



INDICATORS OF ENERGY ACCESS IN RURAL AREAS OF TANZANIA: AN APPLICATION OF CONFIRMATORY FACTOR ANALYSIS APPROACH

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ABSTRACT

Energy access plays a crucial role in enhancing the social-economic development among the household members in any nation. Notwithstanding the role of energy access in improving the livelihood of people, provision of energy access has revealed to be a major problem in rural areas of Tanzania. The increased in problem of energy access in rural areas of Tanzania is due to the absence of a unified set of indicators for measuring its energy access in order to improve the livelihood and standard of living of rural households. In order to fill this knowledge gap, this paper focused on determining the indicators of energy access in rural areas of Tanzania.

The study employed Cross-sectional survey type of the research design to collect data from 384 heads of household from the rural areas of Njombe and Iringa regions in Tanzania.



Quantitative Exploratory Factor Analysis using Principal Component analysis and varimax method was employed to determine the indicators of energy access. The identified indicators using exploratory Factor Analysis was further confirmed using Confirmatory Factor Analysis(CFA). The study findings revealed that, the indicators for measuring the provision of energy access to rural households in developing countries including Tanzania ranked based on its importance are: availability, affordability, durability, efficient, no production of smokes, easy to use and ability to keep cooking facilities clean.

Based on these findings, the study concludes that, indicators of energy access are important in enhancing the social economic development and improvement of the livelihood of people in rural areas. In the light of this conclusion the study recommends the government, policy makers, energy experts and other practitioners to make use of the identified indicators when measuring energy access to rural households in Tanzania in order to improve their livelihood and standard of living

Keywords: Energy access, energy sector, energy indicators, rural areas, households, Tanzania

1. INTRODUCTION

Improvement of livelihood of people depends on the provision of energy access which is reliable, available and affordable. Rural households use energy such as electricity, firewood, charcoal or Liquefied Petroleum Gas (LPG) for various activities such as cooking, lighting, transport, agriculture and industries. The use of these energy sources contribute in improving the social economic development of rural households in the developing nations including Tanzania.

Notwithstanding the important role of energy access, yet the problem of energy has emerged to the major challenges in the rural part of the developing countries. Statistics indicate that about 1.3 billion of the world populations do not have access to electricity while about 2.7 billion people of the world population do not have access to modern cooking facilities or fuel (BHATTACHARYYA, 2015).

Consistent to that, the reports from Mainali (2014) and IEA (2012) also evidence the presence of devastating challenge of ensuring the provision of reliable and clean energy for cooking and lighting to 2.8 billion people and electricity to more than 1.2 billion people in the world.



Apart from the energy access being a global challenge, the study by Mainali (2014) insisted that the problem of energy access more serious in rural areas where by more than seventy percent of rural households are being confronted the energy access problem.

Additionally , the study by Mwakapugi, Waheeda and Smith (2010) on Tanzania energy sector indicates that more than 95% of households in rural areas of Tanzania do not have access to energy despite the fact that the country is endowed with different forms of energy such as biomass, natural gas, hydro, coal, geothermal, solar and wind energy.

Equally, the study by IEA(2013) added that more than 37 million Tanzanians population not have access to electricity and modern cooking, heating and lighting facilities. Consequently, large part of rural households relies on the traditional and un-sustainable source of energy such as firewood and charcoals which have in turn, they cause problem to human health and environment.

The problem of energy access in the rural areas of the developing nation including Tanzania is due to the absence of indicators to clarify and make the aggregate information available for various energy access actors such as policy makers, government and energy experts for decision making on energy access issues and ensure provision of energy access for social economic development.

Consistent to that, Bhattacharyya (2016) insisted that the problem of energy access in rural areas of the developing countries is being exacerbated due to the absence of a unified set of indicators for measuring energy access. Equally, the study by Mainali (2014) revealed that absence or missing of the mechanism or indicators of energy access contribute to the problem of energy access in rural areas.

Additionally, study by Mensah, Kemausuor and Brew-Hammond (2014) on energy access indicators trends In Ghana also added that among the unanswered questions include; how can the energy access be assessed using the set of energy access indicators. Various academia and practitioners such as Mainali (2014), Pachauri (2011), Bhattacharyya (2012), Mensah, Kemausuor and Brew-Hammond (2014) and IEA (2016) conducted studies on energy access issues. However, no

such study on indicators of energy access has been conducted in rural areas of Tanzania. Consequently, the indicators of energy access in rural areas of the developing countries including are not known and thus, energy access is measured on ad-hoc basis. This study aims at identifying the indicators of energy access in rural areas of Tanzania

2. METHODS AND MATERIALS

The study employed a cross sectional survey type of research design with structured questionnaire as a survey instrument to collect primary data from 384 heads of household residing in rural areas of Njombe and Iringa regions in Tanzania. The rural households from Njombe and Iringa regions were sampled using Multistage Cluster Sampling and thereafter simple random sampling was employed to sample rural households from Njombe and Iringa regions in Tanzania. Based on the employed sampling techniques, the sample size comprised of 130(33.86%)respondents from Mufindi district, 139(36.19%)respondents from Njombe district, 62(16.15%) from Iringa District and 53(13.80%)respondents were from Makambako Town council making a total of 384 respondents.

The study employed quantitative Exploratory Factor Analysis using Principal Component analysis as an extraction method and varimax as rotation method to determine the indicators of energy access in rural areas of Tanzania. The identified factors using Exploratory Factors analysis were confirmed using Confirmatory Factor Analysis (CFA) under Structural Equation Modeling (SEM). The subsequent sections provide the study findings on the indicators of energy access in rural areas of Tanzania.

3. STUDY FINDINGS

3.1. Indicators of energy access in rural areas of Tanzania

This section sought to determine the indicators of energy access using Confirmatory Factor analysis. The study used nine (9) constructs namely affordability, efficient, availability, easy to use, economical, convenience does not produce smoke, durability and keeping the cooking pot clean.

Respondents were required to indicate their extent of agreement or disagreement on these indicators of energy access from the questionnaire measured using Five likert scale of 1 = Strongly Disagree, 2 = Disagree, 3 Neutral, 4 = Agree,



and 5 = Strongly Disagree. The descriptive analysis results on the indicators of energy access are depicted in Table 1.

Table 1: Descriptive results on the indicators of energy access in rural areas

Indicator of Energy access	Frequency	Mean
Convenience	384	3.63
Keep the cooking pot clean	384	4.24
Does not produce smoke	384	4.32
Economical	384	4.39
Durability)	384	4.42
Efficient	384	4.46
Affordability	384	4.53
Easy to use	384	4.58
Availability	384	4.61

The descriptive study results from Table 1 show that the indicators of energy access in rural areas ranked according to their importance are: availability, easy to use, affordability, efficient, durability, economical, does not produce smoke, the ability to keep the cooking pots clean, and convenience. Exploratory Factor Analysis using Principal Component analysis (PCA) with Varimax was performed to determine indicators for measuring energy access in rural areas of Tanzania. The extracted loading values for each factor are presented in Table 2.

Table 2: Loading values for each indicator of energy access extracted using Principal Components Analysis Method

Indicators of energy access in rural areas	Loadings Factors (λ)
Affordability	0.63
Efficient	0.68
Availability	0.72
Easy to use	0.55
Economical	0.51
Convenience	0.16
Do not produce smokes	0.66
Durability	0.74
Keep the cooking pot clean	0.83

The study results from Table 2, show that eight indicators out of nine have the loading factor values (λ) greater than the minimum recommended value of 0.30 ($\lambda > 0.30$). These indicators can be expressed in order of importance as: keeping the cooking pot clean, durability, availability, efficient, do not produce smoke, affordability, easy to use and economical. Thereafter these indicators were rotated

using Varimax method whereby only indicators with Eigen-value greater than one were retained. The description on how variances of these components have been explained by nine indicators is as presented in Table 3.

Table 3: Total variance explained by the indicators of energy access in rural areas

Component	Initial Eigen Value			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% Var	Cum %	Total	% Var	Cum%	Total	% Var	Cum%
1	3.98	44.21	44.21	3.98	44.21	44.21	3.16	35.06	35.06
2	1.44	16.03	60.25	1.44	16.03	60.25	2.27	25.19	60.25
3	0.95	10.60	70.85						
4	0.70	7.77	78.62						
5	0.58	6.44	85.06						
6	0.45	4.94	90.00						
7	0.38	4.18	94.18						
8	0.33	3.67	97.85						
9	0.19	2.15	100.00						

The study results from Table 3 depict that two components of indicators of energy were established after rotation of the factors. The study showed that the first factor accounted for 35.06% of the variance and the second factor accounted for 25.19 % of the variance. These study findings imply that 60.25 % of the variance is accounted for by the first two factors, while the remaining 39.75% of the variance is accounted for by other factors. Based on the study findings, the study propose the two categories of indicators named as Techno-economic and financial indicators of energy access as shown in Table 4.

Table 4: Rotated Components Matrix of the indicators of energy access in rural areas

Indicators of energy access in rural areas	Factor loadings		Proposed name of the indicators
	1	2	
Keeping the cooking pot clean	0.909**		Techno-economic Indicator
Last longer(Durability)	0.848**		
Does not produce smoke	0.805**		
Economical	0.630**	0.332	Financial indicator
Always available		0.856**	
Cheap/affordable		0.787**	
Easy to use		0.714**	
Efficient	0.469	0.642**	

** = Highly correlated and accepted loading factor.

In Table 4, the study findings show that the indicators of energy acces in rural areas of Tanzania under Techno-economic category are keeping the cooking pot clean, durability, “does not produce smokes” and “economic indicators. Besides, the

study findings depict that the indicators of energy access under the category of financial are availability, affordability, easy to use and efficient.

The identified indicators using Exploratory Factor Analysis were subjected into Structural Equation Modelling through Confirmatory Factor Analysis for confirmation purposes. Confirmatory Factor Analysis was performed by the aid of AMOS software version 18. The confirmatory Factor Analysis results are as presented in Figure 1.

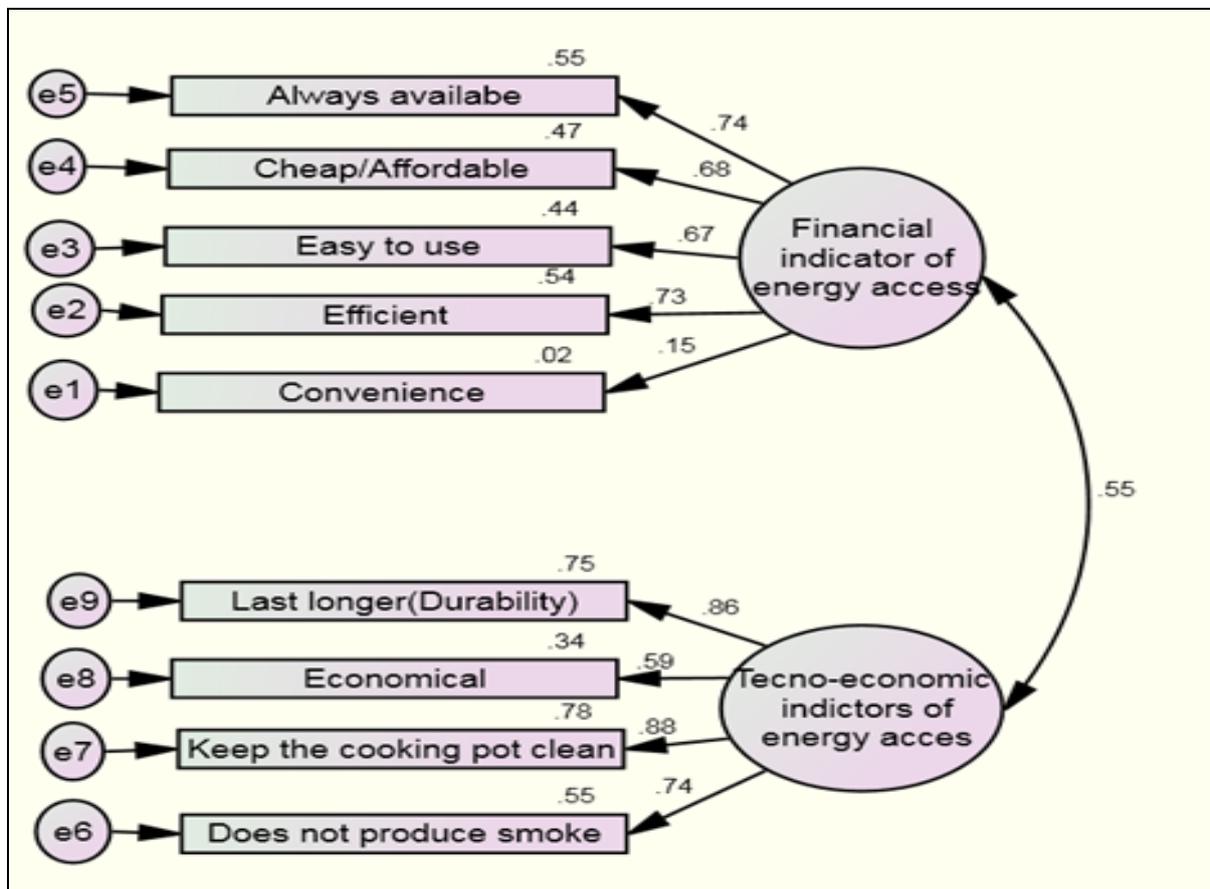


Figure 1: Confirmatory Factor Analysis on indicators of energy access in RURAL areas of Tanzania

The study results from Figure 1 show that all indicators under tecno-economic have loading factor values greater tha the minimum recommended value of 0.30. Additioally, the study findings from Figure 1 indicate that four indicators out five under financial category have loading factor values greater than the minimum recommmeded value of 0.30.

Consistent to that, the study findings from Figure 1 show that 55% of the variance in financial aspects of energy access in rural areas is explained by the indicator named availability, 47% being explained an indicator named affordability,

while 44% and 54% of the variances in financial indicator of energy access in rural areas is explained by indicators named easy to use and efficient respectively.

Equally, the study findings in Figure 1 depict that about 75% of the variance in techno-economic aspects of energy access in rural areas is explained by indicator named durability while 34% of its variance is explained by an indicator called economic. Furthermore, the study findings confirm that, about 78% and 55% of variance in the techno-economic indicator of energy access are explained by indicators named keep the cooking pot clean and does not produce smoke respectively.

4. DISCUSSION OF STUDY FINDINGS

The study findings imply that the identified indicators of energy access are important when measuring the energy access in rural, areas for social economic development and livelihood improvement. For example, the observed high rank of affordability and availability indicators by majority of rural households in Tanzania indicates these indicators plays important role in improving their livelihood and standards of living.

To them, affordability implies the purchasing ability of the heads of household in acquiring the required energy sources such as firewood, electricity, gas or charcoals. The rural households argued that the price to purchase solar power as a source of energy for lighting or installation costs for electricity should cheaper enough for the household members with a low level of income to afford it. Regarding the availability as indicators of energy access, rural households explained that, in order for any energy source to be accessible it must be available in the first place at the time when it is needed.

Additionally, the rural households claimed that availability as an indicator of energy access must focus at ensuring that energy facility should be placed in the same geographical location they dwell. To insist on availability as indicators of energy access, rural households pointed out that shops for selling electricity, gases should be near to their place of domicile and they should be available all the time as well.

Energy access being available was found to reduce the cost regarding money and time to seek for services from far distances. Apart from availability and

affordability, the households in Tanzania indicated that variables such as reliability, durability, easiness to use, and do not produce smoke are also important indicators of energy access in rural areas.

Regarding reliability, rural households insisted that they need to be supplied with energy system or energy source which is capable of performing its intended tasks without or at minimum failure. Being reliable, the efficiency of the system will be enhanced and the same time its cost is also saved.

Regarding durability, respondents required the energy sources such as solar panel, solar batter or gases to be used for a long time before they fail or break down. Thus, durability as an indicator of energy access helps in reducing the operating costs such as maintenance costs.

Additionally, durability reduces the percentage of income to be spent in purchasing the modern cooking facilities or electricity. Regarding easy to use as an indicator of energy access, rural households expressed their views that the energy system like gases or electric devices should be made with simple technology such that even those people with low level of education can use without any problem. It was revealed that being easy to use as an indicator of energy access can reduce problems to the users such as accident or losses of energy.

The study further points out that energy access should be clean in such a way that they should keep the cooking pot clean after use. It was further insisted by the household members that the energy sources for cooking or lighting should not produce smoke so as to reduce the health damages to the users.

Some of the findings on indicators of energy access have also been reported by other previous studies while others are not. Examples of other studies having similar findings include that of Sudhakara (2015) on access to modern energy service which showed that energy access is measurable indicators such as availability, affordability as well reliability.

Similarly, the study done by Mensah, Kemausuor and Brew-Hammond (2014) on energy access trends in Ghana reported similar findings that affordability is an important indicator of energy access and it has a direct link with improved in the level of income. Thus, being able to afford to purchase the modern source of energy contributes to the improvement of the standard of living of rural household members.

Mensah, Kemausuor and Brew-Hammond (2014) added that affordability of energy access helps household members start engaging in various small business activities like charging of mobile phones, welding activities which consequently would increase their level of income. Equally, the findings of the present study are also in line with the study done by Coelho and Goldemberg (2013) on energy access, a lesson from Brazil and perspectives for replication in other developing countries which showed that social, economic development can be realised through the provision of energy which is affordable and available.

Interestingly, some of the findings of the current study are not reflected in the previous studies. While other studies focused much on availability, affordability and reliability indicators in measuring energy access, the current study has added on the body of knowledge other indicators such as easy to use, last longer, do not produce smoke and the ability to keep the cooking pot clean.

These rather contradictory results may be due to several reasons. Firstly, majority of other studies focused on urban areas leaving the rural areas uncovered. Secondly, other previous studies covered only electricity in assessing energy access leaving the cooking and lighting facilities such as firewood and charcoal uncovered.

5. CONCLUSION AND POLICY IMPLICATION OF THE STUDY

Based on the study findings, the current study concludes that indicators of energy access namely: availability, affordability, easiness to use, efficiency, durability, keeping the cooking facilities clean, reliability and cleanliness are important in enhancing social economic development and improvement of livelihood of rural households in Tanzania.

Therefore, energy experts, government, energy agencies, policy makers and other stakeholders should make use of these indicators in order to establish plans, strategies and programs for ensuring provision of energy access to rural households for the purpose of improving the livelihood and standards of living of people in rural areas of Tanzania.

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