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# Exogenous Determinants of Rural Electricity Connection to Residential Consumers in Kasulu District, Tanzania

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***Abstract***:
*Access to clean and reliable sources of energy like electricity to rural consumers is a pressing issue globally but mostly to the Lowest Economic Developed Countries (LEDCs). Tanzania being among, has special target of connection electricity to rural residents. However, connection of electricity has been overtly explained by various factors. Therefore, this study was conducted specifically to examine how exogenous factors can influence household to connect electricity. The study design was cross-sectional withy sample size of 250 households connected to electricity. Results from Multiple Regression Model (MRM) indicates that number of households connected to electricity is determined by bureaucratic procedure($p< 0.01$), quality of residential house in terms of roof andwalls, distance from power distribution line, materials and technical costs and economic status ($p<0.001$) had peculiar influence on household to connect electricity. Due to financial constraint, households have devised financial resources mobilization strategies to meet connection costs. These included, taking loans (from banks, savings and credit co-operative societies) and selling assets. However, some household have advantages by having a good number of income contributors. The results for Pearson's Product Moments of Correlation Coefficient (PPMCC) showed that there was moderate positive correlation between household income and number of contributors, $r=0.354$ ($p< 0.001$). The study concludes that electricity connection at the household should consider safety of consumers; yet consumers residing near the distribution have advantages bound with financial relief for upfront cost. Bureaucratic procedures can scale down number of consumers in rural areas. It is recommended that; the utility supplier should provide more incentive based on flexible power connection procedures. Fixed cost for upfront costs be devised while the utility provider continues carrying service line costs even for those situated far from power lines.*

***Keywords:*** *Rural electricity, connection, exogenous determinants, residential*

## 1. Introduction

Rural electrification through different sources of electric energy has caught attention of development planners especially in the lowest economically developed countries. Electricity is cleanest form of energy which can easily be transformed from one form to another. Supply of electricity to consumers in rural areas differs drastically from one region to another as well as country to country. The OECD countries have almost achieved 100% electrification rates in both rural and urban, North Africa have achieved a tangible rate of electrification to rural and urban consumers where more than 90% have access(Baher, 2013; World Bank 2012. Most of the Sub-Saharan Africa has poorest rate of electricity connection especially to rural consumers where the connection is averagely 12-15%(International Energy Agency-IEA, 2015). The lower rates of electricity connection to residential consumers could adversely be contributed to poor electricity production and distribution. These are considered as endogenous factors which consumers can hardly control.

In Tanzania, electrification projects are implemented in various areas including typical rural, Districts headquarters, business centres and small townships through Rural Electrification Agency (REA, 2011). The agency works in collaboration with state utility company; Tanzania Electric Supply Company (TANESCO) in implementing power supply projects (TANESCO, 2005). Electricity supply in rural areas is implemented through extension of the national grid and the well-established mini grid projects (URT, 2010).Rural electrification projects have been implemented in various African countries including Kenya, Uganda, Malawi and South Africa (Kimani and Karekezi, 2010). The connection determinants differ from one country to another because for some scheme's electricity connection is free in South Africa, while in Senegal the connection has been scaled down to a more manageable cost. In 2011 there was a rise in electricity connections in Tanzania because 13.9% of the total Tanzanian population had electricity of which 2 % was from rural areas (International Energy Agency, 2011). In 2016 the rate of electricity access especially in rural areas had risen to 32% (United Republic of Tanzania- (URT, 2016)

According to URT (2009), the existing electricity supplies in both rural and urban settings are delivered at very high costs. Some consumers are within the reach of electricity distribution but yet they are not connected. This is due to the view that electricity connection in Tanzania and Africa in general is not for free, connection requires a consumer to meet important criterion mostly exogenous. A study conducted by Mwihava (2010) indicated that for residential consumers to be connected to both national and mini grid electricity, consumers must be able to afford connection costs.

The cost can necessitate extra household strategies to mobilize funds. Some strategies could pose detrimental effects on household expenditure due to high interest loans. The nature of population distribution in most rural areas can be considered as possible indicator of power connection. This is because of the fact that sparsely distributed populations can aggravate high connection costs due to consumers distance from distribution lines was another factor for electricity connection.

Among the factors for power connection was uncertainties over electricity charges and safety standards (Smith, 1992). Safety standards were hinged on the quality of houses that, corrugated sheets roofed houses were viable in order to get power connection. Smith's findings did not put into consideration that power charges are not static due to production cost fluctuation. However, the study considered less in indicating the problems that are associated with power supply for houses with no iron sheet roofs in rural Tanzania and Africa. Kandawire (2005) found that distance to payment centre can determine electricity connection in rural areas. The issue of the long-distance walk to payment canters was considered as a factor that discouraged other consumers from getting power connection. This does not apply at the moment due to modern technology of electricity bill payments like the use of Banks and Mobile Phones (TANESCO, 2010). However, the distance can still be a little factor due to improved means of transport in some rural areas in Tanzania.

Studies conducted by African Energy Policy Research Network (AFREPREN) (2007) revealed that, cost of connection is an important element to access electricity. The study further pointed out that the connection charges range from less than $20 to over $4,000[1], so far, the cost factors is similar to the studies by Kandawire (2005), Mwihava(2010) and Kimambo (2012)showed that high connection tariffs have effects on household decision to respond to electricity connection at the household. Kimambo (2012) revealed that the connection charges in Tanzania ranges from USD 270-1957[2].This basically sounded less manageable to both rural and urban customers most being deprived by income poverty. Households in rural areas often have particular problems in raising cash and may have to sell land or livestock in order to afford the connection charges (Smith, 1992).

Christian, Benjamin and Johannes (2011) had a view that limited local availability and the quality of electrical appliances, the quantity of power supply, monthly electricity consumption and purchasing power of rural customers, had vital role in determining electricity connection. These results seem to rely on economic capabilities of the rural people to buy modern appliances, and it means that those who cannot afford modern appliances will not be motivated to seek for connections. Electricity price may change due to the nature of electric plant (NRECA, 1993). Blennow (2004) had a different ideas based on the findings that, presence of financial institutions and investment credits determine the distribution of electricity in rural areas and hence benefit the households. These points are projected on economic issues only, the social determinants are overlooked. In Tanzania, electricity connection to rural households including Kasulu district is coupled with various factors. Proximity to electricity distribution lines do not obviously guarantee consumers to be connected. Generally, despite tangible efforts by energy utility in Tanzania, number of households connected to electricity has remained low (36%)in rural areas (United Republic of Tanzania, 2016), although there is a marginal increase compared to the efforts. Various aspects including exogenous factors has been underrated in assessing electricity connection among the rural customers in Tanzania. This has enticed the study to address the gap. Further, the study examined the key strategies devised by rural electricity customers to mobilize financial resources to meet connection costs.

## 2. Methodology

### *2.1. Study Area*

The study was conducted in Kasulu District, Kigoma region, western Tanzania. Kasulu District is one of the leading Districts in Tanzania with massive number of households connected to mini grid electricity supply. The mini grid in the district had been installed as an alternative effort toward rural electrification and the achievement of universal access to clean and affordable sustainable energy to the populations which are not connected to the national grid

### *2.2. Research Design*

Cross-sectional research design was used in the current study while relying on both qualitative and quantitative aspects. Cross sectional research design was used because it allows for acquisition and create a scope of gathering more information that enabled the researcher to come up with reliable and valid findings. Furthermore, quantitative paradigm was used for the purpose of dealing with quantitative data.

### *2.3. Sampling Procedures and Sample Size*

Probability sampling methods was used in the current study to avoid biases in selection of respondents. Random number table was used to obtain respondent households. Households involved in the study were those connected to electricity utility for at least one year to reveal the challenges encountered in power connections. The sample size for the study was 250 household obtained using the formula by Yamane 1967 at 95% confidence interval and 5% precision to 1000 households connected to utility.

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

n= Sample size

[1] Exchange rate: 1 USD=1255.00 TZS (Bank of Tanzania, 2007)

[2] Exchange rate: 1 USD= 1575.00 TZS(Bank of Tanzania,16th December,2012)

N=Total population of the connecetd households fitting the study
e= ±0.05 precision
1=Constant
$\boldsymbol{n} = \frac{1000}{1+1000*(0.05)^2}$= 250

*2.4. Sources of Data*

The current study employed both primary and secondary data. Primary data were gathered from respondents during the actual visit of the field. Likewise secondary data were obtained from secondary sources related to electricity supply Secondary data included those already collected and compiled by TANESCO, Rural Energy Agency (REA) and national bureau of statistics.

*2.5. Data Collection and Analysis*

During household survey various tools were used to gather data. The tools included structured questionnaire applied to gather quantitative data. Questionnaire was researcher administered in order to provide direct clarification. Documentary review was used to obtain data based on electricity connection response among the rural consumers. Interviews were conducted to a range of energy utility officials including transmission and distribution engineers. Data analysis was carried out using multiple regression model to analyse exogenous predictors for electricity connection among the rural residential consumers in Kasulu District. The multiple regression model was given by such a below equation

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

Where: $Y$ = Number of households connected to electricity from the utility supplier

$\beta_0$ = A constant term

$\beta_{1-k}$ = Partial coefficients

$X_{1-k}$ = Predictor variable

$\varepsilon_i$ = Random error term

## 3. Results and Discussion

*3.1. Exogenous Predictors for Number of Households to Connect Electricity*

A multiple regression model was used to ascertain predictors for number of households connected to electricity in the study areas. Model assumptions; multicolinearity was found to be < 0.5. Collinearity diagnostics indicated tolerance values (>0.10), while the variance inflation factor (VIF) for variables (< 10). Assumption for the model and its goodness of fit indicated acceptability. $R^2$value was 0.333 while F-Test was 18.125. Thus, the model was a significant predictor for rural households connected to electricity, F (10, 239) =18.125, $p$<0.001. The regression results are presented in Table 1

| Regressand variables | *B* | Std.Error | *B* | T | Sig. | Tolerance | VIF |
|---|---|---|---|---|---|---|---|
| **(Constant)** | -1.564 | .428 | | -3.653 | .0001 | | |
| $X_1$. Bureaucracy | .182 | .064 | .152 | 2.835 | .0050 | 0.637 | 1.570 |
| $X_2$.Roofing materials of the house | .075 | .037 | .090 | 2.049 | .0410 | 0.948 | 1.055 |
| $X_3$.Housing wall make up | .381 | .070 | .260 | 5.461 | .0001 | 0.810 | 1.234 |
| $X_4$.Distance from distribution line | .393 | .071 | .260 | 5.566 | .0001 | 0.840 | 1.191 |
| $X_5$. Occupation of household head | -.183 | .075 | -.114 | -2.434 | .0150 | 0.837 | 1.195 |
| $X_6$.Material and technical cost | .440 | .078 | .262 | 5.625 | .0001 | 0.847 | 1.181 |
| $X_7$.Enterprises establishment | .103 | .074 | .069 | 1.390 | .1650 | 0.753 | 1.327 |
| $X_8$.Upfront cost for connection | .304 | .073 | .201 | 4.158 | .0001 | 0.788 | 1.269 |
| $X_9$.Income of the household | 8.371E-008 | .000 | .253 | 4.594 | .0001 | 0.605 | 1.654 |
| X10.Size of the main house | -.022 | .045 | -.022 | -.485 | .6280 | 0.931 | 1.074 |
| | Model goodness of fit | | | | | | |
| N | 250 | | | | | | |
| Durbin-Watson | 1.5 | | | | | | |
| F-test | 18.125 | | | | | | |
| $R^2$ | 0.333 | | | | | | |
| $R^2_{Adjusted}$ | 0.315 | | | | | | |
| ANOVA model significance | *p*< 0.001 | | | | | | |

*Table 1: Predictors for Number of Households' Connection to Electricity*

The findings in Table1 indicate that various factors can better predict the rural consumers' connection to electricity. Thus, the number of households connected to utility is determined by both practical and theoretical predictors.

3.1.1. Bureaucratic Processes

The results in Table 1 indicates that bureaucracy had significance value of ($p$<0.01) because consumers had to spend more than four weeks making closer follow up for electricity connection. However, there are a lot of time consuming procedures for power connection coupled with unavailability of electric poles and smart meters. The procedures included payment followed by more than four weeks wait in most cases, wiring and inspection demands of utility supplier. Further, the current study found that some consumers had spent at least 16 weeks making irregular journey to utility suppliers to push for electricity connection. Political leaders have made possible push to ensure that materials are available for power transmission and distribution to consumers.

3.1.2. Residential Housing Quality

Residential housing quality in this study was measured in terms of the nature of roofing materials and wall makeup. The roofing materials was significant at ($p$<0.05) while housing wall was significant at ($p$<0.001).The quality of house in terms of wall and roof was a great factor of observation because it was associated with safety of consumers. Residential houses roofed with grasses, or muddy did not qualify for electricity connection. This was because of the fact that during rainy seasons most houses leaked and this could cultivate electrical shocks especially when water contact live power cables. In the past two decades, rural Tanzania has experienced visible improvement in housing quality, this was due to economic stability to some rural dwellers which enabled them to re-structure housing standards to meet power connection criterion. Nonetheless, housing wall statistical significance indicated that during wiring for power installation it was important for installation cables to remain intact with the wall or inside the wall. The muddy wall and any other wall make which could not provide maximum support for electrical cable installation were not visibly influencing consumers' connection to electricity from utility supplier. A field photo presented in Figure 1 indicates that, although the houses are roofed with iron sheets, yet the consumers are not connected to electricity due to housing wall factor which could not provide wiring installation support.

*Figure 1: Residential Houses Created with Muddy Walls*
*Houses with Mud Walls and Iron Roofs Were Not Connected to Electricity Even If They Were Close to Electric Distribution Line and Despite the Fact That the Clients Wanted Electric Services (Photo by Muhihi B)*

3.1.3. Distance from Power Distribution Lines and Upfront Costs

In most cases rural settlement lacks linear pattern which creates a cost full effect for those willing to connect electricity from utility. Regression results in Table 1 indicates that bothupfront costs and distance of consumers from power distribution line had statistical significance at ($p$<0.01). This is an indicative that the more the distance from electricity distribution lines the less likelihood to be connected to electricity. The common distances referred to by the utility supplier indicated that consumers residing not more than 90 meters from power lines were eligible for power connection. The long distance from power lines usually excavated high upfront cost for connection because it could require a customer to pay for extra electric poles which in turn can be not affordable. The upfront costs payable directly to utility company had direct relationship with the distance. This is confirmed by indicative upfront costs(Value Added Tax inclusive) that as distance from power line increases the upfront costs increases too.Figure 2 indicates residential consumers residing within 30 meters being connected to electricity at lowest upfront cost of US $ 80 as compared to those residing 90 meters who were eligible of paying US $ 210.The more the distance the more the charges for upfront cost. The rural consumers due to unplanned settlement some did not manage to be connected to electricity due to higher cost for electrical poles for extension of service line to the household.

*Figure 2: Residential Power Consumers Residing Close to the Distribution Line Customers Who Reside Near the Distribution Lines Specifically 1-48 Meters Were Eligible for Easy Power Connection (Photo by Muhihi. B)*

3.1.4. Household Income and Occupation

The results from Table 1 indicate that households' income has statistical significance at ($p$<0.001) while occupation of the household head was at ($p$<0.05). Statistical significance for household income is a clear indication that the economically diminished households could not afford to pay for various cost for electricity connection. The cost ranges from upfront to technical and materials aspects. The household income in rural areas is predominantly contributed to by agriculture as a main occupation by 75% (URT, 2015).The rural areas are faced with various economic hardships which are defined by occupation with unclear bright future of success. Poor access to markets and transportation challenges had led to sporadic incomes to many rural occupants which in turn define their ability to connected electricity. The government workers, business men and women are highly on the capacity to meet connection demands than the counterparts with economic instabilities

3.1.5. Materials and Technical Costs

Materials and technical costs had statistical significance at ($p$ <0.001). This is an indication that that electricity connection in Tanzania has diverse demands which in turn determine the number of consumers or households to be connected to power supply. Countries like Senegal and Ethiopia had special scheme for free and cheaper provision of electrical materials to rural power consumers to cut down the connection cost. Electrical materials are sold at very high prices especially in the study areas and regions which are located at the countryside. Fixed and negotiable costs for electricity has been a huge burden for most of rural power consumers due to their sporadic income coupled with high domestic demands for family substance. Procedures for Power connection require consumers to pay fixed cost for upfront and wiring inspection connection.

*3.2. Households' Financial Resources Mobilization for Electricity Connection*

The current study sought to investigate strategies for financial resources mobilization to meet fixed and negotiable costs for electricity connection. Financial resources or income status of the household had statistical significance level at ($p<0.001$) in determining the number of households to be connected to rural electric supply (Table1).The findings about financial sourcing strategies are presented in Table 2

| | Primary Initiatives | Frequency | Percent |
|---|---|---|---|
| | Bank loan | 9 | 3.6 |
| | Loan from Friends | 42 | 16.8 |
| | Loan from SACCOs | 29 | 11.6 |
| | Loan from Lending and borrowing groups/VICOBA | 21 | 8.4 |
| | Loan from Relatives | 23 | 9.2 |
| | Didn't take loan | 126 | 50.4 |
| | Total | 250 | 100.0 |
| | Secondary initiatives | | |
| | Sold assets | 61 | 24.0 |
| | Long time financial saving | 85 | 34.0 |
| | Savings and Sold assets | 104 | 42.0 |
| | Total | 250 | 100.0 |

*Table 2: Primary and Secondary Financial Resources Mobilization Strategies*
**SACCOS=Savings and Credit Co-Operative Societies, VICOBA=Village Community Bank*

The findings in Table2 indicate that rural consumers have devised different strategies forfinancial resources mobilization. Ability to pay for electricity costs is importantly determined by households' economic status. The primary strategies used to sources money included taking loan from different places including banks, Savings and Credit Co-operative Societies and Village Community Banks. About 50% of the respondents depended loan as their primary means of collecting money for electricity connection while another 50% took no loan. The rural economy in Tanzania is mostly shaky as about 80% of the population depends on agriculture which is not assured by market forces. One of the key roles of village community banks and SACCOS has been visible in economic provision for rural people by providing financial support for the needy.

Rural dwellers like in urban areas usually depend on multiple economic activities ranging from agriculture and, business and entrepreneurships. This is merely geared at ensuring household sustenance are met. Nonetheless some residential consumers had secondary strategies for financial resources mobilization. These include selling assets like pieces of and cattle (24%), long-time financial savings (34%), saving and selling assets (42%). Some these strategies had dramatic effects on household economies due to the fact that it could cultivate transient poverty and among the consumers who could remain without assets or non-productive assets. The rural economy is vulnerable; the dire need of electricity connection among the rural people has caught massive attention. Consumers had willingness to catch electricity at their households due to its nature of being cleanest form of energy with multiple uses while ensuring social well-being of the consumers.

In rural areas where agriculture is dominant, household income has always been equated with many factors but more importantly the numbers of household members who contribute income from various sources. Household income being one of the peculiar factors which determine the number of household to be connected to electricity has become paramount in this study to find out how it relates to the household members. To ascertain this phenomenon a correlation between household members (18+ years) who contribute income versus aggregated household income was conducted using Pearson's correlation. The results are presented in Table 3.

| **Correlations** | | | |
|---|---|---|---|
| | | Members who contribute income at the household | Total household income |
| Members who contribute income at the household | Pearson Correlation | 1 | .354** |
| | Sig. (2-tailed) | | .000 |
| | N | 250 | 250 |
| Total household income | Pearson Correlation | .354** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 250 | 250 |

*Table 3: Correlation between Income Contributors and Household Aggregated Income*
***. Correlation Is Significant at the 0.01 Level (2-Tailed)*

A Pearson product-moment correlation (PPMC) was run to determine the relationship between households' income and number of household members who contribute income. The results in Table 3 indicate that there was moderate positive correlation between household income and number of contributors which was statistically significant ($r=0.354$, $n=250$, $p < 0.001$). Financial resources acquisition in rural areas has been associated with agricultural depending on the household labor force in the field, those who work in formal and informal sectors as well. Connection of electricity is appealed to be important if the household income is well aggregated and thus any policy intervention should be based at making electricity connection affordable depending on the available financial status of the household.

## 4. Conclusion

Electricity connection to rural household requires lenient and friendly exogenous factors which can influence a number of consumers to access modern energy supply. Basing on the findings and methodology used, it has been found that there are various factors for electricity connection especially for rural consumers which require policy and procedural considerations. Consumers residing closer to the power distribution lines have advantages to connect by paying a minimal amount of money for upfront compared to distant consumers. Electricity connection to household is also concerned with quality of residential a houses in terms of roofs and wall. This was reported significant due to the fact of ensuring safety to consumers. The rural consumers' depends on multiple strategies to out sources income to meet electricity connection. The income is contributed to by various factors. Nonetheless, further findings indicated moderate positive correlation on aggregate household income versus household members who contribute income for various needs including electricity connection and general household sustenance

## 5. Recommendations

The current study recommend to the vertical state energy utility supplier that some of the key predictors for number of households to connect electricity are based on supplier performance. Exogenous factors like bureaucracy which is coupled with shortage of electrical poles and rental meters should be re considered. The upfront costs for electricity connection should be maintained on the fixed terms. Where a customer is away from distribution lines, network build up costs should be the responsibility of the supply. More, the government should centralize and diversify market access for rural agricultural products to enhance household income stabilization.

**6. Conflict of Interest**

The author declares that he has no conflict of interest and that the study was solely funded by author. Therefore, the results of this study were not influenced by any second or third part and any other associated factors.

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