Residential Demand for Utilities in Rwanda: Example of Electricity and Water

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Dedications

To all students of MSc. Economics, Batch 6

Declaration

I, MBONIGABA Emmanuel declare that this MSc. Economics thesis entitled “Residential Demand for Utilities in Rwanda: Example of Electricity and Water” contains my works and the works of other but clearly referenced as required.

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Date of Submission………../…………/2017.

Certification

This is to certify that Mr. MBONIGABA Emmanuel has submitted this Master’s thesis to the University of Rwanda, College of Business and Economics (CBE) for examination with my approval as the University Supervisor;

Signed…………………………………………Date……………/…………/………………

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Abstract

This draft paper analyses the households demand for utilities in Rwanda: Example of electricity and water. The study uses secondary data from EICV4 conducted by National Institute of Statistics of Rwanda (NISR) in 2013/2014 to investigate the expenditure elasticity for water and electricity. For comparison reason, model is specified by basing on both Working-Leser model and Engel function which are often used in some economics studies especially households' consumption together with total expenditure. The findings reveal positive expenditure elasticities and less than one for both consumption of electricity and water. Specifically, the expenditure elasticities for electricity are 0.60 and 0.52 while expenditure elasticities for water are 0.30 and 0.27 respectively for Working-Leser model and Engel function. These elasticities therefore suggest for water and electricity to be necessary goods. Households' characteristics tend to have very little influence on consumption of these utilities as indicated by the level of significance of parameters. But the coefficients of household size are positive and significant to the consumption of these utilities. In end of this study, recommendations for further research on these utilities are given.

Key words: Total expenditure, elasticities, water, electricity, Rwanda

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Chapter one: General introduction

1.1.Introduction

Households' total expenditure is often constituted by food and non- food expenditures especially expenditure on articles purchased by household. Those expenses are very important in household usual life specifically for home activities like taking care of family members, cooking foods, and cleaning different things and areas in households. Such leisure time and residential activities in household require the use of water and energy i.e. electricity. The food served at lunch or dinner time results from different combinations, first of food itself, secondly utensils, thirdly water and very importantly the source of energy used. Apart from that, member of the family at home, need things that would help them to be connected with world around them. In area of short distance, households are easily connected where one who needs to communicate to others has to travel to other areas with of course cost of transport and time. Sometimes it becomes challenge to communicate thought travelling and even not possible at all. The reason why, members of family prefers to owns means of communication that utilizes technology and energy. Households therefore strive for example to purchase television sets for entertainment, telephone handsets for telecommunication, computers for different uses and so many other articles for different activities. It is to this extent the current research work studies the allocation of portion of budget to electricity and water.

In this report, we estimated a model of household electricity and water demand to mainly evaluate how the proportion of household expenditure-expenditure share-varies with total expenditure or alternatively how amount spent on consumption of water and electricity changes with change in household total expenditure. The report also considers the influence of control variables like household size, geographical localization and type of inhabitant settlement. Electricity and water expenditure share are defined as the individual consumption expenditure on electricity and water divided by the total expenditure on consumer goods and services by a given household.

Broadly speaking, in this study of household water and electricity consumption, one of the main objective is to analyze the relationships between electricity/water expenditure and income or total expenditure of household. The study also aims at presenting econometric estimations and elasticities of consumption of electricity and water specifically household's total expenditure in relation to expenditure share and amount spent on each item. Of course, the study also considered households size, housing types, and location and urbanization settlement as covariates alongside the treatment variable.

The study estimated the model adapted on Working-Leser model and Engel function, using data for a representative sample of Rwanda households from the Rwanda - Integrated Household Living Conditions Survey (EICV4), 2013-2014, cross-sectional sample, conducted by NISR. The rich detail on households' size, localization and habitation characteristics in dataset allow us to model the considerable responsiveness in households' water and electricity consumption. This research work has faced challenge of data availability on prices variability for water and electricity consumption.

Findings from studies conducted on subject interests are useful in policies formulation and decision making. Relating to this study, the literature review indicates rich findings from various studies on the residential demand for electricity and water in many part of the world have different important policy implications regarding especially, utilities provision and regulation. The recent study thus also suggest certain things considerable in policy making. The precise and accurate results on estimation of price and income elasticities would inform policy makers, how and to what extent these results can be helpful to design and plan for utilities supply policies.

As the study uses data on Rwanda case, it is now deemed necessary to present in the section of introduction, the recent and past situation on consumption of both utilities in Rwanda. Thus, the report briefly gives an overview on results from the thematic report on utilities and amenities after NISR conducted EICV4. It also gives an overview on current commercialization of these both utilities especially the structure of pricing for low and high consumers (residential and commercial).

1.2.Brief history of electricity and water in Rwanda

Rwanda, a Sub-Sahara African country with population approximately estimated to 11.61 million of people has different type of source of energy and improved water sources which are very important in its socio-economic development aspects. As per World Bank website, [1] the percentage of access to electricity (% of population) is 19.8% and percentage of improved water source (% of population with access) is 76% as per figures of end 2014 (World Bank, 2017). The EICV4 conducted in 2013/2014 through the report on utilities and amenities, reveals that at national level, 25% of households are within 0–4 minutes walking distance of an improved drinking water source while 58% of households are within 0–14 minutes walking distance one-way. The proportion of households having access to improved sanitation increased from 75% in 2010-11 to 83% in 2013-14. For use of electricity, the highest proportion of households using electricity for home lighting is found in Kigali city (73%). In other provinces the proportion of households using electricity for home lighting ranges between 9% and 15% (NISR, 2016).

In the past, the consumption of electricity in Rwanda was very low in 2008. The rate stands at 4% of total energy use, where the rest is occupied by 85% of biomass while the petroleum account for 11% (the African Development Bank, 2013). Later on, as per United Nations Development Program/human development report (UNDP, 2015), Rwanda was found in low human developed countries where total electrification rate was 18.0% of total population and 7.7% of rural population. By end 2015 the Word Bank indicated a rate of 76.1% of Rwanda population with access to improved water sources. This is a percentage of the population using an improved drinking water source which first includes piped water on premises like piped household water connection located inside the user's dwelling, plot or yard; secondly includes other improved drinking water sources like public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection (World Bank, 2016). [2]

A country like Rwanda has programs, implemented through its institutions, specially dedicated to provisions of utilities to the population. For example in strategic plan 2013/14-2017/18 for water sanitation, the country targets to achieve 100% coverage rate by 2017 for water supply and sanitation sector as revealed by Ministry of Infrastructure (MININFRA, 2013). In term of electricity, the country target to achieve the generation capacity of 563 megawatt (MW) and access to electricity of 70% by 2017/18 (Rwanda Development Board, 2017). As improved access to

[1] See http://data.worldbank.org/indicator/SH.H2O.SAFE.ZS provide information on percentage of population with access to electricity and http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS and provide further information on access to improved water sources. The website was accessed on July 6, 2017

[2] See http://data.worldbank.org/indicator/SH.H2O.SAFE.ZS?locations=RW Accessed on March 23, 2017

these utilities is often indicated by a number of population with access to improved water source, distance to improved water source and number of households connected to grid, Rwanda population has reached the rate of 85% of Rwandan households with improved drinking water source (National Institute of Statistics of Rwanda (NISR, 2016) while according to Nelson, (2017) Rwanda's national electrification rate has reached 31% (3% off-grid, 28% on-grid).[3]

In the past, Rwanda had different agencies in charge of production and distribution of these two utilities and their names and structure have been frequently changing. Some names of agencies are REGIDESO "Régie de distribution d'eau", ELECTROGAZ, Rwanda Electricity Corporation and Rwanda Water and Sanitation Corporation (RECO-RWASCO), Energy Water and Sanitation Authority (EWSA) and some others. Very recently, the government of Rwanda has separated Energy and Water utility agency into corporations in charge of electricity, water and sanitation utilities development and distribution.

To this end, Government adopted the corporatization model as a vehicle to implement the required reforms. The law repealing EWSA Law of 97/2013 of January 31, 2014 paved the way for the creation of two corporate entities which were subsequently incorporated in July 2014 with 100% government shareholding. The Rwanda Energy Group Limited (REG Limited) and its two subsidiaries; The Energy Utility Corporation Limited (EUCL) and The Energy Development Corporation Limited (EDCL) entrusted with energy development and utility service delivery while the Water and Sanitation Corporation (WASAC) has the mandate to develop and operate water and sanitation infrastructure and deliver related services in the country. [4]

Table 1: **Residential and non-residential customers' electricity price**

Residential customers		**Non- residential customers**	
Consumption (kWh) block/month	Frw/kWh (VAT exclusive)	Consumption (kWh) block/month	Frw/kWh (VAT exclusive)
[0-15]	89	[0 -100]	189
[>15 – 50]	182	>100	192
>50	189		

Source: REG official website

[3] See https://www.usaid.gov/powerafrica/rwanda Accessed on August 12, 2017
[4] See http://www.reg.rw/index.php/about-us/history the web site provide further information on history of Rwanda Energy Group. Accessed on August 12, 2017

The overall assurance of utilities is headed by the Ministry of Infrastructure which intervenes in utilities policy and sector matters. Ministry of Finance also comes in under the aspect of financing arrangements, investments and subsidies. The Rwanda Utility Regulatory Authority (RURA) with the role of compliance issues of the EUCL, EDCL and WASAC. For the current price and charges of utilities, the Management of EUCL informed the public new electricity tariff as approved by the RURA in table 1, 2, 3 and 4.

Table 2: **Industrial electricity customers' charges**

Small industries: including Water treatments plants, Water pumping stations and Telecom towers		
Flat rate	Rwf/kWh	126

Source: REG official website

Table 3: **Industrial electricity customers' charges**

Medium industries: (0.4 Kv<V≤15kv)		
Energy Charge	Rwf/kWh	90
Max. Demand Charge (17H00- 23H00) Peak	Rwf/KVA/month	10,469.55
Max. Demand Charge -(08H01'- 16H59') Shoulder	Rwf/KVA/month	5,588.41
Max. Demand Charge-(23H01' – 08H) Off-Peak	Rwf/KVA/month	1,891.54
Customer Service Charge	Frw/Customer/Month	3,125

Source: REG official website[5]

Water tariff and charges

Table 4: **The cost per m^3 is set according to the consumption as indicated below**

Monthly Consumption	**Tariff Excluding VAT (18%)**
At Public Water Kiosk	Frw 323 per unit (m^3)
Between 0 and 5 m^3	Frw 323 per unit (m^3)
Between 6 and 20 m^3	Frw 331 per unit (m^3)
Between 21 and 50 m^3	Frw 413 per unit (m^3)
Between 51 and 100 m^3	Frw 736 per unit (m^3)
Above 101 m^3	Frw 847 per unit (m^3)
Industries	Frw 736 per unit (m^3)

Source: REG official website

Government of Rwanda through Economic Development Poverty Reduction Strategy (EDPRS) II/Energy Sector Strategic Plans prepares to extend grid network to cover 48% of the households by 2017/2018. The current strategy is set to increase electricity access generation from 110.44 MW of installed capacity to around 563 MW and connectivity from the current 16 percent (end June 2012) to around 48% percent in 2017/2018. For access to drinking water, the EDPRS II/water

[5] See http://www.reg.rw/index.php/our-business/customer-services/electricity-tariff the website provides information on prices charges of both water and electricity. Accessed on August 12, 2017

sanitation strategic sector aims to increase the proportion of the population accessing safe water from 71 % to 100 %, and the proportion with sanitation services from 75 % to 100 %. It was also planned to increase the proportion of the rural population living within 500m of an improved water source from 63.3%[6] to 100%, and to raise the proportion of the urban population residing within 200m of an improved water source from 64.2% to 100% by 2017 (MININFRA, 2013).

With total expenditure of households, it is interesting to know how the expenditures on these two utilities behave in terms of total expenditure. We need to find out how changes in households' total expenditure affects amount spent on these two utilities or expenditure share allocated to electricity and water. Amount spent on these two utilities may increase in the same proportion as households' total expenditure increase or may increase in the proportion which less than proportion change in households' total expenditure.

The objective of this study is thus to examine the expenditure elasticities for electricity and water for targeting the nature of both two goods in Rwanda. Based on EICV4 dataset of 14, 419 Rwandan households, we analyzed the influence of amount spent and expenditure share allocated to electricity and water i.e. the influence of total expenditure, household size measured by the number of individuals per household, use of flush toilet (water), effect of urban area and type of inhabitant. For the case of Rwanda, type of inhabitant includes: Clustered area "umudugudu", Unplanned clustered rural housing, isolated rural housing, unplanned urban housing, Small settlement and Modern planned area.

This research work is outlined in six sections. Section one is about the general introduction to the research, section two concerns the literature review, section three details data and methodology used, section four presents empirical results and section five deals with summary and recommendation.

[6] Economic Development Poverty Reduction Strategy (EDPRS II) presents percentages which come from Rwanda Integrated Household Living Conditions Survey EICV3 conducted National Institute of Statistics of Rwanda.

Chapter two: Literature review

In this section, we present different existing literature on specification and estimation modeling used to study the electricity and water demand especially residential consumption. Methodology used, data and results of previous research on water and electricity are also presented. Residential electricity and water consumption is generally perceived to be in function of own price and incomes. Depending on different situation met but different researchers, other factors are included on models specification and estimation of electricity and water consumption. For instance some include and exclude stock of electrical energy-using equipment and households' characteristics. Research works also use different types of data and technics depending different reasons probably explained in their research works. The first part of this literature review addresses the household or residential electricity demand while the second one reviews the literature on demand of water.

2.1. Electricity demand

This section presents the contribution of other studies done on residential electricity demand or in other words electricity demand by households. The literature review does not focus on particular areas either developing or developed countries, it is mixed but groups literature of interests according to methodology used and approach. Lots of studies share a common purpose, which is to measure how electricity demand responds to price and income changes and how other control variables influence the demand on electricity use.

Several studies have been done to address various aspects of electricity demand. Some target electricity demand and its determinants (Filippini, 1998; Reiss and White, 2005) other assess the causality between electricity consumption and economic growth (Aqeel and Butt, 2001; Bayar and Özel, 2014; Chontanawat et al., 2006; Kasperowicz, 2014 and Lee C. and Lee J., 2010). The findings of these studies on economic growth reveal a relationship between Electricity consumption and economic growth (income) in countries as bidirectional relationship or causality between energy and economic growth. Interchangeably; times series, panel and cross section data type are used through micro and macro econometrics estimation.

Viewing examples method in macro econometrics estimation, the electricity demand is studied by Nawaz et al., (2013) using macroeconomic data on Gross Domestic Product (GDP) and electricity consumption per capita to assess the contribution of economic growth. The empirical analysis used for electricity demand in Pakistan employed autoregressive distributed lag (ARDL) and smooth transition autoregressive model (STAR) to estimate linear and nonlinear electricity demand function. The analysis was based on time series data covering the period from 1971 to 2012. In the results, the short run estimates show that GDP per capita has a positive effect to electricity consumption. The estimated coefficient under short run is 0.24, which is percent level implying that increase in the growth rate of GDP percentage points increases the growth of electricity consumption. Other estimation results have shown that there is a long run relationship among electricity consumption, GDP per capita and electricity prices.

Based on cointegration and stationary time series, Bianco et al. (2009) in his paper entitled "Electricity consumption forecasting in Italy used linear regression models" investigated the influence of economic and demographic variables on the annual electricity consumption in Italy then forecasted long-term electricity consumption. The study considered time period for the historical data which ranges from 1970 to 2007. Different regression models were developed, using historical electricity consumption, GDP, GDP per capita and population. Linear logarithmic form and multiple regression models were firstly used to link the quantity of annual domestic non domestic electricity consumption to electricity price and GDP per capita. Secondly to investigate the annual consumption of electricity up to 2030. The domestic and non-domestic short run price elasticities were found to be both approximately equal to -0.06, while long run elasticities were equal to -0.24 and -0.09, respectively. In the following paragraphs, the emphasis is rather put on residential electricity consumption instead of on macro level in order to relate to subject of interest.

Apart from economic growth that is seen to influence the electricity consumption, activities needing energy may themselves have influences on the level of electricity consumption. Some studies have analyzed the influence of equipment on the consumption of electricity. For example Richardson et al. (2010) noted the pattern of electricity use in an individual domestic dwelling. The consumption was found to highly depend on activities of the occupants and their associated use of electrical appliances. Barnes et al. (1981) incorporated in model, the influence of appliance stock. Equation on electricity consumption for categories of appliances was specified as the product of a utilization rate and a scaling function which represents the potential for electricity consumption. The parameter estimates on appliance variables were generally found consistent with a priori notions regarding electricity consumption. Other scholars face difficulties on availability of cross-sectional data of appliance prices (Filippini and Pachauri, 2002). Naglis and Sulte (2006) concentrate on interpretation price and income elasticities even though theory postulates that electricity demand is dependent upon the stock of electrical. Reiss and White (2005) in their research for Household Electricity Demand, estimated the model using extensive data for a representative sample of 1300 California households and treated the electricity used by each of a household's individual appliances as a latent outcome. The household demand was treated as the sum of electricity used by distinct number of appliance categories.

Using data on Quebec residential users' five-year postal survey conducted by Hydro-Quebec in 1989, Bernard et al. (1996) applied the micro modelling approach to study the residential electricity demand. The study has used a continuous/discrete framework and model parameters were estimated using a two-stage approach. At the first stage the decisions regarding space and water heating systems are modelled with multinomial probit framework. Then, at the second stage, the demand for electricity conditional on the chosen heating system was estimated using ordinary least squares. The estimation considered energy prices and household incomes and various characteristics. In the results, the short-run and long-run price and income elasticities had the correct signs. For instance, the estimated price and income elasticities are respectively -0.93 and 0.09.

The estimates from residential electricity models applied reveal slightly different results for consumers who face declining block rates schedules. To demonstrate the effectiveness of the Two Stage Probit (TSP) model Terza (1986) estimated linear electricity demand using the TSP, OLS, and Instrument Variables (IV) methods on issue of artificial linearization and overcompensated correlation. The size of the TSP estimated price elasticity of electricity demand relative to the estimates obtained by OLS, IV, and 2SLS reveals the difference. The elasticities computed at the mean marginal price and consumption levels are, respectively, -1.63, -2.01, -1.20, and -1.6. It is shown that the estimated price elasticity obtained by the TSP method is smaller (in absolute value) than the OLS estimate, and exceeds the estimate obtained by the IV and 2SLS methods. The data used were taken from household survey conducted by the western Pennsylvania power company in 1979. The results by the Two Stage Probit reveal that electric heating and whole-house air conditioning are significant and substantial influences on household electricity consumption.

Household income, occupancy, appliance stock, and the all-electric dummy also have significant effects.

In estimating price and income elasticities of electricity consumption, the residential demand for electricity is specified using the basic framework of household production theory. Models are specified in log-log form or linear double logarithmic form. Filippini and Pachauri (2002) found the estimated own price elasticity was -0.32 during the winter months, -0.39 during the monsoon months and –0.16 during the summer months while the income elasticity was approximately 0.7 in all three seasons. Shi et al. (2012) is estimated residential electricity demand for China. The results found reveals own price elasticity of electricity of -2.477 significant at the 1% level while income elasticity was estimated to be 0.058. In addition, the high income group was found to be more price elastic than the low income group, while rural families are more price elastic than urban families.

Elasticities are estimated through different modeling and types of data. Athukorala and Wilson (2009) investigated the short-run dynamics and long-run equilibrium relationship between residential electricity demand and factors influencing demand in Sri Lanka. The analysis has used time series annual data from 1960-2007 and models were estimated via unit root, cointegration and error correction models. The long-run demand elasticities of income, own price and price of kerosene oil (substitute) were estimated to be 0.78, -0.62, and 0.14 respectively. The short-run elasticities for the same variables were estimated to be 0.32, -0.16 and 0.10 respectively. Holtedahl and Joutz 2004) added to the model proxy variable, urbanization, to capture economic development characteristics and electricity-using capital stocks not revealed by variable income. Dergiades and Tsoulfidis (2010) modeled residential demand for electricity in Greece by ARDL approach to cointegration. In results found, the estimated elasticities displayed the expected signs where electricity price average had negative sign and positive sign for the rest of the variables. The same modeling was adopted by Narayan and Smyth (2005) in estimating the long- and short-run elasticities of residential demand for electricity in Australia.

The models described above tended to have used time series data to study short and long run demand for electricity however the current study may be considered as the short run residential electricity demand as it uses cross section data from EICV 4. The findings cannot be generalized as the study lacks data on prices and covers the very short period of time.

2.2. Water demand

Several studies were conducted on water demand as survey by Arbués et al. (2003) on the review of estimation of residential water demand. The studies are much especially found on developed countries with few on developing world. Nauges and Whittington, (2010) have said that analysis of demand for water in developing countries is complicated by abundant evidence that, contrary to what is observed in most developed countries, households usually have access to several types of water sources some of free of charge.

Some assess directly the water demand (Ahmad et al., 2016; Nauges and Whittington, 2010), determinant of access to water (Abdu et al., 2016; Ahmad et al., 2010; Amponsah et el., 2009) others are interested in determinants of water consumption (Rauf et al., 2015 and Schleich and Hillenbrand (2007). Studies on water are so many as revealed by Berg and Marques (2010) in their work on literature survey on quantitative studies of water and sanitation utilities. Different methodology and modeling technics also exist as revealed by Worthington and Hoffman (2008) in their work on empirical survey of residential water demand modelling. They considered survey of empirical residential water demand analyses done in the period of 25 years and discussed model specification and estimation and the outcomes of the analyses.

Most of literature accessed and found analyze the water demand by households which are found in residential areas. In analysis, researchers fit models by adding control variables like household education and age after considering main variables like income and prices Ahmad et al. (2016) used survey data of 1,200 households from Faisalabad city in Pakistan and analyzed the household demand for water in urban areas of Pakistan especially price and income elasticities of water demand. Findings reflect that price and income elasticities vary across different groups. Price elasticities range from -0.2 to -0.45, and income elasticities vary between 0.005 and 0.19. Schleich and Hillenbrand (2007) additionally found results which suggest that household size, the share of wells and summer rainfall to have a negative impact on water demand. In contrast, higher age was found to be associated with higher water use.

As previously seen for electricity consumption modeling, some studies were done using co-integration and error-correction methods in estimation model of water demand. Espineira (2006) estimated short- and long-run price elasticities of residential water demand. By using monthly time-series data from Seville, Spain, price-elasticity of demand was found to be around -0.1 in the short run and -0.5 in the long run. Kostas and Chrysostomos (2006) estimated water demand determinants, annual time series on residential water demand for the metropolitan Athens area for the period 1981-1999 however the demand is modeled in log form based on utility function.

Through cross section data, Schleich and Hillenbrand (2007) modelled the determinants of residential water demand in Germany. Through Ordinary Least Squares the model was estimated in log-linear form. Estimated results for the price elasticity was -0.229 which implies that the response of residential water demand in Germany is rather inelastic. The income elasticity in the new states was found to be 0.685. Furthermore, results suggest that household size, the share of wells and summer rainfall have a negative impact on water demand. Tabieh et al. (2012) applied instrumental variables (IV) estimation techniques to model residential water demand. The residential water demand function was based on cross-section data of 1360 household. The results indicated that the estimated residential water demand elasticity is negative responsive to price (-0.47) for the basin for example. In estimation, the number of bathroom and house type were used as a proxy for intensity of water-using capital had the predicted positive effect on water demand.

Through panel data from 31 Chinese provinces from 2000 to 2011, Jia and Bao. (2014) estimated the determinants of increase in residential fresh water demand in China using Ordinary Least Square (OLS) and Fixed Effects (FE) approaches. The estimated results found showed that the rapid increase in China's residential water demand is led by the improvement of household income, the aging society and the urbanization. The results found the consideration of dynamics of socio-economic conditions and urbanization in reforming water and urban development policies, such as enhancing the capability of water supply services, integrating rural-urban development and encouraging water conservations. Massimiliano and Anna (2005) also applied log-linear model to panel dataset consisting of 125 municipalities observed over four years (1998-2001). The estimated water demand price elasticity was negative, showing values between -0.99 and -1.33. Income elasticities were found positive but lower than one. They are in the range between 0.40 and 0.71.

The current study has been able to find previous studies on the cases of Rwanda, Uwera (2013) made a thesis on Water Demand and Financing in Rwanda: an empirical analysis. She made an independent survey on urban water use. The data set used came from a household survey conducted from January to April 2011 involving 700 households in five urban areas of Rwanda. She used both discrete choice and linear models to estimate the demand. The full income elasticity was found to be 0.10 while the monetary income elasticity was very low (0.03) compared with the full income elasticity.

The concluding remarks on literature review is that most journals and articles reviewed tend to use time series data on prices, incomes and other control variables. It is difficult to find journals and articles that analyze the residential water and electricity using cross section data on household total expenditure. However the current study has been able to find some studies, one study on total expenditure elasticity non-durable consumption, electricity included, of European households (Salotti et al., 2015). The expenditure elasticity for electricity consumption ranges from 0.05 (United Kingdom) to 0.33 (Spain) for Energy-consumption results while. Another one by Bekele et al. (2015) on energy demand in Ethiopia. Cross sectional data from 466 households in 2012/13 were used and household energy demand is estimated by the share of energy purchase from their total expenditure. The results found indicated energy to be a necessary goods as per a positive income elasticity (0.61).

This study tempts to address the Residential Demand for Utilities in Rwanda especially for Electricity and Water by treating households' total expenditure as main explanatory variable. Published research works on residential electricity and water demand for Rwanda case seem now not available basing on our best knowledge of previously searching research activities done.

Chapter three: Methodology

The section of methodology is a pillar in research work and through methods; it describes the reasons for the application of specific procedures or techniques used to identify, select, and analyze information applied to understanding the research problem, in order to allow readers to critically evaluate a study's overall validity and reliability. The methodology section of a research work also tries to answer questions on how was the data collected or generated and the analysis of data. To this topic of research, this section of methodology enables the survey of empirical literature review, model specification and estimation, selection of variable and details of data to be used.

Relating this to research topic, which is in other words the consumption of utilities (electricity and water), the main aim of this chapter is to determine a model that is able to satisfactorily fits household budget share individually allocated to the consumption of electricity and water. To achieve it, the study also considers the identification of factors that affects the level of consumption of utilities (electricity and water) i.e. income, household's size, locality, type of habitation, and importantly the aggregate expenditure.

3.1. Theoretical Framework

The theoretical framework used for this research study is based on the expenditure function theorized in consumer theory from microeconomics specifically under Marshallian demand where the quantity demanded is in function of own price and income ***xi (p, y)***. Expenditure function is expressed through different steps in the consumer theory. Through uncompensated and compensated price elasticities and the income elasticity in Cowell (2006) the Slutsky equation can be expressed in terms of these elasticities and the expenditure share of each commodity in the total budget. In the consumer theory by Jehle and Reny (2011) the expenditure/income share of each commodity **i** is expressed as follows:

$$s_i \equiv \frac{p_i x_i(p,y)}{y} \text{ so that } s_i \geq 0 \text{ and } \sum_{i=1}^{n} s_i = 1. \tag{3.1}$$

The symbol S_i denotes the income share, or proportion of the consumer's income, spent on purchases of good i. The share of each good must of course be non-negative and sum to 1.

In empirical studies, Bekele et al. (2015) adopted the same theory framework while studying the determinants of household energy demand in Ethiopia. The Almost Idea Demand System (AIDS) model which has similar procedure with Engel expenditure model was estimated where share of household energy expenditure is regressed on total expenditure. Households' characteristics were also included as control variable. Filippini (1995) likely used AIDS to Swiss Residential Demand for Electricity by Time-of-Use. The share of per capita electricity expenditure is obtained by dividing expenditures on each type of electricity by total electricity expenditure.

Apart from energy sector, similar modeling was empirically used in variation of budget shares with total expenditure by Creedy and Sleeman (2006) in the study of Indirect Taxation and Progressivity: Revenue and Welfare Changes. Chern et al. (2003) used the same modeling in Analysis of the food consumption of Japanese households with the objective of analyzing food consumption patterns in Japan and conducting an econometric analysis of Japan's food demand structure.

3.2. Model Specification

The study adopts a model that describes the relationship between the covariates and control variables of interest used as explanatory variables and amount spent on utilities separately for electricity and water. The studies seen in section of literature review differ in terms of data used, country and time coverage, and econometric techniques employed modeling specification and estimation. For the current study, the choice of the econometric technique depends on the characteristics of the available data. For example it is not easy to apply econometric technics using data on time series for the case of Rwanda water and electricity consumption as the price has been almost the same. As data availability plays a crucial role for identifying the empirical strategy capable of delivering the needed parameter i.e. elasticities, the current study strives to find econometrics model that can uses amount spent on a good and total expenditure and makes some analysis. Although the literature on electricity and demand commonly use double log form, the equation (3.2) was therefore found to well connect the explanatory variables with dependent variable and log form is used after in equation (3.5) for reason of comparability.

The model specification form of electricity and water consumption in this research activity is adapted to Working-Leser model. As specified by Chern et al. (2003), the original form of the

Working-Leser model was discussed by Working (1943) and Leser (1963) and details functional form by Intriligator, Bodkin and Hsiao (1996) and Deaton and Muellbauer (1980a)[7]. Explanation of the utilities (Electricity and water) expenditure share is parametrically done by estimating a functional equation relating the utilities expenditure to the total household expenditure and other household characteristics. The reason why the study choses to employ the so called Working-Leser specification a form also discussed by Deaton and Muellbauer (1980) in 1980) in his work of Economics and Consumer where budget shares are linear in the logarithm of total expenditure. In this study, the specification is extended, without price, to include the effect of households' characteristics and dummy variables i.e. location as control variables to budget share allocated to utilities.

$$w_i = \delta_i + \beta_i \log m + \gamma_i \log h_c + D_z + \varepsilon_i \qquad (3.2)$$

Where w_i is the expenditure share allocated to the consumption of utilities, m is the total expenditure, h_c is the total household characteristics (household size), Dz stands for dummy variables (geographic localization, urban housing area and use of flush toilet), and ε is the error term. The error term, ε_i, are random disturbances assumed with zero mean and constant variance. Sigma γ, δ_i, and β are unknown parameters to be estimated. This model is estimated separately for two types of goods, electricity and water, by the ordinary least squares (OLS).

These parameters are estimated by regressing budget share respectively for the consumption of electricity and water on total expenditure levels. The summation of all shares equal to one and is satisfied by ordinary least squares estimates of each budget equation, separately estimated for electricity and water consumption as said before.

To estimating the total expenditure elasticity for electricity and water, we used elasticity formulas for the Working-Leser model. The expenditure elasticity (e_i) can be expressed as:

$$e_i = 1 + \left(\frac{\beta_i}{w_i}\right) \qquad \text{Alternatively,} \qquad (3.3)$$

[7] See http://www.fao.org/docrep/005/y4475e/y4475e07.htm The working-Leser model is also read from and used by on FAO official website under Analysis of the food Consumption of Japanese households. It is under FAO economic and social development paper. ISSN 0259-2460. Website accessed on August 05, 2017

$$e_i = 1 + \frac{\beta_i}{\delta_i + \beta_i \log m + \gamma_i \log h_{c_i} + D_z + \varepsilon_i} \quad (3.4)$$

Alternatively, elasticity (3.4) is obtained by replacing **w*i*** by its value from (3.2).

Where in (3.3) **w*i*** is the sample average of the expenditure share of electricity on one hand and water on the other hand. Elasticity $\boldsymbol{e_i}$ informs about a proportionate change of electricity and water expenditure in response to a change in the total household expenditure. As our primary goal, in other words, is to analyze the expenditure elasticity of electricity and water demand the symbol $\boldsymbol{e_i}$ in equation (3.3) and (3.4) measures the effects total expenditure/income of households on expenditure share allocated to the consumption of both utilities.

Alternatively total expenditure elasticity as parameter of interest can be estimated through Engel function. As the equation (3.2) cannot directly give expenditure elasticity by amount spent on each utility commodity, elasticity of total expenditure on electricity and water can be estimated through the following equation adapted from Engel function (Fagiolo, 2001).

$$\log x = \delta + \beta \log m + \gamma h_c + D + \varepsilon \quad (3.5)$$

Where $\boldsymbol{x}$ is amount spent separately on electricity and water, $\boldsymbol{m}$ is total expenditure spent by households on all articles and goods, electricity and water included. Other variables and parameters are estimated as before in equation (3.2). From Equation (3.5), the responsiveness of amount spent, first on water and secondly on electricity consumption by change in total expenditure, $s = \frac{\partial x}{\partial m}\frac{m}{x}$ can be obtained. **β** is the parameter of interest in our study and can be interpreted as the total expenditure elasticity, by evaluating the percentage change in the dependent variable as total expenditure changes by 1%. In the end expenditure elasticities can also be calculated at means of expenditure share of water and electricity in equation (3.2).

3.3. Variables

The economic approach to water and electricity demand estimation uses econometric techniques described above to get parameters and estimates for water and electricity consumption. To achieve it, there is need of set of variables of interest the reason why we make a selection and description of both dependent and independent variables in the next section.

Dependent Variables

In this research we have two type dependent variable under analysis which relate to both electricity and water consumption. In equation (3.2) the dependent variable, w_i, measures the share of amount spent by household on separately electricity and water consumption in the period of last four weeks of the survey. It is calculated as the ratio of the total amount spent on item i.e. electricity in four weeks to the monthly total expenditure of household. In equation (3.5), the dependent variable, log(x), measures the logarithm of amount individually spent on electricity and water. In dataset, amount spent is described as amount paid for electricity in last four weeks of the survey while amount spent on water is described as amount of the last water bill. As said in previous paragraphs, electricity and water consumption data are taken from EICV4 conducted by National Institute of Statistics of Rwanda (NISR, 2016).

Independent Variables

From an economic perspective, the household consumption for utilities is a composite and derived consumption, consisting of the direct consumption for example purposes and the indirect demand for electricity and water as a tool useful to different household activities such as powering home appliances, cooking, cleaning, washing, body hygiene and gardening and so many others. It is to this extent to which we believe that utilities consumption responds to changes in incomes or total expenditure, own prices, households' activities, geographic location together with types of habitat, and other relevant variable. However, in our model, variable "price" and "household activities" are not concerned due to data unavailability at this time.

Total expenditure: in dataset, total expenditure is described as aggregate consumption/aggregate expenditure in January 2014 prices. As our dependent variable in the model is on monthly basis, the aggregate expenditure is divided by twelve months to get monthly household total expenditure.

Household size: in this study, it is preferred to measure household size by number of persons per household. It is measured as discrete variable. It is observed in EICV 4 dataset that number of persons per household varies between 1 and 18 individuals. Hughes-Crom (1985) also added in the study Nairobi households and their energy use the factor of household size.

Flush toilet: The study also has considered to include the type toilet in the water consumption model because the level of residential water consumption may be associated to the use of flash toilet. It is used as dummy variable in the model. Codification of 1 stands for use while 0 stands for not use.

Location: this variable is used as geographical localization of households either urban or rural. Geographical localization may influence the consumption of both water and electricity. Regional dummies is included to capture differences across regions not accounted for by the other explanatory variables in the regression equation. Depending on the characteristics of a given area, the NISR (2016) defines the urban domain as the combination of urban and semi-urban, whereas the rural domain is composed of rural and peri-urban. Urban area is used a dummy variable and codification of 1 stand for being urban while 0 stands for not being in urban area.

Type of habitant: It expresses the type of habitant settlement in which households are found. It has five categories namely clustered area "Umudugudu", Unplanned clustered rural housing, isolated rural housing, unplanned urban housing, Small settlement and modern planned area. It is used as dummy variable in model. The study only considered modern planned and unplanned urban areas because most of electricity and water users are found urban areas. Tiwari (2000) also considered type of dwelling as control variable to electricity consumption and it is close to type of habitant. Type of dwelling were introduced to reflect for example the effect design, construction techniques and materials on residential electricity consumption

It is expected to get most coefficients with correct signs and statistically significant especially: total expenditure (Engel function), household size, use of flash toilet, urban area, modern planned areas, unplanned urban housing. The coefficient of total expenditure in Working Leser model is expected shows the nature of electricity and water rather than the magnitude.

3.4. Data

This study uses the research methodology to enable the process of achieving answers to problems through systematic data collection, analysis and interpretation. In research, it is obviously important to deeply check on the sources of data that would give most appropriate responses to the questions and which methods and tools most appropriate to collect the relevant data. This study thus uses secondary data from Rwanda EICV4 conducted by the NISR in the year of 2013-2014. This last Survey was conducted over a 12-month cycle from October 2013 to October 2014 and Data collection was divided into 10 cycles in order to represent seasonality in the income and consumption data (NISR, 2016).

This EICV4 is preceded by three EICVs conducted in 2000/01, 2005/06 and 2010/11. In the current one, the primary sampling units are the 2012 census enumeration areas. Enumeration areas were previously classified as urban, semi-urban, peri-urban or rural. In EICV4, urban and semi-urban are close to urban while rural and per-urban are close to rural. This results in a final distribution of 17.2% urban households and 82.8% rural households in the sampling frame (NISR, 2016). Details are provided in data documentation on the ample size of 14,419 households from new sample of 12,312 households was drawn using the 2012 Rwanda Population and Housing Census and households from 177 EICV3 villages (NISR, 2016).

This study has selected variables from EICV4 to analyze the consumption of electricity and sources of water among households. The following table summarizes variables that are expected to influence the use of electricity and water sources. The table illustrates selected variables list, their label, number of observations, mean, standard deviations, and the minimum and maximum value. Tables 5, 6 and 7 gives some statistical details on the variables employed in the estimation of the household demand model for electricity and water.

Table 5**: Details on selected variables in data set**

Variable	**Label**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
s5cq16	Main source of lighting in home	14,419	7.420556	3.36827	1	11
s5cq17	Amount paid for electricity in last 4 weeks	2,595	2,683.20	4,306.80	0	100000
Consumption	Aggregate consumption/ae in Jan14 Prices	14,419	315,400.30	488,295.20	7,338.55	7,338.55
ur2_2012	Urban/Rural 2012 (2 Categories)	14,419	1.842222	0.3645453	1	2
s5aq1	Type of habitant	14,419	2.125321	1.279677	1	6
pid	Personal Unique Identifier	66,081				
s5cq1	Type of main source of water	14,419	6.267286	2.881483	1	12
s5cq9b	Amount of last water bill	1,098	4,502.26	10177.91	0	170,000
s5cq20	Types of toilet	14,419	2.226021	.6419901	1	5

Source: Table is produced from NISR dataset for EICV4 in the file of households

Some of the variables above are categorical and used in the model as dummy, the reason why the following table illustrates categories and corresponding frequencies of different variables included in models.

Table 6: **Categorical variable are transformed into dummy variables to ease the analyses**

Urban/Rural 2012 (2 categories)	Freq.	Type of habitat	Freq.	Type of toilet	Freq.
Urban	2,275	Umudugudu	7,119	Flush toilet	254
Rural	12,144	Unplanned clustered rural housing	1,290	Pit latrine with solid slab	11,624
		Isolated rural housing	3,849	Pit latrine without slab	2,053
		Unplanned urban housing	1,631	Other	4
		Small settlement	305	No toilet whatsoever	484
		Modern planned area	225		
Total	**14,419**		**14,419**		**14,419**

Source: Table is produced from NISR dataset for EICV4 in the file of households

Among 14,419 in the survey, they do have different sources of lighting home and access to different water sources. The following table gives a brief description of them.

Table 7: **Households main source of lighting and type of main source of water**

Main source of lighting in home	Frequency	Type main source of water	Frequency
Electricity from EWSA	2,552	Piped into dwelling	62
Other electricity distributors	42	Piped into yard	1,036
Bio Gas	1	Public standpipe	3,555
Generator	3	Borehole	292
Oil Lamp	729	Protected well	121
Firewood	874	Protected well	182
Candle	1,020	Protected spring	5,606
Lantern (Agatadowa)	1,953	Unprotected spring	1,272
Solar panel	256	Rain water	98
Batteries+ Bulb	6,490	Tanker truck	16
Other (specify)	499	Surface water (river or lake)	1,904
		Other	275
Total	**14,419**	**Total**	**14,419**

Source: Table is produced from NISR dataset for EICV4 in the file of households

Chapter four: Empirical findings

In this section we evaluate how households' consumption behavior, say expenditure share and amount spent on water and electricity is determined by specific variables (e.g. total expenditure, household size and other demographic characteristics). Before presenting finding, in the following paragraph the study briefly talks about test conducted for goodness of models.

As equation (3.2) and (3.3) are estimated using OLS method, it is necessary to conduct heteroscedasticity and collinearity test. Both models were augmented to minimize model suffering from heteroscedasticity. It is known that OLS to be performed well assumes a constant variance, therefore the heteroscedasticity test is very important to test if this assumption hold in the model performed. Breusch-Pagan test for detecting heteroscedasticity is performed. The test indicates for electricity chi2 (1) = 390.02with Prob > chi2 =0.0000 and chi2 (1) = 1087.99with Prob > chi2 =0.0000 for water. This is addressed in STATA by augmenting the model by "robust". Robust standard errors were therefore calculated due to the heteroscedasticity in the models. Collinearity is also tested through Variable inflating factor (VIF) after removing redundant variables and it indicates collinearity being removed[8] The collinearity test is used to find possible redundant variables in the model (the variables which one can linearly predict the other (s).

Detailed estimation results are presented in table 8 and 9. The estimates of t-statistic values and p-values (rounded to two and three decimal places) are also reported in this table. With expenditure share as dependent variable, we obtained a negative sign for the total expenditure as determinant of the electricity and water expenses share in the total expenditure. This probably indicates that expenses on these utilities do not grow as total expenditure grows. However, the coefficients the number of persons per household for are positive for both water and electricity as factor for this expenditure share. Number of persons positively and significantly affects allocation of these two utilities expenditure share. Expenditure share on electricity and water may increases as number of electricity and water users increases. In other words, the individuals per household increases, the more lighting home and water are needed. Urban area, and modern planned area carry wrong sign and are not statistically significant in both approaches. Their coefficients in table 8 and 9 are not

[8] *The post command in STATA provides Variable inflating factor (VIF) are less that tree which indicates the absence of collinearity*

even significant different from 0 at the 95% confidence level. It is indicated by very low t-statistic and p-values above 0.05.

Table 8: Estimates of parameters of model of expenditure share based on Working Leser model

Variables	Water				Electricity			
Expenditure share	Coef.	t-statistic	P-values	Expenditure Elasticity	Coef.	t-statistic	P-values	Expenditure Elasticity
Total expenditure	-0.06006	-5.02	0.000	0.30298	-0.02424	-14.98	0.000	0.60253
Number of persons per household	0.051392	5.08	0.000	1.59648	0.03373	18.92	0.000	1.55312
Flush toilet	0.023017	1.91	0.234	1.26714				
Urban area	-0.00722	-0.25	0.851	0.91619	-.000285	-0.09	0.926	0.99533
Modern planned areas	-0.02557	-1.14	0.529	0.70322	0.01759	4.71	0.000	1.28850
Unplan. urban housing	-0.02919	-1.15	0.232	0.66127	0.02583	9.48	0.000	1.42353
Constant	0.696234	5.50	0.000	9.08071	0.2576	14.35	0.000	5.22336

Note: *Expenditure share is the dependent variable in our regression and variables below it are independent variables.*

For this study, we are more interested in expenditure elasticities, in other words we are looking for a proportional change in expenditure share and amount spent on electricity and water for a change in total expenditure.The coefficient of interest of total expenditure in equation (3.2) cannot be interpreted directly as the elasticity like in Engel function in (3.5), but we calculate elasticity[9] using (3.3) or (3.4) which gives total expenditures elasticity for water and electricity in table 8. Expenditure elasticity estimates for electricity are **0.60** in Working Leser and **0.52** in Engel function both without factor own price. Expenditure elasticity estimates for water are **0.30** in Working Leser model and **0.27** in Engel function. In both, expenditure elasticities for both water and electricity are very close.

The signs and magnitudes of the estimates in table 8 and 9 generally agree with prior studies on electricity consumption, although there are a few exceptions on expected sign of urban area. In modeled equation (3.2), the expenditure elasticities for both water and electricity are significant and carries the expected sign. For example, the estimated expenditure elasticity is **0.30** for water and **0.60** for electricity and agree with previous studies. On electricity side, Bernard et al. (1996); Salotti et al. (2015); Bekele et al. (2015); Filippini and Pachauri (2002) and Athukorala and Wilson

[9] ***Note:*** *The expenditure elasticity is calculated according to equation (3.3) or (3.4) using the log(total expenditure) coefficients and the expenditure share averages calculated as mean of each household expenditure share on electricity and drinking water.*

(2009), using different modeling, have found income elasticity to be less than one in analysis of residential electricity consumption. While on water side, Massimiliano and Anna (2005); Schleich and Hillenbrand (2007) and Ahmad et al. (2016) have found income elasticity to be less than one for residential water consumption. The coefficient of electricity expenditure carries the negative sign likely same as Filippini (1995) using AIDS model for Swiss residential electricity demand. He found significant coefficient of real electricity expenditure which shows that the budget share of peak and off-peak electricity to be sensitive to changes in total electricity expenditure.

Table 9: Estimates of parameters of model of amount spent on each utility based on Engel function

Variables	**Water**			**Electricity**		
Amount spent on each good	Coef.	t-statistic	P-values	Coef.	t-statistic	P-values
Total expenditure	0.27796	6.65	0.000	0.52120	30.07	0.000
Number of persons per household	0.59920	12.54	0.000	0.59525	26.64	0.000
Flush toilet	0.33644	4.34	0.000			
Urban area	-0.21074	-1.92	0.055	-0.02620	-0.75	0.451
Modern planned areas	0.16093	1.47	0.141	0.31159	5.00	0.000
Unplanned Urban housing	-.025311	-0.29	0.773	0.40974	12.26	0.000
Constant	4.06356	8.62	0.000	0.97360	5.07	0.000

Note: *Amount spent is the dependent variable in our regression and variables below it are independent variables.*

Since water and electricity consumption and the regressors are in logarithms in model of amount spent, the coefficients are directly interpretable as demand elasticities in table 9. The expenditure elasticities for both water and electricity are significant and carries the expected sign. The estimated expenditure elasticity is **0.27** for water and **0.52** for electricity. The demand for water and electricity is responsive to the level of expenditure with expenditure elasticity of less than one and leads to ideal considering these goods as necessary goods. Since this elasticity is below unity, expenditure growth apparently results in a less than proportional increase in water and electricity consumption.

These total expenditure elasticities are associated with normal and as values are below one the nature of these goods is associated with necessary goods. The negative of sign of coefficient of total expenditure is associated with drop in expenditure share on either electricity of water as total expenditure increases. In short run, the level of consumption of electricity is not probably expected to increase as total expenditure increase. The fact water and electricity are utilities of everyday life that households find them difficult to maintain short-run changes in behaviors associated with total expenditure changes. It may be happen in the long run when households acquire new equipment with an increase in individuals per household. Bekele et al. (2015) also found total household expenditure and energy budget share to be negatively related where coefficient of household's total expenditure shows the nature of energy goods but not the magnitude of the change (Gundimeda et al, 2006). Briefly the household's total expenditure rise and energy i.e. electricity budget share tend to decline.

Household size, measured by the number individuals per household, seems to influence water and electricity consumption of household in both models. The estimated household size elasticity or coefficients are significantly different from 0 at the 95% confidence level. In both table 8 and 9, these are the columns "t-statistic" and "P-values" specifically for household size. Typically, a t-statistic above 2 or below -2 is considered significant at the 95% level and in the above output, coefficients for number of individuals per household are statistically significant according to t-statistic and p-values. For example in table 9, both water and electricity have positive coefficient **0.5** and it implies that the larger the household size, the higher the expenditure for both commodities. Our findings on household size agrees with Bernard et al. (1996) who noted that the number of persons and the size of a residence causes more electricity to be used. The positive sign on household size is not same as Bekele et al. (2015) who found negative sign for family size but significant. He explained that it may be due to the exploitation of economies of scale associated with relatively less per capita energy demand for larger household family size.

Apart from the price of water which may determine the level of its consumption, households with flash toilets tend to use much water. In our current study the coefficients of flash toilet (0.33) in table 9 has correct sign and statistically significant different from 0 at the 95% confidence level. Its t-statistic is equal to 4.34 while p-value is equal to 0.000.

The negative coefficients on urban area on the consumption of water is also of unexpected sign and not generally significant as indicated by t-statistics and p-values, and may be attributable to very little number, in the survey, of household purchasing water while others may use other alternative free water sources (rain water, public stand pipe, …etc.). The non-significance is probably due to very little number of urban household (2,275) in the survey which is associated with very little number of households consuming water by purchases.

Type of habitant characteristics (modern planned area and unplanned housing) seem to significantly influence the electricity and but not water consumption of households. For water consumption, unplanned urban housing and modern planned area dummies in table 8 and 9 show a negative relation with water consumption even not significant different from 0 at the 95% confidence level consumption probably due to very little number of households which uses water on charge and other free water sources i.e. rain water. For electricity urban characteristics, the result on the dummy variable related to the urban planned area and unplanned urban housing probably suggest that households living in cities show a higher electricity consumption than those living in non-urban. This result are in accordance with assumption that cities are characterized by more developed electricity distribution systems with more access to electricity.

Chapter Six: Summary and recommendation

This document provides results of the estimation of household water and electricity consumption, specifically estimates of the total expenditures elasticities. Estimates are based on data from the EICV4 survey conducted by NISR in 2013/14. The document illustrates the empirical analysis performed for the purpose of getting results. Models are used to determine the responsiveness of income (total expenditure), household size and other variables relating to demographic and geographic characteristics of households on total expenditure share and amount spent on each good in analysis. The estimated models demonstrate the importance of household expenditure and other geographical characteristics in determining electricity and water consumption.

A positive total expenditure elasticity of consumption of electricity and water is associated with normal goods. As total expenditure elasticity of consumption of those utilities of is less than one, it implies that both water and electricity falls in the category of necessity goods. The estimates of the total expenditure effects obtained are less than one and this probably implies the inelasticity of household consumption of electricity and water with respect to the total expenditure.

In the results, it has been revealed that household total expenditure and the size of households tend to have influences on the consumption of these utilities. Except for results of the consumption of water, the location and urbanization also tend to have a relationship with the consumption of electricity. In his section we therefore discuss the link relationship between the use of utilities and infrastructures and highlight the role to be played by the public and everyone to access utilities. In policy planning, it is necessary to observe the nature of article purchased by households and minimize scarcity. Finding indicate that both electricity and water are necessary goods which primarily support the living conditions. Households for satisfying all needs requiring the availability of water and electricity, the side of supplier has therefore to be ready to much the demand as people tend to move from isolated areas (where for example water is free of charge) to clustered urban or rural areas. Household tend use of electricity and water as necessary goods probably because their utility satisfaction is derived from appliances and technologies requiring electricity use and water and sanitation.

Furthermore, results revealed modern planned area to have a link with use of utilities except water which would probably mean that population moving to modern housing area has probably potential demand for utilities than other people located in isolated areas. There are some reasons which may explain that situation. In the 1st case, infrastructures are very expensive to be distributed all over the country and it takes time to connect each and every household to water pipe and electricity grid. As effect household tend to reside clustered areas where access to utilities is facilitated by short distance. In 2nd case people tend to be near utilities services for operation and maintenance services of utilities infrastructure. This results from a good plan of inhabitant settlement and grouped settlements which reduce the distance carried out by customers and enable them to gain time and concentrate to other economic activities.

As the current study lacked data on price on electricity and water, this study is suggesting to potential researches to conduct research activities at household level specifically on electricity and water demand by incorporating in models factor own price, prices of energy sources and price of appliances. The study will be expected to provide income and prices elasticizes and the influence of home appliances on the level of consumption. Where applicable, potential researchers also suggested to use panel data by combining previously and recent EICVs conducted in Rwanda in order to reflect the factor “time” in study.

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