting household income. This is by reducing the cost of basic services while proliferating home-based enterprises and employment in processing firms. Electricity alone is not enough, hence, require intermediaries and complementarities of development assets and individual motivation for practical effect. The paper extrapolates that education and gender of household head offer substantial effects in moderating constructs to bring income on stage. Thus, there is a need for ministerial cross-cutting engagement to ensure access to roads, markets and financial resources for household income growth. The paper provides novelties in the analytical method, theory development and new literature lights in rethinking some of the rethinking of energy income nexus, given the state-of-the-art.

Keywords: Rural Electricity, Household income, Nexus, Quality, Household

5.2 Introduction

The effort for income poverty reduction is a global agenda rooted in Sustainable Development Goal One (SDG1) “ending extreme poverty in all forms”. While developing countries like Bangladesh, Haiti and Tanzania take diversified strategies for ending income poverty, the key focus has been placed on the rural electricity supply (Saing, 2017; Bosu *et al.*, 2017; Matinga & Annegarn, 2013). However, the strategy is seemingly hardly surprising (Lewis & Severnini, 2019), because it is thought to have nexus with welfare improvement (Kumar & Rauniyar, 2018). Electricity supply also aims at serving about 1.2 billion people (17% of the global population) who lack access to modern energy (International Energy Agency, 2015); about 85% with no access to electricity are in Sub-Saharan Africa (SSA) and Southern Asia (SA). However, those with access (83% globally) are troubled by the intermittent supply of up to 20 hours per month (Min, O’Keeffe, & Zhang, 2017). This low-quality supply of electricity is, however, more pronounced in rural SSA and SA.

The paper validates an ongoing debate of electricity income nexus by answering the key questions: first, whether quality electricity (alone) intertwined with other resources (development assets like land and access to financial services; individual motivation such as desire for income) predict household income and second if complementarities and intermediaries have a positive effect in bringing rural household income on stage. Household income includes the income of the household head and all people aged 18 years and above in the household (Guzman, 2018). Income is about financial and non-financial assets (Barker, 2010) which are proxy of many indicators like health, education, age, gender and time (Peters & Sievert, 2015; Barron & Torero, 2014). People in rural areas of SSA (41%) suffer from high levels of income poverty (World Bank, 2018). In Tanzania, particularly in Kigoma region about 48% live below the poverty line (Kilama, 2016). The scenario is rooted in persisting electricity poverty, unworking policy, political structures, lack of markets for agricultural produces and unequal access to available resources. With such many contributors to income poverty; electricity poverty is seemingly a great cause (Khandker, Barnes, & Samad, 2009).

Electricity access is viewed as a remedy in reducing income poverty, nonetheless, it should not be regarded as the end in itself, but the means to stimulate small business, access to information and opening arrays of economic opportunities (Kooijman, 2008). For that, the paper argues that electricity should be studied in complement with other resources for robust inferences. Additionally, individual motivation as an intangible resource and household strength (wealth background, experience and skills in resource mobilization) should not be overlooked because income generation lies in the best decision and skills to capitalize on the readily available opportunities and resources. To that end, this paper is built on Resources-Based View (RBV) and Partial Least Structural Equation Model (PLS-SEM) to find out if the desired resources predict household income. The need to understand the nexus between rural electricity and household income is a concern of development planners; in fact, it has been a subject of enquiry in economic literature (Sekantsi & Motlokoa, 2015). The focus on income is palatable due to that, it is not the end, but the means to achieve other facets of development (Besley , 2007).

Bridge, Adhikari, and Fontenla (2016) argue that in developing countries, income is difficult to measure income due to many economic activities taking place in informal markets. However, in studying electricity versus income, (Magnani & Vaona, 2016; Béguerie & Pallière, 2016; Lee, Miguel, & Wolfram, 2016; Stern, Burke, & Bruns, 2016) revealed mixed results. This is linked with: first, negligible considerations on whether electricity was of a quality (reliability, voltage stability) to render effects; second, methodological approaches where various studies (Princewill, Dekor & Bonny, 2019; Vaona & Magnani, 2014; Niu *et al*., 2013; Akpan, Essien, & Isihak, 2013; Lipscomb, Mobarak, & Barham, 2013;) have modeled electricity as the sole predictor of income. This is contrary to Bastakoti (2003) who maintains that electricity with no complimentary service will not create any necessary development impact. In the same vein, different analytical methods have been used to model income; for example, Khandker, Barnes, and Samad (2009); Kumar and Rauniyar (2018) used Propensity Score Matching (PSM); Akpan (2013) and Lee *et al*. (2016) used Ordinal Least Squares (OLS) to deduce the positive impact of electricity on household income. For that, the results could hardly be dependable as Van de Walle *et al*. (2015) explicated that with such models impacts could be correlated with omitted variables, yet, there could be external effects.

In unceasing considerations of complementarities, like Bastakoti (2003); Lenz *et al*. (2016) and Torero (2015) argued for the need to include such complementarities (education, roads, water and land) in the energy-income assessment. Thus, to shed light on the shadow, this paper considers quality electricity as a strategic resource of interest which has to be modeled along the tangible and intangible development assets (Figure 5.1). Besides, the inclusion of intermediaries like household strength and interaction effects of age, gender and education is paramount for robustness of inference. The paper's approach is also supported by Akter, Wamba and Dewan (2017) who suggested that "we live in a complex, multivariate world (and that) studying the impact of one or two variables in isolation, would seem relatively artificial and inconsequential". For that, the income of the household if linked only with one variable (electricity) would result in shaky fallouts.

5.3 Theory Underpinning the Study

5.3.1 Resource-Based View

Resource-Based View (RBV) was first propounded by Wernerfelt in 1984; ironically most of Wernerfelt's arguments did not grow (Barney & Clark, 2007) until developed by Barney in 1991 (Montgomery, 1995). RBV determines strategic resources for an organization's Sustainable Competitive Advantage (SCA). In this paper, the household is viewed as the heterogeneous organization which requires diverse resources (assets) and favourable conditions to accrue income for the reason that different types of resources have different effects and scale (Barney & Clark, 2007). The RBV assumes that to attain income goal, tangible and intangible internal resources must fully be used. The resources include physical, financial, human and household capital resources. Barney (1991) poses the assumptions (VRIN) for resources that they must be Valuable, to allow the household to accrue better income; Rare among the households; Imperfectly imitable, cannot easily be replicated, and finally Non-substitutable. Indeed, for theoretical model development as shown in Figure 5.1, intangible valuable resources like quality electricity and human behavioural assets such as individual motivation which is a driver of decision making in income generation in the complex environment have been considered (Guay *et al*., 2010). Nonetheless, it also leans on tangible development assets composed of land, financial, workforce and household strength (DFID, 2000)

5.4 Theoretical Model and Hypotheses Development

5.4.1 Quality electricity criteria for household income generation

Quality electricity (Figure 5.2) has been equated with income growth at the household and national level (Kooijman, 2008). Electricity income nexus has been a subject of debate from energy development economists (Pempetzoglou, 2014). Burlig and Preonas (2016); Lee, Miguel and Wolfram (2016) report mixed results about electricity's impact on income. At the same, Economic Consulting Associates (2014) infers that there is little direct evidence of income being influenced by electricity. Nonetheless, at the national level, Shiu and Lam, 2004, Lee and Chang (2008) stated electricity to income (GDP) causal flow while Kahsaia *et al*. (2011) and Ozturk (2010) found bidirectional flow between energy and income. Moreover, Lee (2006) reports income-energy consumption causal whereas Payne (2009), Huang, Hwang and Yang (2008) Fatai, Oxley and Scrimgeour (2004) found no causal relationship. The mixed result is perhaps due to methodological approaches; for example, Kembo (2013) used scale measures to infer electricity to income effect, Lee and Chang (2008) used Granger causality, while Fatai *et al*. (2004) used Toda and Yamamoto test.

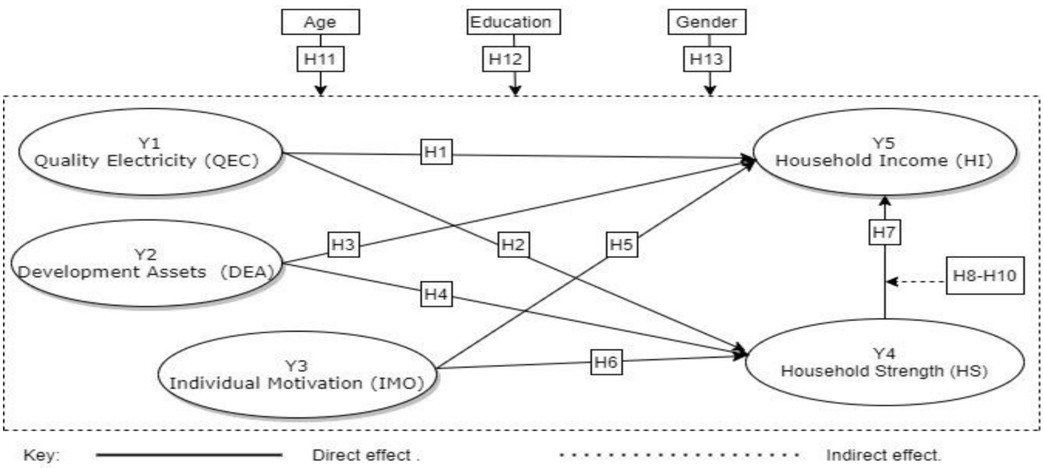

Figure 5. 1 : Theoretical Model

In their studies Lipscomb *et al*. (2013) and Dinkelman (2011) argues that electricity influences women's income growth through employment and home-based business activities; although the wage increase was not clearly indicated (Van de Walle *et al*., 2015), there was evidence that electricity improves the income of women through business indicators. While Iyke and Odhiambo (2012) infer distinct causal effect of electricity on the income of consumers; Van de Walle *et al*., (2015), connected and unconnected consumers can benefit through business opportunities that come along, for example, electrified markets. Besides, Khandker *et al*. (2009) and Lenz *et al*. (2016) advocated that electricity improves domestic expenditure, education and income through increased demand of service. However, in typical rural Africa, the evidence of impact remains weak (World Bank, 2008 in Lenz *et al*. 2016), because micro-enterprises are affected by limited markets and intermittent power. The debate portrays mixed result on the electricity income relationship. Again, this could be associated with the types of variables measured. For example, Lewis and Severnini (2019), Torero, (2015), Barron and Torero (2014), Nakata and Kanagawa (2008) inferred that electricity, saves the time about nine hours per week (water pumping and washing) and let people engage in business, it improves health and education for more study hours which are long time proxy of income.

Lewis and Severnini (2019) indicated that with electricity, on farm activities were improved through milking machines, production and income and saved milking time by 50%; more importantly land value and housing quality increased given *ceteris paribus*. However, Peters and Sievert (2015) commented that electricity increases income by 34% for off-farm activities; this is cultivated by an increased business (Rud , 2012). On similar views, Akpan (2013) stated that 16.2% more profit from business connected to electricity a phenomenon supported by Kembo (2013) and Lee *et al*. (2016) that in rural Kenya, 53% of the business; cornmeal, barber shop, salon and small food stands had a better performance. Quality electricity offers a flair for micro-business to enjoy an extension of working hours and reduction of operation cost, especially though milling machines. In fact, the continued mixed results on electricity income nexus among many reasons are centred on less consideration of quality indicators of electricity (Figure 5.2) as ascribed by Stern *et al*. (2016) and Akpan (2013) that persisting reliability problem of electricity affects firms and income generation at all levels.

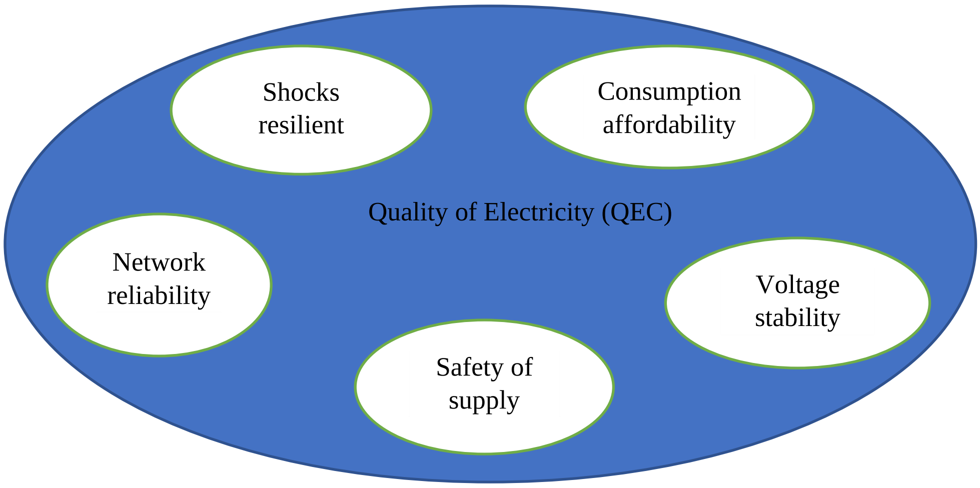

Figure 5. 2 : Quality of Electricity

Source: Chatterton (2014); Bhatia and Angelou (2015)

The question of power quality based on voltage stability, system shock resilience and safety of supply must be considered in qualifying electricity. Electricity with such qualities adds to household strength and capability. Voltage stability enables all necessary appliances, be ice boxes, bulbs, milling machine and Television (TV) to operate properly. A power system which is resistant to shocks emanating from weather condition and human activities usually energizes the household. While reliability is understood to be the ensured and continued supply of electricity, the household can benefit by reducing costs on backup devices and fuel, hence, saving income in expenditure basket. Further, for the household to feel secured, affordability of electricity consumption should be a priority, hence, households should not use more than 5% of the income on electricity (Bhatia & Angelou, 2015). Consequently, it is hypothesised that;

Hypothesis 1: Quality electricity (QEC) has a significant influence on household income

(HI)

Hypothesis 2: Household strength (HS) is significantly explained by quality electricity

(QEC)

5.4.2 Development assets (DEA) and rural household income

In reality, there might be no single factor and asset to affect household income, but a combination of many not limited to land, financial, technology and human capital (DFID, 2000). For that, Torero (2015) and International Energy Agency (IEA)

(2013) consider electricity as essential for development: though it adds to household strength, alone may not be able to create all conditions for economic and subsequent income to the rural poor. Thus, for vigorous inferences, incorporating various key resources along electricity may not be an option. For instance, in assessing the impact of electricity access on borrowers from commercial banks, Magnani and Vaona (2016) proposed some other related indicators, like availability of funds and unemployment insurance. This signifies that single factor for some outputs is not guaranteed.

Matinga and Annegarn (2013) attested that electricity income nexus was unclear (no business stemmed from electricity access, no extended business hours) and may not materialise because of the lack of complementary services and resources. Indeed, disregarding the rest of assets and factors in predicting household income, spurious and injurious results become so obvious. This is because rural households have for a long time benefited from other resources (land and livestock) even before the electricity connection. Consequently, for robust results and unlike previous studies (Princewill *et al*., 2019; Palit & Bandyopadhyay, 2016; Burlig & Preonas, 2016; Bezerra *et al*., 2017; Bosu *et al*., 2017; Magnani & Vaona, 2016; Sekantsi & Motlokoa, 2015) this paper models quality electricity along the rest of development assets like land, technology and human workforce while assessing if resources availability predicts household strength. Accordingly, it hypothesises that:

Hypothesis 3: Household income (HI) is significantly explained by development assets (DEA)

Hypothesis 4: Development assets (DEA) significantly influence household strength (HS)

5.4.3 Individual motivation (IMO) for household income

Motivation refers to the reasons underlying individual's behaviour (Guay *et al*., 2010), it is the attribute that pushes human to do or not to do something, it is a root for decision making for a course. Motivation can be intrinsic if animated by personal satisfaction and enjoyment, thus people seek achievement because they possess an effective desire; it is extrinsic if manifested from external pressures (Kaplan, Karabenick, & DeGroot, 2009). Motivation is therefore considered to be an intangible resource which makes up individual behaviour (Pro-active behaviour) as it constitutes a significant force (Montgomery ,1995). When people are deprived by responsibilities, desires for recognition and acceptance they develop behaviour for income, either through micro-enterprises, saving and or purchases of assets. Udvari and Voszka (2018) have studied motivation's influence on student's expectation and decision and found its significant influence. However, the income of household in relation to electricity has always been assessed in the absence of motivation consideration. An organization (household) having intrinsically and extrinsically motivated individuals is considered as having key strength as it helps goal achievement at all levels. Thus, it is hypothesised:

Hypothesis 5: Household income (HI) is significantly explained by individual motivation (IMO)

Hypothesis 6: Individual motivation (IMO) has a significant influence on household strength (HS)

5.4.4 Household strength (HS) as a mediator

The strength of the household lies in its wealth accumulation background and resource mobilization strategies (Department for International Development , 2000). Strength is considered an important complementarity and should not be underrated in assessing income generation because having development assets is one thing and having the ability to capitalize on them is a different thing. For resources to yield better, complementarities should be called in the analyses (Lenz *et al*., 2016). Thus, for similar views, Torero (2015) explained the importance of some complementarities and intermediaries such as education, roads, health, water supply and markets in assessing the impact of electricity on income. In unceasing recognition of intermediaries, Bridge *et al*. (2016) modeled electricity's ability to predict income through a simultaneous system of equations via Three-Stage Least Squares (3SLS). In fact, there was a direct and indirect impact through the intermediate effects of education and agriculture. Reliance on electricity, individual motivation, development assets like land, technology and fiscal assets, in the absence of intermediaries could hardly offer assurance of improving household income through home-based business establishment; for that, the paper hypothesises that:

Hypothesis 7: Household strength (HS) significantly influence household income (HI)

Hypothesis 8: Household strength (HS) significantly mediates the relationship between quality electricity (QEC) and household income (HI)

Hypothesis 9: Household strength (HS) significantly mediates the relationship between

development assets (DEA) and household income (HI)

Hypothesis10: Household strength (HS) has significant mediation effects on the relationship between individual motivation (IMO) and household income (HI)

5.4.5 Age, education and gender as moderators

In this paper, age is the number of years a person has already lived (Sungiato, 2017). Human age is classified into four categories, as a child (0-12 years), adolescent (13-18 years), adult (19-59 years) and senior adult (60 years and above) (Nithyashri & Kulanthaivel, 2012). Basing on energy and mobility capability (Tiruwa, Yadav, & Suri, 2018), this paper classifies and model age as a categorical moderator where 18-50 years is active age while 51 years and above less active age. Speaking on that, age has been argued one of the key drivers of success in accruing income. It is associated with work energy, risk-taking, mobility and information processing which Walsh, Evanschitzky and Wunderlich (2008) argued that it deteriorates with ages. Age is an important moderator in technology acceptance (Tiruwa *et al*., 2018) while in business it is the best moderator for satisfaction and loyalty (Mithal & Kamakura, 2001). To the best knowledge of the present author, age has not been included in energy studies as a moderating variable leading to a miss-out of the robustness of inferences, it is therefore hypothesised that: -

Hypothesis 11: The influence of QEC, DEA and IMO on HI is significantly moderated by age.

Regarding education, it entails knowledge and skills acquired through the formal system (Hahn & Truman, 2015), it can also be acquired through the non-formal or informal system. Actually, education plays a central role in labour markets; in fact, there is overwhelming evidence that education correlates with earning (Jamison, Jamison, & Hanushek, 2006; Card, 1999). For that, any inference that places less emphasis on education as an observable heterogeneity in predicting household income poses a significant drawback. Turčínková & Stávková (2012) stressed that the household whose head has primary or no education are vulnerable to income poverty. Therefore, resources availability could be beneficial to educated members than counterparts. This is because education is likely to provide planning skills, lobbying and ease access to and mobilization of resources. In that line, this paper places emphasis on education as observable heterogeneity that could moderates constructs, thus, hypothesises that:

Hypothesis 12: The influence of QEC, DEA and IMO on HI is significantly moderated by education.

On the gender of household head; while it draws attention in development planning, its analysis has ambiguous inferences. In appraising it, Gonzales *et al*. (2015) induced that, women are still, on average, have lower access to resources like financial services than men. This prompt difficultness in business start-up and therefore exacerbating inequality. Indeed, gender could, therefore, halt and determine income growth or not. Thus, from empirical reviews, this paper hypothesises that;

Hypothesis 13: The influence of QEC, DEA and IMO on HI is significantly moderated by gender

5.5 Methodology

The study was conducted in two districts of Kasulu (Kigoma region) and Uyui (Tabora region) in Western Tanzania. Four (4) villages were purposively selected from each district based on being earlier recipient (6 years) of electricity through Rural Energy Agency (REA) and the state energy utility; Tanzania National Electric Supply Company (TANESCO). The regions where the district and villages were drawn are among the low-income earning, for example, in Kigoma about 48% lived below the basic needs poverty line while Tabora had 32% (Kilama, 2016); thus, making it appropriate to investigate if the prevailing power supply has a causal effect on household income along with other resources as in Figure 5.1. Due to many interrelationships of variables in the theoretical model, quantitative design with unique Partial Least Squares Structural Equation Modeling (PLS-SEM) was used. The paper used the sample size of 374 households obtained through Yamane (1967) sample size formula. Further, a proportionate sampling technique was used to obtain a sample representative from eight villages of the two districts. Using random number Table, respondents were randomly selected. A bipolar scale of one to seven was used to collect data on measurable indicators. It was validated for face and content validity; it was reliable at 0.69 and 0.78, an acceptable range in social sciences (Heale & Twycross, 2015). Qualitative data were collected through Focus Group Discussion to obtain more information to supplement quantitative analytics.

5.5.1 Measures

The measures for five unobservable constructs were developed and operationalized from empirical reviews *(Appendix 5.1)*. Quality Electricity (QEC) was measured by five formative indicators: safety of supply and affordability were adopted from the multi-tier framework for power quality used in Bhatia and Angelou (2015). Shock resilience was borrowed from Dzobo, Gaunt and Herman (2012), voltage stability from Chatterton (2014) while reliability was from Bhatia and Angelou, (2015), Chatterton (2014) and Bastakoti (2003). Development Assets (DEA) had five measures; workforce, information technology and communication, land, fiscal capital and social networking, all borrowed from Department for International Development (DFID) (2000) in Sustainable Livelihood Framework (SLF), but differently used by Steel & Van Lindert (2017), Peters, Vance, & Harsdorff (2011). Nevertheless, on Individual Motivation (IMO), measures were; self-realization from Kéri (2018 in Udvari & Voszka, 2018), while desire for better living, personal satisfaction and safety were borrowed from Urošević *et al.* (2016) and from Lai (2011), was responsibility. The household's strength (HS) had two measurable indicators, background in wealth accumulation and experience and skills in resources mobilization. The household income construct (HI) had five measures too, assumed from Steel and Lindert (2015) was financial savings; Micro enterprises start-up from Peters *et al*. (2011), Béguerie (2016) and Kumar & Rauniyar (2018); employment (Dinkelman, 2011); electrical assets (United Republic of Tanzania , 2017) while owner-occupied dwelling was assumed from Lewis & Severnini (2019)

5.5.2 PLS-SEM description and Justification

The paper used PLS-SEM with SmartPLS3.2 software (Ringle, Wende, & Becker,2015). PLS-SEM is a causal modeling that maximizes the explained variance of the endogenous construct (Hair *et al*., 2014a). The paper applies a conceptualized model with latent constructs in Figure 5.1, thus, in models with latent variables, PLS-SEM is "virtually without competition" (Wold, 2006). Further, the paper uses the skeletal RBV theory, thus, PLS-SEM is useful for estimating and develop it (Hair *et al*., 2014a). In fact, PLS is a full-fledged estimator for SEM (Henseler, Hubona &

Ray, 2016) which in this milieu possesses Pareto efficiency over Propensity Score Matching (PSM), Ordinal Least Squares (OLS), Difference in Difference Estimator (DDE) and Covariance Based (CB) - SEM. It has strong causal effect predictive power and can be used for non-normal data (Hair *et al*., 2014b); handle multicollinearity, robustness in the face of data noise and missing data (Garson, 2016). It is the finest second-generation technique (Hair *et al*.,2014a), which enables the incorporation of unobserved and observable variables (Chin, 1998a). Although it has myriad algorithms; Hair, Ringle and Sarstedt (2014c), PLS-SEM if appropriately applied, is indeed a "silver bullet" for estimating causal models.

5.5.3 Data Analysis and PLS-SEM algorithms

In order to test hypotheses stated in the theoretical model in Figure 5.1, the two-stage approach suggested by Hair *et al*. (2017) and Sarstedt *et al*. (2014) were used. The outer model was evaluated to establish if the quality criteria for formative and reflective construct were met while noting the relationship between observable and unobservable variables (Sarstedt *et al*., 2014). The inner model evaluation involved path analysis based on the relationship between latent exogenous and endogenous construct. Hair *et al*. (2017) stipulated that PLS-SEM is robust on distribution assumptions; hence, significance and relevance of formative composite indicators, weight and path coefficients were tested by running a bootstrapping routine with samples resampled to 5000 (Henseler, Hubona, & Ray, 2016).

Three path models were run, first with and without mediator; the purpose was to test if household strength (HS) mediator has a role on household income (HI) by comparing variance explained (R^2) values and path coefficients. Then, a path model with moderators (age, education and gender) was executed through bootstrapping routine to find out the effects of observable heterogeneity on exogenous latent constructs for vigorous inferences. The effect size (f^2) for exogenous latent constructs was calculated followed by blindfolding procedure for assessing predictive relevance of endogenous constructs through Stone-Geisser Criterion (Q^2) (Vinzi *et al*., 2010). Then, Importance -Performance Map Analysis (IPMA) as part of the advanced analysis was conducted for expanded results. Garson (2016) stated that IPMA aims at the determining the relative importance of the construct towards outcome variable for policy and managerial actions; it is undeniably useful for comparing the most important antecedent on target construct (Hair *et al*., 2017; Ringle & Sarstedt, 2016).

5.6 Results

5.6.1 Measurement model evaluation

The outer model assessed the contribution of each indicator in representing its associated construct and measures how well the combined set of indicators represent the construct (Duarte & Amaro, 2018). The current study's model has reflective and formatively measured constructs (Table 5.1); thus, both the outer weights and loadings have been considered (Garson, Partial Least Squares: Regression and Structural Equation Model, 2016)

5.6.2 Reflective measurement model assessment

The structural model has two reflectively measured constructs (factor-based). These included household strengths (HS) treated as a mediating variable and endogeneity household income (HI). The model assessment results for convergent validity are presented in Table 5.1.

Table 5. 1: Quality criteria for reflective model

Construct	Code	Loadings	t-Statistics	P-Values	VIF <5	AVE >0.5	CR >0.7
Household Strength [HS]	HS 1	0.764	14.602	0.000***	1.112		
	HS2	0.855	26.603	0.000***	1.122	0.657	0.848
Household Income [HI]	HI1	0.708	22.720	0.000***	1.899		
	HI2	0.908	74.741	0.000***	3.386		
	HI3	0.834	35.246	0.000***	2.198	0.537	0.792
	HI4	0.510	8.271	0.000***	1.213		
	HI5	0.641	16.388	0.000***	1.394		

****Significant at p < 0.01; VIF=Value inflation factor; AVE=Average Variance Extracted; CR=Composite Reliability; HTMT=Heterorait-Monotrait Ratio*

The convergent validity criteria in Table 5.1 indicates the extent to which indicators belong to one latent variable and actually measures the same construct (Benitez, Henseler, & Castillo, 2019).The convergent validity was assessed through indicator and construct reliability. For indicator reliability, all the outer loadings were significant at 0.01 level (bootstrapping routine with 5000 resamples) and above 0.5 parameter value. Henseler, Ringle, and Sinkovics *et al*. (2009) and Chin (1998b) suggested the indicator loadings to be at least 0.6 and ideally higher than 0.7: Vinzi *et al*. (2010) and Garson (2016) proposed a stringent rule "above 0.708". In a similar line, Avkiran and Ringle (2018); Hair *et al*. (2014a) and Hair *et al*. (2014c) stipulated that indicator with weaker loading (below 0.4) should be ruled out from the scale especially if it leads to increase of AVE and CR, thus, outer loadings of 0.5 and above is adopted. To sum, the convergent validity results convey that each construct measures what it is supposed to measure.

The construct reliability and validity were tested through two indices (Rouf & Akhtaruddin, 2018): (1) Composite Reliability (CR) for HS was 0.848 and 0.792 for HI, all these values were above 0.7 which is a conservative cut-off point (Rigdon, 2013; Sarstedt, Ringle, & Hair, 2017). Thus, all reflective constructs have better internal consistency. (2) Average Variance Extracted (AVE) which reflects the average communality for each latent factor in a reflective model (Rouf and Akhtaruddin, 2018; Hair *et al*, 2017). For a good and adequate model, AVE should be greater than 0.5 (Höck & Ringle , 2006). In Table 5.1, AVE for each construct was above the limit; 0.657 for HS while HI had 0.537 providing that the constructs have captured more than 50% of the variance.

Nonetheless, discriminant validity (Table 5. 2) is meant to ensure that a constructed measure is empirically unique and represents phenomena of interest that other measures in the structural model do not capture (Henseler, Ringle, & Sarstedt, 2015). This validity assessment is only limited to reflectively measured construct (Abdi *et al*. 2013; Chin 1998a); it was measured through Fornell-Lacker criterion and Heterorait-Monotrait ratio (HTMT) (Richter *et al*., 2016; Henseler *et al*., 2015). For the Fornell-Lacker criterion, discriminant validity is measured by comparing the value of squared correction between constructs and the average variance extracted (AVE) for the reflective constructs (Nikbin & Hyun, 2017). For well-established discriminant validity, the correlation value should be less than the square root value of the AVE along the diagonal as indicated in Table 5.2

Table 5. 2 : Discriminant validity analysis

The Fornell-Lacker criterion							Heterorait-Monotrait ratio (HTMT)	
	Constructs	**DEA**	**HI**	**HS**	**IMO**	**QEC**	**HS -> HI**	**95% CI**
1	Development Assets (DEA)						**Critical value**	**< 0.85**
2	Household Income (HI)	Formative model	**0.755**		Formative model	Formative model	0.5	0.419-0.603
3	Household Strength (HS)		-0.236	**0.811**				
4	Individual Motivation (IMO)		0.397	-0.479				
5	Quality Electricity (QEC)		-0.747	0.375				

Thus, Table 5.2 provide that the square root of each construct's AVE along the diagonal is greater than its highest correlation with any other construct in. This superiority validates the establishment and existence of discriminant validity (Chin, 2010). The Heterorait-Monotrait ratio provides maximum supports for discriminant prevalence in PLS-SEM. Garson (2016), HTMT is the ratio between correlations of indicators across constructs measuring different phenomena to the correlations of indicators within the same construct. Henseler *et al*. (2015) and Gold, Malhotra, and Segars (2001) suggest that any HTMT value below 0.9 signifies the establishment of discriminant validity. Nonetheless, the critical value of 0.85 has been assimilated for decision (Kline, 2011); consequently, the results uphold that HTMT values of 0.5 favours discriminant validity prevalence. Additionally, through bootstrapping routine it was found that at 95% confidence interval the HTMT value did not exceed the range (0.419-0.603), thus, validity is established. Generally, these results indicate that, household income and household strength were correctly measuring different aspects, therefore the results of prediction of the model remain valid.

5.6.3 Formative measurement model assessment

Hair *et al*. (2017) suggested consideration of collinearity, significance and relevance of outer weights in the evaluation of the formative model. Nevertheless, Rick and Jasyn in Avkiran and Ringle (2018) as in this study (Table 5.3) added and reported outer loadings for robust assessment.

Table 5. 3 : The quality criteria for formative model assessment

Construct	Code	Outer weights 0 ± > 1	P-Values	Outer loading	P-Values	VIF<5
	QEC1	0.563	0.000***	0.656	0.000***	1.260
	QEC2	0.226	0.002***	0.521	0.003***	1.484
Quality Electricity [QEC]	QEC3	0.782	0.000***	0.861	0.000***	1.165
	QEC4	0.701	0.000***	0.721	0.000***	1.448
	QEC5	0.434	0.000***	0.562	0.000***	1.120
	DEA1	0.423	0.004***	0.600	0.000***	2.307
Development Assets [DEA]	DEA2	0.402	0.000***	0.534	0000***	1.310
	DEA3	0.584	0.000***	0.658	0.000***	1.858
	DEA4	0.299	0.006***	0.742	0.006***	1.168
	DEA5	0.643	0.000***	0.702	0.000***	1.073
	IMO1	0.341	0.003***	0.600	0.000***	1.414
	IMO2	0.473	0.000***	0.528	0.000***	1.363
Individual Motivation [IMO]	IMO3	0.507	0.000***	0.657	0.001***	1.261
	IMO4	0.599	0.000***	0.824	0.000***	1.506
	IMO5	0.700	0.000***	0.712	0.000***	1.432

***significant at $p < 0.01$; VIF= Variance Inflation Factor

Table 5.3 summarises that the outer weights were below the limit of 1, hence indicates a stronger contribution to the construct (Garson, 2016; Rick and Jasyn in Avkiran and Ringle,2018). Although the variables were within the range, they have different strength in contributing to the construct. The weights can be estimated by partial multiple regression where the latent *Y*'s construct turns to represent a dependant variable and associated indicators *x*'s are the independent variables. According to Hair *et al.* (2017) and Garson (2016) outer weights show contribution (relationship) of indicators on the formative construct. Thus, the results indicate that the manifest variables have different contribution on the construct respective construct. All outer indicators were retained because they have significant outer weights ($p < 0.01$).

The outer loadings for formative indicators were above 0.50 cut-off point (Hair *et al.*, 2014a and Diamantopoulos, 2006) and were all significant at $p < 0.01$. It is noted that formative indicators do not necessarily correlate highly because they represent constructs independent cause (Edward & Bagozzi, 2000), neither they are interchangeable (Diamantopoulos & Winklhofer,2001). Generally, all conditions indicate that the model demonstrated no multicollinearity between indicators as verified through Variance Inflation Factor < 5 (Hair *et al.*, 2006; Diamantopoulos & Siguaw, 2006)

5.6.4 Structural model evaluation

PLS-SEM, unlike CB-SEM, does not have a normed and standard goodness-of-fit statistic (Henseler & Sarstedt,2013), hence, requires specification of a variety of parameters to confirm the model fit (Ma *et al.*, 2019). Thus, the structural model assessment quality (Figure 5.3) is based on the capability of predicting the endogenous constructs and associated criteria. Further, the structural model is based on testing the ascribed hypotheses. Also, see section 5.5.1 for variable definition and appendix 5.1 for keys for variables indicated in Figure 5.3

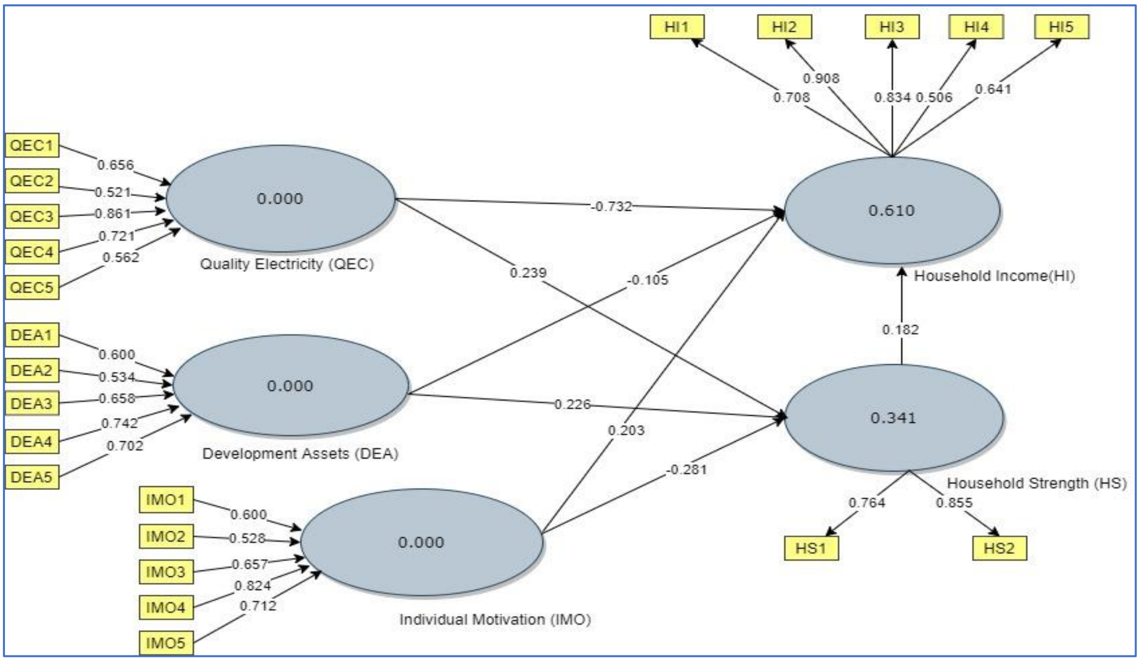

Figure 5. 3 : A path analysis

In Figure 5.3 the inner model indicates substantial predictive accuracy with R^2 = 0.610 for household income (HI) while household strength (HS) had $R^2 = 0.341$, the latter is deemed good in consideration of the theory and potential antecedents, thus, giving the model a nod of a good fit. For continued R^2 evaluation, Hair *et al*, (2014a) suggested a measure of effect size (f^2) for uncovering the magnitude of effects of exogenous latent constructs on endogeneity. The f^2 is estimated by assessing the R^2 value when an exogenous construct is removed from the model and see if it has a feasible effect on endogenous. The decision rule in assessing f^2 is based on the conservative cut-off points, 0.02, 0.15 and 0.35 respectively, representing small, medium and large effect (Hegner-Kakar *et al.*, in Avkiran and Ringle 2018). Esposito

Vinzi *et al*. (2010:638) from Cohen (1988) proposed a formula (equation 4.1) for effect size in PLS-SEM (Path Model)

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}} \quad \text{...(4.1)}$$

$R^2_{included}$ is the value of R^2 of endogenous construct when a specific exogenous construct is included while $R^2_{excluded}$ is the value when a construct is excluded in running PLS algorithm. The path model in Figure 5.3 shows the value of R^2 when all *Y1* (QEC), *Y2* (DEA) and *Y3* (IMO) are included in PLS algorithm. The f^2 for HS and HI are indicated in Table 5.4.

Table 5. 4 : The effect size of exogenous constructs on endogenous

Sn	Inclusion and exclusion condition	HS	f^2	HI	f^2
1	R^2 when *Y1*, *Y2* and *Y3* are include	0.341		0.610	
2	*Y1* (QEC) excluded	0.276	0.098	0.274	0.861
3	*Y2(DEA)* excluded	0.286	0.083	0.604	0.053
4	*Y3(IMO)* excluded	0.281	0.091	0.585	0.064

In Table 5.4 it is shown that, QEC has higher effect size on all endogenous variables, 0.098 for HS and 0.861for HI. In fact, quality electricity surpasses other resources in adding strength to the household and in predicting income through sophisticated economic livelihood activities and reduced cost on household sustenance. The development assets and individual motivation have very small effect size on both constructs. Apart from effect size; Stone-Geisser Criterion (Q^2) for evaluating model's predictive relevance was conducted through blindfolding procedure with omission distance of seven (Sarstedt *et al*., 2014). While Vinzi *et al*. (1998) suggested the use of construct cross-validated communality (Q^2), Hair *et al*. (2014) recommended construct cross-validated redundancy (Q^2) which this paper adopts because it focuses on outcome constructs. The prognostic results hiked above the conservative bottom-line value of zero (Avkiran and Ringle, 2018) for each endogenous construct; for HI the Q^2 = 0.317 and (HS) = 0.20 confirming model fit. For a similar disposition, the q^2 effect size was assessed (using blindfolding Q^2 value) for the relative impact of predictive relevance; like the f^2, it follows 0.02, 0.15 and 0.35 stringent rule and similar calculation process (equation 4.2)

$$q^2 = \frac{Q^2_{included} - Q^2_{excluded}}{1-Q^2_{included}} \quad \text{..(4.2)}$$

Thus, when *Ys* are excluded, the Q^2 values for household strength (HS) and the q^2 *effect* in parenthesis were *Y1* = 0.129 (0.043); *Y2* = 0.129 (0.043), *Y3* = 0.147 (0.021). The reality is undeniable, all exogenous construct had small predictive relevance on HS. For HI, the Q^2 values when *Ys* are excluded with q^2 effect size in parenthesis were *Y1* = 0.102 (0.292); *Y2* = 0.304 (0.001); *Y3* = 0.299 (0.008). Accordingly, the result indicate that quality electricity (*Y1*) had approximately large predictive relevance on HI beating the odds; it proves empirically to be an important element compared to other antecedents.

Evaluation of significance and relevance of path relationships which was conducted through bootstrapping routine for 374 cases, 5 000 resampling and no sign changes option (Hair *et al*., 2017; Vinzi *et al*., 2010). In Table 5.5, the bootstrapping results are presented

Table 5. 5 : Bootstrapping results for direct and indirect paths

Path	Hypotheses	Path coefficient	T-statistics	P Values	Supported
Direct effect					
QEC -> HI	H1	-0.732	22.43	0.000***	Yes
QEC -> HS	H2	0.239	6.792	0.000***	Yes
DEA -> HI	H3	-0.105	1.348	0.178	No
DEA -> HS	H4	0.266	5.265	0.000***	Yes
IMO -> HI	H5	0.203	3.463	0.001**	Yes
IMO -> HS	H6	-0.281	5.958	0.000***	Yes
HS -> HI	H7	0.182	5.040	0.000***	Yes
Mediation effect (analysis)					
QEC -> HS -> HI	H8	0.044	4.224	0.000***	Yes
DEA -> HS -> HI	H9	0.049	3.507	0.000***	Yes
IMO -> HS -> HI	H10	-0.051	4.148	0.000***	Yes

***Significant at $p < 0.01$

The result in Table 5.5 affirms that for direct effect, the path of DEA -> HI (H3) was rejected (β= -0.105; it was not at $p < 0.05$; it upholds the absence of development assets' (DEA) direct effect on household income (HI). For that, HI can be contributed to by other constructs or through complementarities. Further, the antecedents articulate that having resources is one thing and turning them into direct household income is another phenomenon. Briefly, on HI, it is depicted that QEC -> HI path had very strong prediction power than the rest (β= -0.732; $p < 0.01$); for one unit decrease of QEC there is -0.732 decrease on HI. Nonetheless, the path of IMO follows with strong prediction power on HI (β = 0. 203; $p < 0.05$). This depicts that while electricity plays a monumental role in predicting HI, it cannot suffice alone unless it is combined. Although DEA was not significant on HI, it adds on HS (β =0.266; p < 0.01) while IMO add strongly significantly also (β =0.281; p < 0.01). In fact, all resources add on HS which is an important element in propagating HI through the indirect path.

5.6.4.1 Mediation analysis

Mediation analysis in Table 5.5 advocates the presence of full and partial mediation (Vinzi *et al*., 2010; Hair, 2014 and Hult *et al*., 2014). Since the direct path of DEA to HI was insignificant (β= -0.105; $p < 0.05$), upon mediation the path became significant, hence, it is illustrated that HS fully and strongly mediates the effects of DEA on HI (β=0.049; $p < 0.05$). This indicates that development assets as suggested in RBV guarantee less household income unless the quality and strength of the household have been considered, otherwise it is “poverty amid resources”. Moreover, IMO was found to have effect on HI through HS ($\beta = -0.051$; $p < 0.01$), this was a partial mediation because although the direct effect was significant as well; upon encountering a mediator the relationship was triggered to negative.

More importantly, the effects of QEC on HI is partially mediated (with the change in direction of effect) by HS (β = 0.044; $p < 0.01$). The effects signify that, in making household income better, no single resources can suffice. Nevertheless, the effect of electricity on household income is crucial but not enough to bring household income at a higher stage. For robust inferences about mediation effects, Vinzi *et al*. (2010), Avkiran and Ringle (2018) suggested an independent structural path model that does not include a mediator (Figure 5.4). The standard guideline for assessing mediation effect (R^2, f^2 effect size and Q^2) was adopted from Avkiran and Ringle (2018); Abdi *et al*. (2013) and Esposito Vinzi *et al*. (2010)

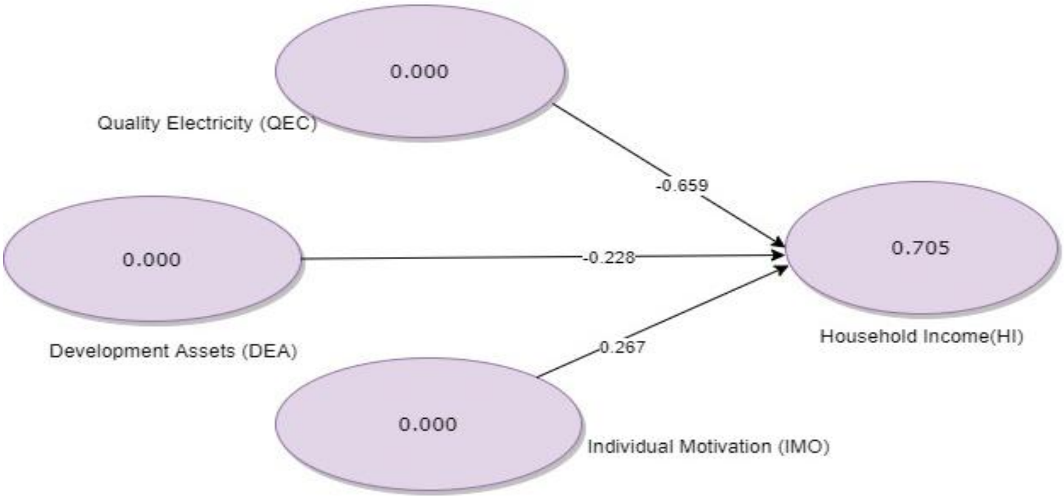

Figure 5. 4 : Path analysis (impact without a mediator)

For variance, there was a substantial increase on R^2 for HI endogeneity with a mediator from R^2 = 0.610 in Figure 5.3 to R^2 = 0.705 without a mediator in Figure 5.4. The shrinking R^2 value of HI in the mediated model is a shred of analytical evidence that some of the effects of the exogenous construct are channelled through the mediator. Accordingly, an increase of the R^2 in a model with no mediator indicates that the effects which were held in mediation have been released to some extent. The R^2 and f^2 effect size for exogenous construct on HI endogeneity in parenthesis were; QEC = 0.366 (1.149); DEA = 0.653 (0.176); IMO = 0.654 (0.210). It is evident, QEC is far better with very high effect size, it is superior than DEA and IMO in predicting HI with strong path coefficient. Similarly, the predictive relevance Q^2 value was 0.361 for HI indicating the best fit because this value is > 0. Regarding the significance of paths, QEC to HI coefficient value for an unmediated model (Figure 5.4) has shrunk unlike in Figure 5.3; this is an expression that, when QEC is intertwined with intermediaries, the prediction becomes substantial. Moreover, DEA in Figure 5.3 does not predict HI but when a mediator is excluded DEA effects become real (-0.228; p < 0.01), demonstrating that some resources can just help income generation even if intermediaries are rare.

5.6.4.2 Moderation analysis (observed heterogeneity)

Table 5.6 shows the relevance of the prior variable and uncovering the observed heterogeneity effects regarding the inner constructs. The paper executed heterogeneity using the three moderators; Age, Education and Gender of the household head. The HI had a substantial increase in R^2 from 0.610 (Figure 5.3) to 0. 715. This indicates the presence of significant moderation effects of the variables on exogenous constructs.

Table 5. 6 : Bootstrapping results for moderator analysis

Paths	Hypotheses	Path coefficients	T Statistics	P Values	Support
Age					
*QEC -> HI_	H11	-0.025	0.404	0.686	No
*DEA -> HI_		0.068	0.219	0.827	No
*IMO -> HI_		0.058	0.502	0.616	No
Education					
*QEC -> HI_	H12	0.246	2.927	0.004***	No
*DEA -> HI_		-0.270	0.695	0.487	No
*IMO -> HI_		0.133	1.536	0.125	No
Gender					
*QEC -> HI_	H13	-0.013	0.252	0.801	No
*DEA -> HI_		-0.019	0.278	0.781	No
*IMO -> HI_		0.209	4.136	0.000***	Yes

***significant at $p < 0.01$

The results in Table 5.6 illustrate that the influence of QEC on HI is strongly moderated by education (β = 0.246, p < 0.01) while the effect of IMO on HI is strongly moderated by gender (β = 0.209, $p < 0.01$). The results deduce that a household could reap income regardless of the moderating variables in some context. Generally speaking, the results portray that having quality electricity with the complementarity of education surely exacerbate the likelihood of yielding substantial household income; this could be through micro-business start-ups such as TV show centres, milling machines and restaurants which are some of features of rural business. More importantly, individual motivation works well when gender is considered; for example, looking at the traditional stands in the study areas, men are obliged to provide for the family, thus, prompted and extrinsically motivated to go into economic success, although women play a large part as well, this has not changed. However, although age and education do not influence DEA and IMO in predicting HI, this could only be a statistical evidence but practically they could predict income at the household. For example, DEA like land, access to fiscal resources information and technology could have large effect in predicting household income only if they are presented to the educated people then the counterparts.

5.6.5 Importance-performance map analysis (IPMA)

IPMA offers important insights into the role of antecedent constructs and their relevance for managerial and policy actions (Grønholdt *et al.*, 2015, Martensen & Grønholdt, 2010). Although IPMA focuses on exogenous and manifest variables as well (Avkiran and Ringle, 2018); the paper was keen on exogenous composite construct only. IPMA indicates the performance of each construct on a scale of 0-100 (Ringle & Sarstedt, 2016) while importance is based on the total effect of the model (Garson, 2016). In fact, importance is indicated by the total direct and indirect effects of the exogenous construct on the target endogeneity construct in the structural model. The prior requirements check for IPMA was performed. For instance, a quasi-metric scale for all indicators in the PLS-SEM (Path Model); all indicator coding had the same scale direction (Sarstedt and Mooi, 2014).

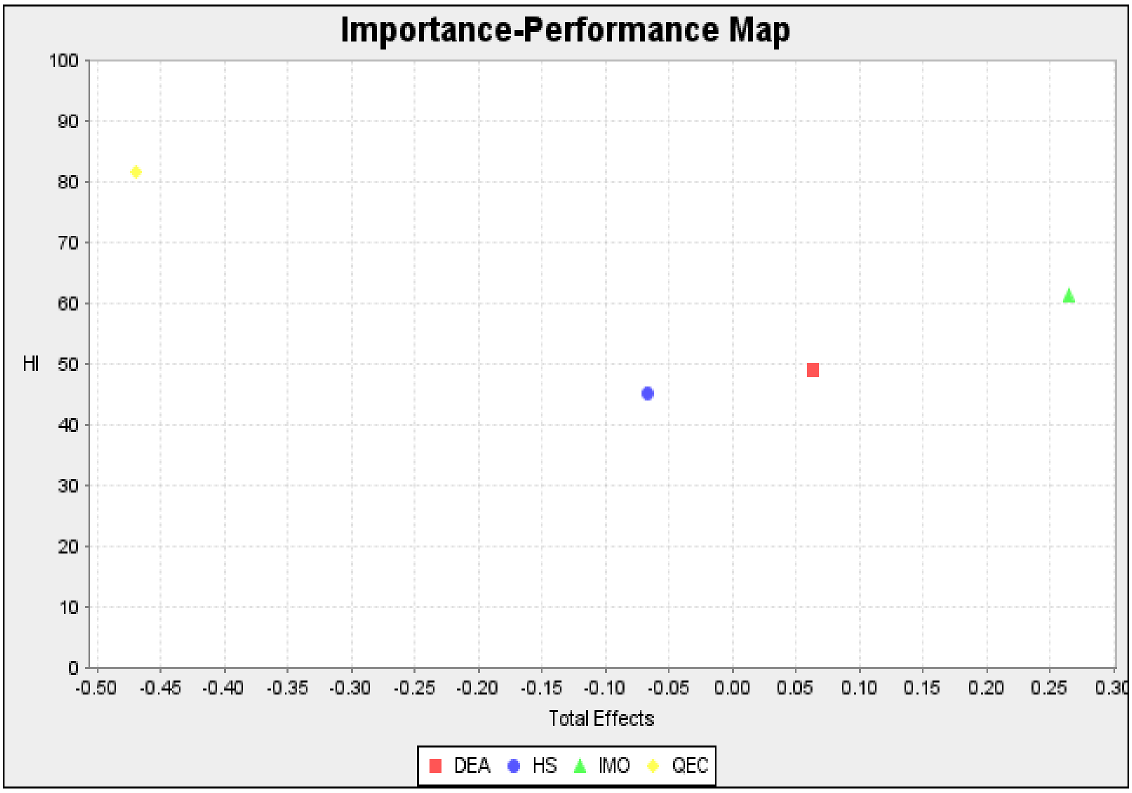

Figure 5. 5 : IPMA for the target construct HI

Figure 5.5 explicates that QEC has very high performance of 81.66 on HI and importance of -0.470 unstandardized total effect. This result provides evidence that despite the presence of various resources in the community, yet, without access to modern energy like electricity development based on increasing household income will mostly be despaired. Thus, it is inferred that quality electricity is a precious driver of household income. This is due to its substantial roles in propagating large, medium and small economic undertakings such as metal welding and brick making. Nonetheless, the role of IMO with 61.113 performance and 0.264 importance needs a nod. It means, with electricity availability, people should be motivated to work and earn income. Although DEA and HS have the performance of 49.064 and 45.138 but a total effect of 0.063 and 0.067 expel them from a region of importance in explaining HI. However, their importance should not be neglected because proper use of development assets like land and access to financial resources could define the levels of individual development. Generally, any intervention for household income should consider QEC, IMO DEA and HS on the basis of performance. Regarding the importance, QEC and IMO take frontline urgency. For that, it is attested that both internal and external resources provide a contribution in achieving income for household sustenance and that no resources can work alone.

5.7 Discussion

The paper aimed to: (i) examine the influence of quality electricity, development assets twined with individual motivation on household income, (ii) evaluate the mediating effect of household strength and moderating roles of priori variables in perpetuating household income. This paper extrapolates that quality electricity surpasses development assets and individual motivation in predicting household income. This was confirmed through alternative hypotheses which indicated electricity had very strong prediction power on household income through direct paths to endogeneity. With quality electricity, people no longer travelled long distances for some services like milling. All these have led to the drastic decline of service costs leading to the increase of financial saving basket at the household. Information from the focus group discussion showed that on milling services there was a decline of price up to 70% after electricity connection; for example, in Uyui (Ilalwansimba Village) with diesel powered milling machine, the cost for husking a bucket of paddy was TZS.3 500/= before electricity connection. Equally, after electricity connection the price shrunk to TZS.500/= this was contributed to by dependence on electric powered milling machines. In furtherance, the FGD consensus was that

…. having electricity is something to cheer up because most of the services here in our village have gone down. Currently, we have only one diesel powered milling

machine which operates as a backup in case of an outage. The price we pay on diesel powered milling machine is higher compared to that we do on electric motored milling machine…..(Focus group discussion, Uyui, 18 February 2018)

The above information from the FGD means, the respondents no longer incur many costs on some sustenance services like milling. This is an indication that there is an income increase as the results of reduced expenditure caused by electricity connection in rural areas. This is key evidence of short-term effect related to income acquisition.

Apart from the declining cost services on milling, it was also indicated that some other services such as kerosene were reported to be high while offering less comfortability to users. Night studies for schooling kids were reported to drain money for Kerosene before electricity connection. This changed after electricity connection; respondents had saved a substantial amount of money after cutting cost from kerosene. These results corroborate the findings by Mazumder, Keramat and Rubel (2011) who reported that in Dumuria rural Bangladesh rural electricity had led to the decline of Kerosene dependence thus reducing expenditure as well.

Moreover, another notable benefit of electricity on business operators was noted. The milling services after electricity connection shifted a paradigm. In Kabanga Village in Kasulu, all milling machine of diesel type were substituted with electric motor-powered milling machines. This was because of the fact that operating a diesel-powered machine was expensive and the margin was little. The most hitting challenge was the high price of fuels which was not predictable as well. The shift of paradigm went hand in hand with increased milling machines which offered diversity of services from grinding to husking. For that, respondents did not travel to the far town areas to seek more milling and husking services for maize and paddy.

Similarly, with electricity availability in the rural areas, there was increased employment resulting from new firms like metal welding, brick making, restaurants and carpentry. The new firms were directly linked with the use of electricity. New business-like food vending along the road was reported as another source of job creation and income growth. In fact, on employability, the results are consistent with Dinkelman (2011) who reported that electricity play important roles in accentuating employment to women by enabling them to allocate more time in productive activities. On firms development, it is in line with Burlig and Preonas (2016) who found that with electricity availability there is new capital invested in small but modern firms such as kioski and hair salon. However, the results contradict Matinga and Annegarn (2013) who reported electricity having no effect on business and small firms. Electricity influences purchase of domestic assets used for collaterals in accessing financial services (United Republic of Tanzania , 2017), The common electrical asset was TV and home theatres to those who owned TV show centres in their premises. Electricity has also led to housing furnishing and modification, hence increased asset value. The result is analogous to Lewis and Severnini (2019) who inferred that electricity in rural areas had led to increased asset value, such as housing and land. The values increase is due to the fact that electricity attracts population growth in some centres which also leads to demands of services such as house for rent.

Further, the paper enumerates that development assets and individual motivations should not be underrated in bringing income on stage because they have a positive effect as also found by Lenz *et al*. (2016) and Torero (2015) that complementarities are useful in accentuating income as well. Although the alternative hypotheses of the influence of development assets (Land, access to financial services, information and technology) on household income was rejected. Upon encountering the mediator it showed significant prediction. Therefore, different resources have a significant contribution to household income. Although quality electricity has emerged to be a powerful predictor of household income through large effect size, but alone cannot work better. Electricity should also be considered as a stimulant of income given availability of all necessary conditions because a single resource, rare, imitable, valuable or vice versa cannot affect income.

The paper empirically demonstrates that household strength as an intermediary is imperative for effective use of resources. The ability of the household to mobilize available resources is vital for firm start-up, planning and decision making. Weak households cannot generate income even if they are presented with the necessary resource; speaking of that, the paper deliberate that for resources to have effects on household income, the strength of a household as an intermediary should become a genuine consideration. This is supported by the alternative hypotheses which were significant based on the indirect effect of household strength's ability to transmit effect from electricity and development assets.

Moreover, the paper authenticates that complementarity of education and gender is paramount in ensuring significant effects of electricity and individual motivation on income. This inference is in line with that of Lenz *et al*. (2016) and Shahabadi, Nemati and Hosseinidoust (2018) that education better complements electricity in crafting household income. In fact, with quality electricity, education offers ability in discovering an array of income generation opportunities just like gender does on individual motivation. Gender determines the level of intrinsic or extrinsic motivation towards income generation if it is discounted from development actions it impairs the efforts and household success in income generation as also reported by Urošević *et al*. (2016).

5.8 Conclusions and Recommendations

The improving rural households' income in Tanzania requires multidimensional and coherent approaches, but for visible results, electricity is not an option but "quality and affordable electricity" remains to be. While this is empirically substantive, the rest of resources like land, technology and communication need an acute consideration as important complementarities. In fact, electricity is a stimulant of income generation if merged with locally available resources and human behavioural traits based on motivations. The arrays of business opportunities and ability in reducing life sustenance costs should not be considered as directly related to electricity but also on the strength of households. Relating household income with a single or two factors is a drawback, thus, a list of conditions and resources play vital roles in household income generation. At the local level, while energy utilities increase the effort in reduction of electricity poverty, it should not be seen as the end but the beginning for ministerial actions to ensure the standard environment for income growth. There must be ministerial cross-cutting engagements in creating conducive and sounding opportunities for income generation. Along this continuum, access to roads, market for agricultural produce, financial services, information and communication technologies must all be ensured by ministerial and local authorities at the village in making income acquisition a sustainable benefit.

5.9 Contribution of the paper

The paper contributes to a blistering paradoxical debate of energy income nexus by revealing empirical arguments on how electricity and allied resources improve household income. The paper presents that electricity surmounts other resources by importance and performance but alone could not work. Unlike previous studies, the paper pose novelties in analytical techniques where a unique PLS-SEM is seemingly emerging as a game-changer in energy economics by disentangling convoluted relationships of the theoretical model. In a parallel vein, it marshals the RBV theory by suggesting empirically that the income goal of a household cannot be brought about by internal resources only. In a state of meagre internal resources, a household can use the external ubiquitous and rare resource to attain an income goal. For that, the paper enumerates that the RBV needs an extension to include external and replicable resources. Nonetheless, the resource will only be valuable if properly used to render effects. Thus, the VRIN assumptions in RBV cannot entirely be depended upon for income success.

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Appendix 5.1: Operationalization of measurement variables

Code	Quality Electricity-QEC (Y1) Exogenous	Details
QEC1	Reliability of network of supply	Electricity is available most of the time is needed
QEC2	Voltage stability	Electricity is capable of running available appliances
QEC3	Safety of supply	Electricity does not cause an accident
QEC4	Affordability of consumption	Consumers spend no more than 5% of income on electricity
QEC5	Resilient to shocks	The network system is not vulnerable to shocks
Development Assets -DEA(Y2) Exogenous		
DEA1	Workforce	There is the skilled, semi-skilled and unskilled human workforce
DEA2	Information and technology	Information accessed lead to economic activity decision
DEA3	Land	The land is adequate and fertile for economic activities
DEA4	Fiscal capital	Feasible access to financial resources to start enterprises
DEA5	Social network and connection	Well linked with others for economic benefits
Individual Motivation -IMO (Y3) Exogenous		
IMO1	Self-realization	There is the fulfilment of one’s potential
IMO2	The desire for better living	Innate feeling and desire to better oneself, growth and advancement
IMO3	Personal satisfaction	Setting income as a goal of happiness
IMO4	Acceptance and recognition	The feeling of being part of the surrounding starter society
IMO5	Responsibility	Driving forces for income generation; being dependable
Household Strength (HS) Endogenous		
HS1	Background in wealth ownership	The household has a long history of wealth ownership
HS2	Skills in resources mobilization	There are skilled members with resources mobilization skills
Household income -HI (Y5) Endogenous		
HI1	Financial savings	Gain fund as a result of reduced life costs
HI2	Enterprises start-ups	There are emerging enterprises in the local environment
HI3	Employment	Emerging job creation among the population
HI4	Domestic electrical assets	The household has valuable electrical assets
HI5	Owner-occupied dwelling	Value of the dwelling unit increased due to electricity

CHAPTER SIX

6.0 Summary, Conclusions and Recommendations

6.1 Summary of the Key Findings

The present study was conducted in rural areas of two Districts: Kasulu and Uyui. The overarching objective was to assess households' short- and long-term socio-economic improvements emanating from quality electricity. The study focused on four specific issues: it examined affordability of electricity from the state energy utility; equally, it assessed reliability of electricity for domestic expenditure on lighting fuels. It also delved into determining the influence of electricity on adoption of Information Communication Technologies (ICT). Lastly, it determined the influence of quality rural electricity on household income acquisition.

The reasons that inspired the present study to be conducted were many: first, there was sluggish clarity on whether investment efforts in electrification are serving the course in rural areas where more than 75% population live with deprived socio-economic indicators. Second, there was a paucity in determining the influence of electricity on household socio-economic dimensions. The influence has always been reported with negligible considerations of reliability and affordability which are decisive indicators of electricity's influence. Finally, it was enticed by an overwhelming shortfall in gauging the influence of electricity on complex socio-economic variables. Electricity has mostly been modeled as a lone predictor of household socio-economic development with less consideration of other development complementarities such as land access to fiscal resources.

6.1.1 Affordability of electricity to rural consumers

Affordability of electricity was examined at two levels; the first was affordability of connection and second was affordability of consumption. In this focus, domestic electrical appliances ownership among the rural households was assessed. To examine affordability, consumers were categorised into five income quintiles. Then, index of Price Income Ratio (PIR) at 10% threshold was used to gauge affordability of connection. On affordability of consumption the PIR at 5% was used along 30kWh as basic need electricity. The results indicated that on connection, electricity was not affordable to 61.76% of the respondents in lowest income quintiles. On aggregate respondents spent 33% of household annual income on electricity connection. This was more than a normal threshold of 10%. Only 2.39% of respondents have spent within the threshold, an indication of noticeable affordability.

On affordability of electricity consumption, the results revealed that respondents of all income quintiles had spent no more than 5% of monthly household income on electricity consumption. Equally the amount of electricity consumed was between 40 and 45 kWh for respondents in the lowest quintile. Respondents in lower, medium, high and highest quintiles consumed up to 57.3 kWh per month. The amount consumed is indeed above the basic need electricity of 30 kWh. The results on the electrical appliance show that after electricity connection at the household electrical appliances increased. For example, TV increased from 8.2% to 59%. Fanatically, electrical appliance ownership was accentuated by knowledge on how to use the appliance, electricity connection, desire for social well-being, economic status and affordability of electricity consumption as indicated through multiple regression.

6.1.2 Reliability of electricity for domestic expenditure on lighting fuels

The study focused on assessing reliability of electricity system and its determinants. It also focused on examining the effect of outages incidences on domestic expenditure on backup fuels. Due to possible volatility of measures, a stepwise analysis technique was used as a remedy. Therefore, the results from the bipolar scale indicated that electricity reliability was enhanced because of: first, voltage fluctuation did not affect appliance use at the household; second, electricity was available most of the time respondents wanted to use it; third, about 74.1% of the respondents indicated that most outages occurred in the morning and afternoon. At that time, the use of electricity was minimal because most respondents had left their homes for farm and off-farm activities. Nonetheless, about 25.9% of the respondents reported evening as the common time of the outages occurs. This offers veracity in the inference that electricity was reliable. Fourth, the duration of the evening supply was 4-5 hours. According to the Multi-Tier Framework, a reliable electric system had to provide more than 4 and 5 hours for evening supply. Therefore, reliability was applauded.

On System Average Interruption Duration (SAID), the results showed that the system was reliable because for the year 2018 respondents in Kasulu had unplanned outages of 154.27 hours equals to 6 days. In Uyui respondents had 361 outage hours equals to 15 days. The results further confirmed prevalence of reliability because respondents had few hours and days in dark to due unplanned incidences. On System Average Interruption Frequency (SAIF); the results showed that Kasulu had SAIF of 130 incidences of unplanned outages. On the same, Uyui had experienced 260 incidences. Although outage frequencies were scary, reliability was ensured given the duration of outages. Spending 6 and 15 days in darkness as the result of unplanned outage duration is somehow better in terms of reliability on annual basis. Moreover, on index measures, high reliability index scored high mean (37) than moderate (30) and lower reliability (26) threshold. The difference between means scores was checked through the One-Way ANOVA test which indicated that the means scores between reliability indices had a significant difference at $p < 0.01$. This gave an indication that the electric system had better reliability. The results for determinants of system reliability as estimated by ordinal logistic regression signposted that reliability of electricity system was significantly predicted by pole decay, weather, fire, and lightning. Vegetation contacts also had prediction power as well. The binary logistic model for domestic outages demonstrated that wiring by a registered technician, household size and school children number, controlled use of electricity at the household predict outage significantly.

Regarding reliability of electricity and expenditure on backup fuels, the prognostic results revealed that on monthly basis, outage incidences exacerbated unplanned expenditure on backup fuels. Generally, respondents had spent TZS 1100/= on other sources. District wise, on backup fuels, respondents in Kasulu spent TZS 800/= and Uyui TSZ1450/=. This disparity was attributed to the levels of reliability which was better in Kasulu, so does the cost on backup fuels. In sum, before electricity connection, the cost on lighting fuel incurred by the respondents was TZS 12000/=. The cost on the same after electricity connection as combined with backup cost (electricity plus backup cost) stood at TZS 10850/=. Surprisingly, the results from the paired sample t-test revealed that the cost on lighting fuel before electricity connection did not differ significantly with cost on electricity and backup fuels combined. The result signifies those outages incidences did not hike domestic expenditure lighting fuels.

6.1.3 The influence of electricity on the adoption of ICT

Adoption of ICT at the household was examined with TV, radio, mobile phone and computers being devices of interest because in the current era of digitalization they constitute rural ICT. Thus, the adoption of ICT was assessed in relation to electricity, then preference on ICT devices by gender of the household head was examined as well. Finally, the practical use of ICT in accessing plausible information was examined. The descriptive results on ICT adoption discovered that mobile phone and TV were highly adopted technologies, 59.8 % of the respondents owned TV, while 68% owned a mobile phone. But before electricity connection, 85% of the respondents owned mobile phone of which 22% of the mobile phones owned supported internet compared to 82% after electricity connection. The computer does not form itself as rural ICT. There was a paradigm shift, before electricity connection, 78% of the respondents owned a radio, 38% purchased new radios after electricity connection, the radios were operated through electricity at this time. These are considered as an improvement in widening information access among rural people.

On ICT preference by gender of the households, it was clear that Mobile phone was ranked first by females with a mean rank of 2015.21 against male's rank of 183.28. Equally, TV was ranked high by males 189.75 versus females' rank of 178.04. These results indicated that female headed households prefer mobile phone than TV, this was caused by its functional simplicity coupled with the role it serves in transactions. Speaking on TV, male liked TV because it is controlled by them easily. Radio was preferred mostly by male headed households while the computer was preferred mostly by male-headed households. Male headed household preferred Radio in the third-place than female headed households. This might be surprising, most female respondents were government workers, something which could have triggered this high preference. The Mann-Whitney U test revealed that there was no statistically significant difference on Mobile phone and TV preferences at $p < 0.05$.

On determinants for ICT adoption, results from the Poisson regression indicated that electricity connection strongly predicts adoption to ICT. Electricity availability plays key parts in ICT especially in reducing the upkeep cost. Some other predictors were income of the household, age of the household head, affordability of electricity consumption, information need and wattage capacity of the appliance. It was explicated that the lesser the age the more the likelihood of adopting ICT than older people. Adults would need ICT to keep themselves aware of some key state issues contrary to the counterparts who have made ICT to be part of the basic need. Against the Technological Acceptance Model, the results strengthen it especially the statistically significant predictors. Moreover, with increasing ICT adoption, gender barriers on information access were barricaded because both men and women have improved TV access hours regardless of the ownership. The results revealed that median TV access hours for female increased from 4 hours before electricity connection to 14 hours after electricity connection. Further, there was fairness in mobile phone ownership between males (95%) and females (65%) at the household.

On practical use of ICT in accessing plausible information, it was found that the adopted ICT are commonly used to search for information based on politics, economic, weather and social issues. Information search behaviour or preference was based on the gender of the household head. Thus, the Chi-square test showed a statistically significant difference in information search by gender of the household head. Likewise, there was no differences in the use of ICT in accessing political, economic, agriculture, social and entertainment information across the ages of the household heads as revealed by the Kruskal-Wallis H Test.

6.1.4 Influence of quality rural electricity on household income

Analysis of quality electricity's influence on household income was guided by key arguments that electricity alone cannot render adequate effects on income especially in the world of multivariate resources. The possible predictors of income were established and modeled along with quality electricity. Partial Least Square Structural Equation Model (PLS-SEM) was used to estimate all the variables by testing alternative hypotheses. The results exhibited that with all key resources being available to the household; quality electricity has very strong significant power to predict household income than other competing resources. It increases household financial income saving as the results of a reduced service cost on lighting fuels, milling and mobile phone charging; these are short term effects that come quickly along with electricity connection. With quality electricity, respondents saved up to 70% of the costs which were incurred on milling service. Convincingly the hypotheses tested indicated that electricity stimulates emergency of small firms like kioski, salon and food vending leading to increased employment.

Moreover, the hypotheses which were tested suggested that development assets such as land, ICT and networking, upon being mediated poses significant prediction power. individual motivation coupled with a desire for a better living has a significant influence on household income. They do so through the intermediate effect of household strength. It is plausible to report that, the bootstrapping results on hypotheses tested endorsed education as an important complementary factor that significantly moderates the effects of quality electricity on household income. The owner dwelling unit as a valuable asset has seen its value increasing after being connected to electricity as well, thus becoming an indicator of income growth among the rural household. The analytical results on effect size specified that quality electricity had a large effect size of 86.1% in improving household income while development assets had 5.3% and individual motivation had 6.4% had very small effect size. Additionally, Importance Performance Map Analysis (IPMA) holds that electricity has high performance in predicting household income by 81.66% and importance by -0.4.70. This was another confirmatory evidence that although electricity works along with other resources, its importance was above the rest.

6.2 Conclusions

Affordability of electricity connection among the rural consumers of the lowest and lower-income level was not feasible. While the upfront cost for electricity connection remained equally minimal; materials and technical costs aggravated more unaffordability. Realistically, unaffordability of electricity connection sparks transient poverty by forcing consumers into loans burden. Electricity consumption was feasible in terms of affordability, respondents had managed to consume far above the basic need for electricity. The income spent on electricity consumption was within their ability and did not exceed the threshold. Nonetheless, electricity availability, consumption affordability and economic status of the household have attracted purchase and ownership of electrical appliances which accentuate the well-being of the rural people.

Reliability of rural electricity system was prevalent, despite some outage incidences. Issues of voltage fluctuation did not affect the use of appliances at the household. Indeed, electricity was available most of the time consumers wanted to use it. On the annual basis, there were few days consumer spent without electricity. The reliability of the system was determined by weather, fire outbreak lightning and vegetation contact. Overwhelmingly, controlled use of electricity at the household, wiring by registered technician and size of the household tend to determine the reliability of electricity at the domestic level. There were minimal effects of outages incidence on domestic expenditure for backup fuels. The cost that a household incurred was tolerable in relation to the utilitarian of electricity. Correspondingly, the total cost on electricity consumption and backup cost when combined did not hike far above the cost spent on lighting fuels before electricity connection.

Adoption of ICT in rural households was enhanced *inter alia*, electricity connection, consumption affordability and income of the household. The common rural ICT which were strongly adopted included mobile phone, TV and modern radios. Electricity was a key influencer because ICT devices like TV needed reliable electricity to power it. Equally, mobile phones, with electricity supply the cost of the upkeep through regular payment for battery charging were eliminated at large. With ICT there was a fair improvement in communication and access to information because females had room to own mobile phones and access TV as well. The mobile phone ownership by women was a milestone improvement in communication and information access. It was found that due to homogeneity age of the household did not segregate people in using ICT of a different type for accessing plausible information. Electricity has closed the domestic gap in access to political, economic, social and weather-related information through ICT adoption.

Quality of electricity supply to rural consumers is important in improving household income. While different resource contributed to household income, electricity played a unique role. Income was made possible through reduced cost on basic services of household sustenance, hence increased the amount saved in the expenditure basket. Electricity has influenced new rural mechanised business such as brick making, carpentry and metal welding. Emerging rural business had offered new job arrays while attracting income growth and positive effects on more opportunities. While electricity is much-admired as strong predictor of income; individual motivation and development assets like land, access to financial services, contributes directly and indirectly on making household income go next level. For that, electricity is not the end in attaining better household income, it is an important catalyst and ingredient of income acquisition, but alone cannot suffice.

6.3 Recommendations

6.3.1 Affordability of electricity in rural areas

Electricity connection was not affordable to consumers of the lowest income. Thus, it is recommended, first, to the State Energy Utility (TANESCO) and Energy and Water Utility Regulatory Authority (EWURA) to device instalment payment modality. This is expected to relieve rural consumers from debts and selling off assets which later creates a vicious cycle of poverty. In that, consumers can be left to pay at least 50 % of the total connection costs including materials. The rest of the amount should be included in the consumption bills for a specific period. Second, to the State Energy Utility, should strive to provide free inspection services for wiring installation at the household level. Third, EWURA should register more independent power producers and distributors in rural areas to increase service competition. This could result in the decline of connection costs. Fourth, the government through the ministry of the industry and trade should subsidise electrical materials to rural consumers to reduce the connection cost. Lastly, because electricity was affordable on consumption, consumers are argued to avail themselves with more income generation activities in their localities, this will add on income growth and poverty reduction.

6.3.2 Reliability of the rural electric system

Notwithstanding the fact that reliability of the system was ensured, the frequency of outages escalated. Thus, TANESCO is recommended to schedule for intensive inspections of system networks to surface alarming faults. This will reduce the frequency of unplanned outages which could minimally or maximally affect consumers. Moreover, TANESCO and REA are recommended to use iron and concrete poles in areas which are prone to termites. This will reduce financial losses emanating from the costs to replace the fallen poles. The iron and concrete poles are also resistant to fire outbreak in bushes where the transmission lines pass; it is also resistant to bad weather coupled with high wind. Additionally, Kasulu and Uyui share the same geographical zone, they are all prone to lightning which has destroyed several transformers. Thus, the State Energy Utility is recommended to ensure availability of enough transformers in their inventory list. The purpose is to reduce time on logistic to replace those which are hit by high intensity lightning despite the availability of arresters.

6.3.3 Electricity for ICT adoption in rural areas

While electricity availability plays a monumental role in ICT adoption by the rural household, it is recommended to the rural people to use ICT to attain well-being. Access to information by using adopted ICT devices should not be the end, but the means to achieve some other facets of development. The adopted ICT can be used by the rural household to establish some small business such as TV show centre and make income grow. More importantly, ICT devices such as mobile phones that support internet should be used to avail educating programmes especially those suiting primary and secondary school students. Any misuse of the devices could aggravate over expenditure on issues that benefits them less. Finally, it is recommended that household continues searching political and economic information and make use of them in changing lives.

6.3.4 Quality rural electricity and household income

Electricity is arguably the best ingredient and pre-requisite to attaining household income. While this claim has proven factual, it is recommended; first, to the government through its ministries that electricity alone is not enough to bring household income at a better level. There must be enough cross-cutting ministerial efforts to create a conducive environment for other income-generating activities to take place. Access to market for example, in rural areas where agriculture is the main activity, should be enhanced well. Thus, while electricity is better for income generation through off-farm activities; the market for farm produces and products from light processing firms need assurance. There must be a proper use of other development assets like land, access to financial resources, information and communication technology, individual motivation based on personal desire to achieve income. In fact, a combination of resources should be in place and a good pace to attain higher income at a reasonable time. Second, to the rural people, it is such crucial to make joint efforts to establish a sustainable business using the available electricity. There could be a joint metal welding firms which can be established in forms of cooperative entity. In that, people can donate small amount of capital and register a highly profitable firm because in rural areas the construction industry is growing faster. There is also a shift of paradigm from timber to metal use in housing construction.

6.4 Contribution of the Study

The present study offers vast contributions ranging from theoretical, policy and development vision, debate in the literature and finally on analytical methodology. In section 6.4.1, theoretical contribution has been explained on energy justice theory, multi-tier framework, technological acceptance model and finally resource-based view

6.4.1 Theoretical contributions

One of the assumptions of the Energy Justice Theory is that there must be justice in accessing electricity. Justice in the price for connection and consumption as well as distribution and transmission. Further, it clarifies that energy is the product of the environment, thus the benefits should be shared equally. In furtherance, it insinuates that there must be recognition justice where all social groups must be served with electricity. Now, the present study validates some assumption, first, the theory holds on the just price for consumption, because the consumers in rural areas had paid a fair price within their ability to pay. The assumption of theory on the just price for connection was found out of the ring. The price was high and so injustice prevailed. Generally, the theory remains valid in some aspects, so far applicability of some of the assumptions seems to be Eurocentric for instance all people to be provided with electricity. This is because in the developed countries, large amount of electricity can be produced and be distributed at an affordable price to all.

Regarding the Multi-Tier Framework, it has the assumptions that electricity should be affordable. Consumers should not pay more than five per cent of the household income to consume 30kWh. Additionally, on reliability, the framework is of the assumptions that, evening supply of electricity should be more than 4 hours, and the frequency of outage should at least be with absorbable range by consumers. Moreover, there should be no voltage instability and accident emanating from the electricity supply. The results of the study validate the assumptions of the framework because electricity was affordable and consumers spent no more than 5% of income for the bill. Respondents had consumed between 40 and 57 kWh. For that, the framework holds and is more relevant. On reliability, it was validated through the assumptions of voltage stability which did not prevent consumers from using the available appliances. Further, electricity supply in the evening was more than 4 hours and most of the time consumers wanted to use electricity the system was live and available. Generally, the framework is relevant in case of reliability and affordability assessment.

Technological Acceptance Model (TAM) has also been authenticated in some of its assumptions that guide ICT adoptions. TAM holds that “perceived usefulness (PU) and perceived ease of use (PEOU)” of any technology is enhanced by the external variables. This assumption was tested positive because technology such as TV and mobile phones were perceived as easy to use after electricity connection which is a background factor. The easiness of use was built on the fact that electricity cuts operation cost of mobile phone charging. In fact, without electricity, it could be difficult for local people to adopt or avail themselves with TV. The reason is that it requires a hard mechanism of private generators to operate. This could be economically challenging in areas where the income of the people is volatile. Education and level of economic status as background factors contribute as well on PU and PEOU. This is because the usefulness of the technology is hinged on how a person benefit from it. In that regard, the adopted technologies such as TV and mobile phone served useful by enhancing access to information and communication.

The Resource-Based View (RBV) has the assumptions that for an organization (household in the present context) to attain its goal, internal resources which could be tangible and intangible must be used fully. Equally, the resources must be valuable, rare, imitable and non-substitutable. The present study gauged both internal and external resources against household income. It is authenticated that, a household like any other organization has its goal (income goal). The desired goal was found being achieved by using both resources tangible (Electricity, Land, Technology) and intangible (Household strength, Motivation). Thus, the RBV’s assumption counts valid because the present study had a similar revelation that both tangible and intangible resources are valuable in predicting income. The resources are not rare (land and electricity), but they are valuable. RBV’s assumptions fall short against reality. Because in achieving the intended goal, household have made use of both internal and external resources. Generally, the RBV needs an extension to include internal and external resources, while noting that resources will only be valuable if it serves a purpose. Equally, issues of imitability and non-substitutability do not count valid especially in the era of innovations and multivariate resources. Additionally, any resource can help an organization to achieve the goals, regardless of whether it is ubiquitous or rare.

6.4.2 Energy policy and development vision

The current energy policy aims at ensuring socio-economic development by increasing production and distribution of reliable, affordable and sustainable access to electricity. For that, the present study, explicitly informs the policymakers about the progress and achievement that are recouped from the available electricity. It informs that unaffordability of electricity connection in rural areas could be a barrier to achieving the desired goals. Thus, an effort must be taken to steer affordability from the policy point of view. On development vision, the present study has articulated various dimension of development which are being achieved. These include the unique role of electricity in income generation in rural areas thus leading to the achievement of Tanzania Development Vision 2025 and the first sustainable development goal based on ending poverty in all its forms.

6.4.3 Debate on energy-socio-economic development literature

The present study contributes to a long time and heated debate about energy development nexus in the literature. Electricity has been considered a prime predictor of socio-economic development by scholars, policymakers, development planners and energy economists at the national and local level. The present study argues that it is challenging to associate the socio-economic development with one predictor. This is because we are living in a multivariate world where several resources are used in attaining development. It is arguing that it could be equivocal to infer electricity as the sole predictor of income, domestic assets and ICT adoption without primarily gauging its quality. The reason is that the effects we see is the results of quality electricity. People might be connected to electricity and yet remain poor if its reliability and affordability limits consumptions.

6.4.4 Analytical methods

The methods of analysis used in studying electricity versus socio-economic issues sufficiently determine the validity of the inferences to be drawn. The first-generation models such as Regression, Difference in difference, Propensity score matching and case studies for qualitative approach have been popular methods in carrying out analysis. With some analytical models, it could be challenging to uphold the confounding factors (Tertium Quid) and unobservable factors. It would also be challenging to handle the complex variables in estimating complex theoretical models. Analytical methods have received less consideration in energy studies. The current study apart from using first generation models, has contributed to analytical debates by delving into the second-generation model that is unique Partial Least Square Structural Equation Model (PLS-SEM). The model allows multiple independent and dependant variables to be estimated together. It upholds both moderators and mediators in a go. It has strong predictive power, making it one of the most reliable models for reliable results because it offers a series of confirmatory advanced analytical options. To the best knowledge of the author, PLS-SEM has not yet been adequately integrated in energy studies. From this point, the model is seemingly becoming a game changer in executing complex issues in energy related studies.

6.5 Areas for Further Research

Generally, it is impossible to capture all the aspects of electricity and dimensions of effects in a single study. Therefore, the following areas are suggested for further researches: -

(i) There is a need to study more socio-economic dimensions like education and health in relations to electricity in rural areas

(ii) Reliability of electricity can still be studied by bringing in the aspects of planned and unplanned outages by using advanced toolbox (SCADA) for data collection

(iii) There is a need to study the economic and social impact resulting from electricity outages incidences in rural areas

(iv) It is vital to undertake a study that estimates how ICT adoption has helped rural consumers in addressing income and well-being issues.

6.6 Limitations of the Study

Several limitations occurred, during data collection some key informants from TANESCO did not want to be recorded by using the voice recorder. This posed challenges in capturing all information at a quick pace. However, to address this, a notebook was used to key information outspoken, in case of information missing out the key informants allowed for further follow-up questions even after a session has timed out. The office assistant in Tabora district was not fast to facilitate data collection permit. For that, the office of the Regional Administrative Secretary provided the permit which was presented to the district authority in Uyui. Moreover, for information regarding objective four (4) some variables were not adequately captured by the questionnaire due to change of analytical method. Therefore, the second round of data collection on those few variables was conducted, although it cultivated unforeseen expenditure , it was well organised.

APPENDICES

Appendix 1: Household survey

Date ………………………

Preamble

Dear respondent,

My name is Bikolimana Muhihi, a PhD candidate at Moshi Co-operative University. I'm conducting a study on "**Rural Electricity for Socio-Economic Improvement in Kasulu and Uyui Districts, Tanzania.** Your household has been selected randomly to be included in this study. Your participation is voluntary. The prime aim of this survey is to collect relevant information useful to assess socio-economic outcomes emanating from the rural electricity supply among the consumers. As a respondent, you are requested to answer all questions clearly, however, you are free to drop from this activity at any time you feel. I would like to assure you that the information you provide will be secured and that a high degree of confidentiality will be maintained in all aspects. Please, feel free to ask for clarification in case the posed question is not clear to you. The time this activity is between 45-60 minutes

Thank you very much.

Questionnaire codes

Questionnaire No. [ ]:

Interviewer…………………..........Region..........................District……......……….: Ward …………………: Village…………..................: Time interview starts …………………end …………

A**: Household demographic characteristics**

Please provide answers according to the instructions given

1. Sex of the household head; Male [ ], Female [ ]
2. Age of household head [ ]
3. Marital status; married [ ] Single [ ] divorced [ ], widowed [ ]
4. Dwelling house features, 1=Iron roof [ ], 2=Grass roof [ ], 3=Tiles roof [ ], 4=Brick/Block wall [ ], 5=Mud and wood wall [ ] ,6=Concrete wall [ ], 7=iron wall [ ]

<u>Do not ask the question, just observe the dwelling unit components</u>

5. Primary economic activity of the household head, Peasant [ ], Govt.Employee[ ], Livestock Keeping [ ], Business [ ]
6. Secondary economic activities; Peasant [ ], Govt.Employee[ ], Livestock Keeping [ ], Business[ ]
7. Education status; 1=Didn't go to school [ ], 3=Primary Education [ ], 3=Secondary Education [ ], 4=Certificate course[ ], 5=Form six, [ ], 6=diploma [ ], 7=advanced diploma [ ],8= Bachelor degree [ ], 9=Post Graduate[ ]
8. Current number of household members residing in for not less than one month [ ]
9. Number of household members above the age of 18 including heads of households [ ]
10. Size of the living houses in terms of rooms for the household members [ ]
11. Household members who own and use mobile phones, 1=Male [ ], 2=Female [ ]
12. Number of houses in the compound [ ] <u>"Do not ask this question , just observe the available houses"</u>
13. Years since electricity connection from the utility [ ]
14. Do you have a bank account? Yes [ ], No [ ]
15. Are you a member of any SACCOS or Landing and Borrowing groups? Yes [ ], No [ ]

B1: Affordability of electricity connection to the household

16. Number of the working members of the households prior to electric connection 1=Male [ ], 2=Female [ ]
17. Sources of income for the household prior to electricity connection; Farm produce [ ], Business [ ], Paid Salary [ ], Fire wood and charcoal selling [ ], Assistance from relatives[ ] , explain others ………………………………………
18. What was the average annual income (TZS) of each working household member prior to electric connection?

    i)……………………………………

    ii)………………………………….

    iii)…………………………………

    iv)……………………………....

    v)………………………………….

    vi)…………………………………

    vii)………………………………

    Total income of the | **TZS** | **household**

19. Upfront charges paid to the utility for electric connection TZS…………………………..
20. Preference mode of payment for electric connection Lump sum [ ], Installment [ ]
21. Did you face any financial difficulties in paying upfront cost; Yes [ ], No [ ]
22. How much did it cost to for technical services? TZS ………………………………
23. How much did you pay for materials TZS…………………………

24. Which is of the following is true about electricity connection price? 1=Unaffordable [ ], 2=Moderately affordable [ ], 3= Very affordable [ ]
25. Was it a challenge to meet cost for electrical wiring? , Yes [ ], No [
26. Did you take any loan to secure funds for electricity connections, Yes [ ], No [ ]
27. If yes where did you take the loan? Bank [ ], Friends/neighbors [ ], SACCOS [ ], Landing and borrowing groups/VICOBA [ ] , Sold the assets [ ]
28. If the answer is yes in 26 , was the loan timely repaid ? , Yes [ ], No [ ]
29. Generally, what was the total cost for electricity connection TZS………………………………
30. What was the share of household expenditure on other important services during the process of electricity connection: Indicate the figure in TZS

    i. Education ………………………….

    ii.Health ……………………………..

    iii.Transport …………………………

    iv.Communication …………………..

    v.Food……………………………….

    vi. Cooking energy fuel……………………….

    vii.Clothes……………………………………..

    Others…………………………………………….

31. Which of the following factors constrained you in the process of electricity connection?

SN	**Constraining factors**	1=weak constraint,2= moderate constraint, 3=Strong constraint, 4=Very strong constraint, 5=Very very strong constraint				
		1	**2**	**3**	**4**	**5**
1	High cost of electrical materials					
2	High charges for technical cost					
3	Unaffordable upfront connection charges					
4	Bureaucratic process of electric connection					
5	Unavailability of poles for distribution					
6	High cost of electric poles					
7	House modification maintenance to meet criteria					

B2. Affordability of electricity consumption for the household

32. Consumption category, low /zero tariffs [ ], High tariffs [ ]
33. Current number of members residing in the household for a month [ ]
34. Present number of working household members 1=Males [ ], 2 Females[ ]
35. Average monthly income (TZS) of each working household member (HHM) for the past three months?
    i……………………….,ii……………………….iii,……………………….,iv………
    …………v……………………,vi……………………vii……………………………..

Total average income of the household for the past three months TZS_________________

36. Amount of money spent on electricity for the past three months TZS……………………
37. Amount of electricity consumed for the past three months -----------------------------
38. Electricity consumed for the current month ……………………………………….
39. Ever failed to purchase power units due to financial constraints? Yes [ ], No [ ]
40. If yes in 39 , how many times for the past three months [ ]
41. Electricity consumption trend 1= Increasing [ ], 2=Decreasing [ ], 3=Constant [ ], explain why? ……………………………………………………

Total expenditure on electricity ………………………., Average kWh consumed ………………….

C. Electricity consumption control mechanisms by the households

42. Indicate the mechanism used to control electricity (select the appropriate mechanism)

SN	Mechanism	Yes	No
1	Use energy saving bulbs		
2	Use mixed sources of energy for lighting		
3	Minimize the number of bulbs		
4	Keep minimal use of heavy electrical appliances		
5	Disconnect electricity for some hours		
6	Switching off some appliance when not in person’s use		
7	Avoid the use of security lights		
8	Set specific time for watching TV/VIDEO		

D. Influence of electric connection on household’s appliance ownership

43. Did you own any electrical appliances before electricity connection? Yes [ ], No [ ]
44. If the answer in 43 is yes, indicate the list of electrical appliances owned
    1=Radio [ ], 2=Solar rechargeable lamp [ ], 3= Mobile phones [ ], 4=TV/Video [ ], 5=Tube lights [ ], 6=Bulbs [ ], 7=Ironing metal [ ], 8=Water heater [ ], 9=Fan [ ], 10=Electric Jug [ ], 11 =Rechargeable lamps [ ]
    Others,……………………, ……………………., ………………………….

45. What sources of energy did you use to run the appliance? 1=Private generators [ ], 2= Solar Power[ ], 3=Dry Cells[ ] others……………………………………

46. Indicate electrical appliances purchased due to electric connection from the utility
1=Radio [ ], **2**=Solar rechargeable lamp [ ], **3**= Mobile phones [ ], **4**=TV/Video [ ], **5**=Tube lights [ ], **6**=Bulbs [ ], **7**=Ironing metal [ ], **8**=Water heater [ ], **9**=Fan [ ], **10**=Electric Jug [ ], **11** =Rechargeable lamps [ ], **12**=Heater[ ] **13**=Blender [ ],**14**=Electric cooker [ ], Others, add on the list……………………, ………………………, ………………………….., ………………

47. Due to electricity availability, do you intend to buy any (More) domestic electrical appliance? Yes [ ], No [ ]
If yes; mention the appliances……………………………………………..
…………………,
If no explain why :…………………………………………………………………………..

48. Who decide on which electrical appliance to buy? 1=Household head [ ], 2=Other household members[ ], 3=All members of the household [ ]

49. Factors that influence purchase of appliances

Factors	**Yes**	**No**
Knowledge on use of the appliance		
Power connection		
Loan ability		
Wattage capacity of appliance		
Appliance being an asset		
Attainment of social wellbeing		
Gender of the household head		
Age of household head		
Level of education		
Affordability of power consumption		
Marital status		

E: Reliability of rural electric system

50. Have you ever experienced power outages? Yes [ ], No [ ]
51. In 50 above Were the power outage informed, Yes [ ], No [ ]
52. Time of the day power outage commonly occurs; morning [ ], afternoon [ ], evening [ ], night [ ]
53. Did the power outage affect you in any way? Yes [ ], No [ ]
For any response Explain ………………………………………………………
54. How many times did power outage occur per week in the last months? [ ]
55. Ever experienced the longest time of power outage in the last two months? Yes [ ], No [ ]
56. If the answer is yes in 55, what was the duration of outage in Minutes ________________

57. What is the common restoration time after outage? 2-5 min [ ],6-9 min [ ], 10-13[ ] , otherwise……….
58. Do you have experience with informed outage? Yes [ ], No [ ]
59. If the answer is yes in 58 how many times in the past two months ……………………………….
60. Was/were the outage (s) planned or forced? A-Planned [ ], B-Forced [ ]
61. How many times have you reported the outage to the utility in the last two months? [ ]
62. At what time of the day do you experience voltage fluctuation; morning [ ], afternoon [ ], evening [ ], night [ ]
63. How many times have you experienced voltage down per week 1[ ], 2[ ], 3[ ], 4[ ],……
64. Which time of the day would you want electric blackout not to happen? 1=Morning [ ], 2=Afternoon[ ], 3=Evening [ ], 4= All day long/24hrs [ ],

F: Determinants of electric system reliability among consumers

65. Please indicate the determinants of system reliability as experienced from the utility service

SN	Sought determinants	Yes	No
1	Fire		
2	Pole decay		
3	Storage of system components		
4	Weather		
5	Human accidents on poles		
6	Lightning		
7	Home appliance failure		
8	Vegetation interference on system		
9	Production machine failure		
10	Transmission breakdown		
11	Insufficient diesel to operate machines		
12	Irregular maintenance		
13	Transformer failure		

G: Consumers perception on quality of electricity from the utility

66. Please indicate your level of agreement or disagreement on the following statements

	Indicative statement					
1	Electricity availability satisfies me	**1=SA**	**2=Ag**	**3=Un**	**4=DA**	**5=SD**
2	Voltage fluctuation rarely occurs					
3	Electricity is available every time is needed					
4	In case of outage there is fast response for restoration					
5	The frequency of outage is not destructive					
6	In most cases the outage duration is tolerable					
7	In bad weather the system can withstand					
8	Electricity supplied is enough to operate the appliances I have					
9	The momentary interruption outweighs sustained interruption					
10	The major outage rarely occurs					
11	The major outage is informed					

Notes: SA=Strongly Agree, Ag=Agree, Un=Undecided, DA=Disagree, SD=Strongly disagree

67. Please indicate the common causes of domestic based outages

Indicators	**Yes**	**No**
Age of household head		
Number of houses electrified		
Gender of household head		
Education level of the household head		
Controlled use of electricity		
Wiring by a registered technician		
Total schooling children		
Household size		

H: Domestic energy pattern for lighting

68. Do you rely on multiple sources of energy for lighting? Yes[ ], No [ ]

69. What kind of energy sources do you use for backup due to electricity outage?

1= Private generator [ ], 2= Kerosene [ ], 3=Plant residues [ ], 4=Candle [ ], 5=Solar Power [ ], 6=Mobile Torch/Rechargeable lamp [ ]

70. What is the cost incurred on backup sources for the past three months? ……………………

71. Cost on backup sources for electricity for the current month………………………

72. Before electricity connection, what was the cost of lighting fuels per month? ………………….

73. Have electricity helped you to reduce expenses on other forms of energy sources? Yes [ ], No[ ]

74. Indicate the monthly expenditure on energy sources for lighting before electricity connection?.......................................

I: The influence of rural electricity on ICT adoption

75. On the following ICT devices which one did you own before electricity connection?

ICT adopted before utility connection			**Internet feature For mobile phone**	
ICT devices			%Yes	% No
Radio				
Mobile phone				
TV				
Computer				

76. What were the constraints in operating ICT gadgets before electricity connection? ……………………………………., ……………………………………………

77. Who was the first to own a mobile phone in this household? 1=Head of household [ ], 2= Subsequent member to the head [ ] , 3= Any other member of the household [ ]

78. Was there any difference in ICT adoption after electricity connection? Yes [ ], No[ ]

79. Indicate ICT gadgets adopted after electricity connection at the household

ICT adopted before utility connection			**Internet feature For mobile phone**	
ICT devices			%Yes	% No
Radio				
Mobile phone				
TV				
Computer				

80. What ICT gadget do you prefer? Please rank them from most preferred to less preferred (1-4)

ICT devices	
Radio	
Mobile phone	
TV	
Computer	

81. Which factor determine ICT adoption at the household

	Yes	No
Information need		
Perceived ease of using		
Economic activities		
Reliability of power supply		
Gender of household head		
Consumption affordability		
Education level		
Income of household		
Age of household head		
Household size		
Electricity connection		

82. Indicate TV access hours (weekly) between male and female at the household before and after electricity connection

a. Before electricity connection Males Hours [ ], Females [ ]

b. After electricity connection Males [ ], Female [ ]

83. Do you use ICT to access information about dimension indicated here under?

Dimension of information	Yes	No
Politics		
Market/economy		
Weather/Agriculture		
Social		
Entertainment		

J. Electricity driven income generating activities in rural areas

84. Do you believe that electricity is necessary for income generation? Yes [ ], No [ ]

85. With what activities (enterprises) do you use electricity for?

		Yes	**No**
1	Kiosk/Grocery		
2	Tailoring Mart		
3	Beverage making		
4	Food processing		
5	Food storage		
6	Milling		
7	Communication center		
8	Mobile phone charging center		
9	Video/TV show center		
10	Welding		
11	Carpentry		
12	Saloon /Hair dressing		
13	Vibrated bricks		
14	Public address system		
15	Poultry		
16	Mechanization		
17	Restaurant		
18	House for rent		
19	Stationery		

86. From the enterprises owned in 85, have you employed any person? Yes [ ], No [ ]

87. Are you employed in any enterprises in 85?

88. Do you expect to establish any enterprises which are electricity dependent for the coming 24 months? Yes [ ], No [ ]. Mention the enterprise ,……………….., ……………………., …………………….

89. In case you own or don't own an enterprise, what other benefits do you get as a result of electric supply?
    a. Selling farm produce to processors [ ]state the amount recouped per month …………………
    b. Employed in processing firms [ ]-
    c. Getting milling services [ ]
    d. Mobile phone charging service [ ]
    e. Saloon service [ ]
    f. Specify others ……………………………………………………………

90. Has electricity increased the working or service hours for any of your activity? [ ], No [ ]

91. State the range of your monthly average income resulting from all electricity directly and indirectly dependable activities; **TZS ……………………..To……..……………..**

92. Is the post electrification income better than pre electrification Yes [ ], No [ ]

93. What social aspect have you improved as the results of income increase? Tick and explain how improvement have been achieved

    a. Education [ ], b. Health [ ], c. Housing [ ], d. Food security [ ], e. Transport [ ], f. Communication[ ] g. Household assets [ ]
    Explain the achievement…………………………………………………………………....

94. What factors determine establishment of electricity dependable income generating enterprises?

SN	Determining factors	Notes: SA=Strongly Agree, Ag=Agree, Un=Undecided, DA=Disagree, SD=Strongly disagree				
		1=SA	2=Ag	3=Un	4=DA	5=SD
1	Electricity connection affordability					
2	Electricity reliability					
3	Capital /Loan accessibility					
4	Customer/Market accessibility					
5	Enterprises management skills					
6	Affordability of power consumption					

95. What are other household sources of income not directly related to electricity [**tick the appropriate**]

    a. Agriculture [ ], b. Fire wood collection and selling [ ], c. Charcoal selling [ ], d. Government employment [ ], e. Lending and borrowing groups [ ], f. Assistance from relatives [ ], g. OTHER SOURCES ………………………………….

96. What is the estimated total income (Range of income) from sources not linked with electricity availability, **TZS……..………… To………..……………..**

97. Quality electricity and allied resources on household income

Code	Quality Electricity-QEC (Y1) Exogenous	Influence of electricity and allied resources on household income indicators
		1=SD, 2=DS, 3=SMD,4= UN, 5=SMA, 6=AG, 7=SA
QEC1	Reliability of network of supply	
QEC2	Voltage stability	
QEC3	Safety of supply	
QEC4	Affordability of consumption	
QEC5	Resilient to shocks	
Development Assets -DEA(Y2) Exogenous		
DEA1	Workforce	
DEA2	Information and technology	
DEA3	Land	
DEA4	Fiscal capital	
DEA5	Social network and connection	
Individual Motivation -IMO (Y3) Exogenous		
IMO1	Self-realization	
IMO2	The desire for better living	
IMO3	Personal satisfaction	
IMO4	Acceptance and recognition	
IMO5	Responsibility	
Household Strength (HS) Endogenous		
HS1	Background in wealth ownership	
HS2	Skills in resources mobilization	
Household income -HI (Y5) Endogenous		
HI1	Financial savings	
HI2	Enterprises start-ups	
HI3	Employment	
HI4	Domestic electrical assets	
HI5	Owner-occupied dwelling	

Notes: DS=Strongly Disagree, DS=Disagree, SMD=Somewhat Disagree, UN=Undecided, AG=Agree, SMA=Somewhat Agree

L. Influence of electricity service on women's workload reduction

98. Indicate who does the following domestic activities before and after electric connection. Select by indicating M for Male and F for Female and or MF for both Male and Female against the activity

SN	Activity	Before electrification,	Hours spent a week	After electrification	Hours spent a week
	Example, Welding	**M**	**20**	**M F**	**15**
1	Cooking				
2	Searching for fire wood				
3	Milling				
4	Water searching/fetching				
5	Ironing				
6	Charcoal searching				
7	Selling items at the market				
8	LPG purchase				
9	Food collection				

99. Alternative methods for reducing domestic workloads

Alternative strategies	Rank by numbering against the most applicable strategy
Distribute duties to girl children	
Distribute duties to boy children	
Adjust waking up time in the morning	
Return home early from work in the evening	
Use improved cook stoves	
Use time efficient energy sources for cooking	
Reduce cooking frequency	

100. What are domestic activities currently done by men as a results of electricity availability [ ], [ ], [ ]

101. Can women access the available domestic digital appliances for leisure? Yes [ ], No [ ]

102. What are domestic electrical appliances controlled by women?

____

103. In case you (woman) don't have modern domestic electrical appliances, which one could you prefer to have, name them in order preference

i.

ii.

iii.

iv.

v

<u>THANK YOU FOR YOUR PARTICIPATION</u>

Time interview End…………………….

Appendix 2: Key informant interview guide for TANESCO

1. Do you think the upfront connection charges are affordable to consumers?
2. Have you experienced any complaints from the consumers about electricity outage, provide the records?
3. Do you inform consumers in case of any emergency interruption?
4. Electricity is expensive to produce and distribute, do you think households are making use of it to increase their income?
5. How long does it take to recover the outage in case it happens?
6. How is the general reliability of electric system in this area?
7. Consumption demand peak for 24 HRS, provide data

Appendix 3: Key informant, district business officer

1. Do you think the business practice is growing in this area?
2. Can you provide the list of newly established businesses after electricity availability?
3. What can you comment about the influence of electricity on enterprises growth in this area?
4. Do you see any increase of revenues as the result of new firms' growth in this area?

Appendix 4: A guide for focus group discussion for Male participants

1. What can you comment on the upfront connection cost directly payable to the utility company?
2. From your experience, do you think the initial charges for electricity connection are affordable?
3. What is your perception on the cost for housing wiring?
4. What is the average monthly cost for electricity consumption at your households?
5. How reliable is electricity supply in your area?
6. How important is electricity in raising income of the households in this area?
7. How has electricity helped women and youth to participate in income generating activities
8. Do you think electricity supply is reliable?

Appendix 5: A guide for focus group discussion for Female participants

1. What are domestic benefits resulting from electricity?
2. Who is responsible for search of sources of domestic energy?
3. How have electricity helped you to reduce domestic work load?
4. Are women participating in income generating activities in this area?
5. Who control electrical appliances in the household?
6. What are the common sources of energy for lighting and cooking for your household?
7. How has electricity helped women and youth to participate in income generating activities