RURAL PLANNING JOURNAL
Website: https://journals.irdp.ac.tz/index.php/rpj

DOI: https://doi.org/10.59557/rpj.25.2.2023.51

# Estimations of Multidimensional Energy Poverty in Tanzania

Geofrey Mhagama Charles and Elisante Heriel,

Department of Official Statistics, Eastern Africa Statistical Training Centre P.O. Box 35103, Dar es Salaam, Tanzania
***Corresponding Author Email:** geofrey.charles@eastc.ac.tz

## Abstract

This study assesses the level of multidimensional energy poverty in Tanzania. The study uses descriptive and inferential statistics based on data from the 2015-2016 Tanzania Demographic and Health Surveys (DHS), as they provide the most comprehensive datasets for this analysis. The analysis revealed that 74.1% of households were in rural areas, while the remaining 25.9% were in urban areas. Moreover, the study found that 80.6% of household heads were considered multidimensionally energy-poor. For inferential statistics, the Alkire-Foster estimates found that 81.2% of households in Tanzania were multidimensionally energy-poor, with higher rates of energy poverty in rural areas (94.2%) and among female-headed households (84.0%). Moreover, the findings show that the dimension of modern fuel contributes the most to the Multidimensional Energy Poverty Index (MEPI) (43.6%) compared to the asset (17.9%) and education (38.5%) dimensions. The study recommends that Tanzania invest in expanding access to modern cooking fuels and electricity, improving asset ownership, and enhancing educational opportunities to address multidimensional energy poverty. We recommend that the government emphasize and focus on both renewable energy and energy efficiency development in the country by implementing energy initiatives based on National Energy Policy 2015 to increase access to modern energy services and share renewable energies in the electricity generation mix to enhance availability, reliability, and security of supply.

**Keywords:** Multidimensional Energy Poverty Index (MEPI), Energy Deprivation level (EDL), Energy poverty and Modern Energy

## 1. Introduction

### 1.1. Background

Energy poverty is a complex issue that affects many aspects of people's lives, such as health, education, gender equality, and economic opportunities (Okyere *et al.*, 2023). The problem requires a comprehensive solution to mitigate social welfare losses and reduce energy poverty. Moreover, energy is the lifeblood of almost all socio-economic activities in the world. In developing countries, especially those in the East African community and Tanzania, energy plays a significant role in addressing poverty. According to the IEA *et al.* (2023), it is projected that around 640,000 people in developing countries in Asia and Africa will still lack access to modern energy services by 2030.

Moreover, IEA *et al.* (2023) described energy poverty as the absence of electricity access and dependence on traditional biomass for cooking and heating (IEA *et al.*, 2023). Other researchers define energy poverty based on factors like minimum energy requirements, energy expenditure, access to improved sources, and the percentage of energy expenditure relative to total expenditure (Floess *et al.*, 2023; Kitole, 2023).

In Tanzania, energy poverty refers to the lack of access to modern energy sources, inadequate energy services, unaffordable

energy, and poor quality and unreliable energy supply for individuals and households (NBS/REA, 2020). Therefore, people are deemed energy-poor if they lack access to viable and enhanced modern energy services and products (IEA *et al*., 2023).

The dependence on traditional biomass for cooking and heating remains a persistent global problem that needs the availability of clean energy to enhance economic development by providing multiple opportunities and improving the overall standard of living (Katoch *et al*., 2023; Drago, 2023; Ang'u *et al*., 2023). The Ministry of Energy in Tanzania oversees and regulates all energy-related matters through the National Energy Policy (NEP) 2015. The policy aims to establish a conducive climate for providing all Tanzanians with affordable, dependable, efficient, and eco-friendly energy services. Despite this, crucial economic sectors such as agriculture, mining, and tourism that contribute significantly to the country's economy still face multidimensional challenges in accessing reliable, affordable, and clean energy to enhance their extensive production (Kitole, 2023).

The 7th Sustainable Development Goal is dedicated to ensuring the widespread availability of cost-effective, reliable, sustainable, and modern energy resources by 2030 (IEA *et al*., 2023). The attainment of this goal holds substantial health, environmental, and economic advantages and plays a crucial role in fostering sustainable development and reducing global energy poverty (Floess *et al*., 2023; Omari *et al*., 2020). Despite global efforts to promote the adoption of modern energy sources, there is still an excessive dependence on conventional, non-clean energy sources, particularly firewood and charcoal (Sule, 2022; Mosses *et al*., 2023). This reliance continues to pose a substantial obstacle to development, with approximately 2.4 billion individuals worldwide relying on traditional solid fuels to meet their household energy needs, particularly for domestic and economic activities (IEA *et al*., 2023).

Globally, it is estimated that 3 billion individuals utilize solid fuels for cooking, heating, and lighting purposes (IEA *et al*., 2023). Moreover, in Africa, more than 82% of the population relies on solid fuels for domestic and economic activities. It is anticipated that the rapid population growth in rural areas will increase biomass users to 2.7 billion by 2030 (IEA *et al*., 2023).

In Tanzania, charcoal serves as the primary cooking fuel for more than 70% of urban households. At the same time, firewood is the predominant choice in rural areas, accounting for over 81% of households (NBS/REA, 2020). Despite the efforts made by the government to improve access to modern energy sources, the majority (almost 90%) of households in Tanzania Mainland use traditional energy sources such as firewood and charcoal as their primary source of energy for cooking (Mosses *et al*., 2023; Kitole, 2023). This situation undermines the international and national initiatives and programs for alleviating and ending all poverty among people by 2030.

The traditional uni-dimensional approach to measuring energy poverty uses single indicators to provide a simple and easy-to-interpret message about one poverty dimension. However, it presents a narrow picture of the poverty situation. Energy poverty is complex and multidimensional and requires an assessment framework that can capture various dimensions affecting the welfare of people beyond their income (Sen, 1999). The Multidimensional Energy Poverty Index (MEPI) is a composite index that captures both the incidence and intensity of energy poverty, providing a tool to support policymaking. The MEPI overcomes the shortcomings of one-dimensional indicators while producing an outcome that condenses the information into a single, easy-to-interpret metric (Nussbaumer *et al*., 2012; Alkire *et al*., 2023). The MEPI measures whether an individual is energy-poor or rich based on how intensely they experience energy deprivation, categorizing energy deprivation by several dimensions with indicators such as access to light, modern cooking fuel, fresh air,

refrigeration, recreation, communication, and space cooling (Nussbaumer *et al*., 2012). The MEPI is calculated by multiplying the ratio of people identified as energy-poor to the total population by the average intensity of energy poverty. However, the MEPI has some limitations, such as collecting data at a household or individual level, which makes it harder to understand the broader national content.

Therefore, by examining MEPI in the Tanzanian context, the study can contribute to improving energy access, efficiency, and sustainability, ultimately leading to better living conditions and economic development. Tanzania faces significant energy poverty issues, with many of the population lacking access to reliable and affordable energy sources (Halkos and Slanidis, 2023). This lack of energy access can hinder economic growth, education, and healthcare delivery. Furthermore, understanding the impact of MEPI in Tanzania can provide valuable insights for similar initiatives in other low-resource settings. Therefore, investigating MEPI in Tanzania is relevant to the local context and has broader implications for global energy access and sustainability.

The researcher opted to estimate multidimensional energy poverty because it differs from traditional energy poverty in that it considers a wider range of factors beyond just income or access to energy. Traditional energy poverty typically focuses on the inability to access modern energy services due to income constraints. In contrast, multidimensional energy poverty considers additional dimensions such as affordability, reliability, safety, and cleanliness of energy sources. This approach provides a more comprehensive understanding of the various aspects of energy poverty and its impact on well-being and development (Mendoza *et al*., 2019).

Ashagidigbi *et al*. (2020) studied the Multidimensional Energy Poverty Index (MEPI) in Nigeria. The study provides the first attempt to estimate household energy poverty status using the National Demographic Health Survey (NDHS) dataset. The analytical techniques adopted in this study were based on the Multidimensional Energy Poverty Index (MEPI). The findings show that the national average MEPI was 0.38, suggesting that most households are multidimensionally energy-poor. Energy poverty is, however, found to be higher in rural areas than in urban areas. They also found that male-headed households, age, rural sector, and Northeastern residents were found to be energy-poverty enhancing factors. In contrast, household income and credit access were energy-poverty inhibiting factors. Middlemiss *et al*. (2019) studied the determinants and drivers of multidimensional energy poverty in Ghana. The study employed a multidimensional energy poverty index to find the probability of a household being multidimensional energy poor. The study showed that the probability of a female-headed household being multidimensional energy poor is 3.42% higher than a male-headed household.

Ang'u *et al*. (2023) conducted a study investigating energy poverty in Kenya and its implications on human health using the multidimensional energy poverty framework, propensity score matching, and marginal structural models. The MEP index for rural areas was high compared to urban areas, and it was recommended that there is a need for deliberate policy action to ensure the availability of modern energy at affordable prices.

### 1.2. Theoretical Framework

The Multidimensional Energy Poverty Index (MEPI), introduced and validated by Nussbaumer *et al*. (2012), takes a multidimensional approach to measuring energy poverty. It builds upon poverty measures developed by Alkire and Foster (2007; 2011) of the Oxford Poverty and Human Development Initiative (OPHI). The MEPI is based on Townsend and Sen's (1999) capability approach, which identifies households as multidimensional energy-poor when they face deprivations in various aspects of energy accessibility, affordability, and

reliability, including health, the standard of living, education, and energy security. The MEPI is a single number obtained from the product of the intensity and incidence of energy poverty. It focuses on the lack of access to modern energy services. According to Sen's capability approach, a lack of access to energy services hurts well-being and leads to energy poverty.

This study marks a significant milestone in addressing household energy poverty in Tanzania through a multidimensional lens. To offer a comprehensive understanding of this complex issue, the study employs the Alkire and Foster (2011) multidimensional approach framework based on capability theory that has not been implemented in Tanzania before. Most of the studies in Tanzania use a uni-dimension approach (Rugaimukamu *et al*., 2023). This study acknowledges that energy poverty has different dimensions, as recognized by Alkire *et al*. (2015), the World Bank (2022), and Nussbaumer *et al*. (2012).

In particular, the study answered two primary research questions:

- What is the most crucial dimension of energy poverty among households in Tanzania?
- Which dimensions contribute the most to multidimensional energy poverty among households in Tanzania?

The study found that most households in Tanzania were highly deprived of multidimensional energy poverty. For example, the Alkire-Foster estimates found that 81.2% of households in Tanzania were multidimensionally energy-poor, with higher rates of energy poverty in rural areas (94.2%) and among female-headed households (84.0%). Moreover, the Alkire-Foster estimates found that the modern fuel dimension was the top contributor (43.6%) to the Multidimensional Energy Poverty Index (MEPI) (43.6%) compared to other dimensions (asset (17.9%) and education (38.5%).

The study recommends that Tanzania invest in expanding access to modern cooking fuels and electricity, improving asset ownership, and enhancing educational opportunities to address multidimensional energy poverty.

This article consists of five primary sections namely, Section 1 presents an introduction; Section 2 consists of the methodology; Section 3 deals with results and discussion; Section 4 presents the conclusion and recommendations; and the fifth section presents references.

## 2. Materials and Methods

### 2.1. Study Area

The study area is the United Republic of Tanzania (Mainland/Zanzibar), located in East Africa between longitude 29° and 42° East and latitude 1° and 12° South., comprising both rural and urban types of residence. This study area was chosen because access to modern energy services is a necessary precondition for achieving development as specified in the Agenda 2030.

### 2.2. Research Design and Data Source

This study is quantitative cross-sectional research designed to use secondary data from the 2015/2016 Demographic Health Survey (TDHS) collected by the National Bureau of Statistics of Tanzania (NBS). The advantage of using this data is that it provides information on energy-related issues and allows decomposition and detailed analysis at the sub-national level by zones, regions, and rural and urban areas. The 2015/2016 Demographic Health Survey (TDHS) comprises 64,880 rural and 16,776 urban households. The study's target population is all households in Tanzania in 2015/2016. The sample design for the survey applied a two-stage sampling technique to provide estimates of indicators for each of the 30 regions in Tanzania. The first stage involved selecting 608 clusters, consisting of Enumeration Areas (EAs) delineated for the 2012 Tanzania Population and Housing Census. In the second stage, 22 households were systematically selected from each cluster, yielding a representative probability sample of 13,376 households at the national level.

### 2.3. Description of variables used in the study

The variables used in the study are described in Table 1.

**Table 1: Description of variables used in the study**

| Variables | Description |
|---|---|
| Number of Household Members | Scale |
| Multidimensional Energy Poverty Index (MEPI) | Binary:<br>0= "Energy not poor," 1="Energy poor." |
| Sex of head of household | Nominal:<br>1= ‘‘male”, 2= ‘‘female’’ |
| Age of head of household | Scale |
| Marital status | Nominal:<br>0=“Never married”,<br>1=” Widowed”,2= “Divorced”,<br>3= Married or living together |
| Type of place residence | Nominal: 1= ‘‘urban”, 2= ‘‘rural’’ |

Source: Researcher (2024)

### 2.4. Data Analysis

The study used descriptive and inferential statistics to analyse the data set with the help of STATA Analytics Software. The descriptive statistics included frequency tables and percentages. In contrast, inferential statistics used the Alkire-Foster methodology to construct the Multidimensional Energy Poverty Index (MEPI) to estimate the deprivation level of multidimensional energy poverty. The study used a cut-off of 0.33 because it is a standard internationally agreed upon cut-off for providing robustness results for identifying multidimensionally poor households (Alkire *et al*., 2015).

#### 2.4.1. Estimating Energy Poverty by the Alkire – Foster (AF) Methodology

The study applied the Alkire-Foster methodology to calculate the Multidimensional Energy Poverty Index (MEPI). This method was used because it provides a single headline measure of energy poverty and can also be broken down and analysed in powerful ways to inform policy (Alkire and Foster, 2011; Alkire *et al*., 2015). To calculate the Multidimensional Energy Poverty Index (MEPI), the following steps were used:

**Selection of dimensions:** The first step was to select the dimensions that capture energy poverty. These dimensions were chosen based on their relevance to the concept of energy poverty, and they included access to clean cooking fuel, access to electricity, and access to modern fuels for lighting.

**Selection of indicators:** A set of indicators was selected for each dimension to capture the various aspects of deprivation. For example, access to clean cooking fuel was measured using indicators such as the percentage of households using solid fuels for cooking, the percentage of households without a separate kitchen, and the percentage of households with poor ventilation.

**Table 2:. Details of the dimensions, indicators, weights, related STGs, and deprivation cut-offs**

| Dimensions | Indicators | Deprivation cut-off (poor if……,…) | Weight |
|---|---|---|---|
| Modern Energy | Type of Cooking fuel | Household members are considered deprived if the household cooks with solid fuels: wood, charcoal, crop residues, or dung beside electricity, kerosene, natural gas, or biogas. | $\frac{1}{6}$ |
| | Electricity access | Members of the household are considered deprived if the household has no electricity access | $\frac{1}{6}$ |
| Asset | Asset's ownership | Members of the household are considered deprived if the household does not own more than one Radio, Television, Telephone, Mobile telephone, bike, motorbike, or refrigerator and does not own a car or truck. | $\frac{1}{3}$ |
| Education | Years of schooling | The entire household is considered deprived if no household member has completed five years of schooling | $\frac{1}{6}$ |
| | Education Attainment | A household is considered deprived if education attainment has no education, incomplete primary, complete primary, incomplete secondary, do not know compared to those with complete secondary and higher education attainment. | $\frac{1}{6}$ |

Source: Modified from Alkire and Foster (2007; 2011)

**Identification of cutoffs:** A cutoff was set for each indicator, indicating the threshold level of deprivation beyond which a person is considered to be deprived in that dimension (Table 2).

## Aggregation of energy poverty indicators by MEPI

- Let the matrix of achievements of $n \times d$ size for persons $i$ across $j$ variable is denoted by $Y = (y_{ij})$
- The achievement of a person $i$ in the variable $j$ is denoted by $y_{ij} > 0$. Therefore, each row vector $y_i(y_{i1}, y_{i2}, \ldots \ldots . . y_{id})$ represents the achievement of individual $i$ in different variables and each column vector $y_j = (y_{1j}, y_{2j} \ldots \ldots \ldots \ldots . y_{nj})$ gives the distribution of achievements in the variable $j$ across individuals.
- A weighting vector $W$ is composed of the elements $W_j$ corresponding to the weight that is applied to the variable $j$. $\sum_{j=1}^{d} W_j = 1$. $k_j$ is defined as the deprivation cut-off in variable $j$, which identifies all individuals deprived in any variables.
- Let $g = \{g_{ij}\}$ be the deprivation matrix whose typical element $g_{ij}$ defined by $g_{ij} = w_j$ when $y_{ij} < z_j$ *and* $g_{ij} = 0$ when $y_{ij} \geq z_j$
- Since the achievement matrix is non-numeric, then its cut-off is defined as a set of conditions in Table 2.
- The entry $ij$ of the matrix is equivalent to the weight $W_j$ when a person $i$ is deprived in variable $j$ and zero when the person is not deprived.
- Therefore, the column vector $c_i$ of deprivation counts, $i^{th}$ entry is given by $c_i = \sum_{j=1} g_{ij}$ denoting the sum of weighted deprivations suffered by person $i$.

- The persons is identified as multidimensionally energy poor by a cut-off $k > 0$ and applying it across the column vector, and considered a person as energy poor if her weighted deprivation count *ci* exceed *k*.
- Therefore, *ci (k)* is set to zero when *ci* ≤ *k* and equals *ci* when *ci* > *k*. Thus, *c (k)* represents the censored vector of deprivation counts, and it is different to *c* in that it counts zero deprivation for those not identified as multidimensionally energy poor

**Therefore,** deprivation scores were calculated for each individual based on their level of deprivation in each dimension. The deprivation score of each household (Ci) was calculated by using eqn.1

$C_i = w_1 I_1 + w_2 I_2 + w_3 I_3 + \cdots \ldots \ldots + w_d I_d$ ..(1)

Where, $I_i = 1$ if the household is deprived in indicator $i$ and 0 otherwise, and

$w_i$ is the weight attached to each indicator i in eqn.2

$\sum_{i=1}^{d} w_i = 1$ .....(2)

**Calculation of MEPI:** The MEPI was calculated by multiplying the incidence of multidimensional poverty (H) by the average percentage of deprivation (A) among the multidimensionally poor.

$MEPI_{overall} = \mathrm{H} * \mathrm{A} = \frac{q}{n} * \frac{\sum_{i=1}^{q} C_i(k)}{q} = \frac{\sum_{i=1}^{q} C_i(k)}{n}$. (3)

But

$H = \frac{q}{n}$ ..... (4)

$\mathrm{A} = \frac{\sum_{i=1}^{q} C_i(k)}{q}$ ..... (5)

Where, H=head count ratio /percentage of poor households/ incidence of poverty, q=number of multidimensional energy poor people identified using the dual cut-off approach and n=Total population.

A= poverty intensity, q=the number of multidimensional energy poor people, and C=is the deprivation score of each poor person.

Contribution of each dimension to MEPI is expressed as;

$Contrib_j = [\frac{\sum_{i=1}^{q} C_{ij}}{\frac{n_i}{MEPI}}] \times 100$.....(6)

Where, $n_i$ denotes the population in each energy dimension and N denotes the total population $n_1+n_2+n_3+\ldots. +n_n$=N

## 3. Results and Discussion

### 3.1. Descriptive Statistics

The findings in Table 3 reveal that the majority of household heads were male (79.7%) while the remaining 20.4% were female. The mean age of household heads was 47.2 % with a standard deviation of 14.4 and a range of 12 to 95. This suggests that, on average, household heads in Tanzania were relatively young with a broad range of ages. The mean number of households was 7.005, with a standard deviation of 3.9 and a range of 1 to 48. This indicates that household size varies across Tanzania, with some households being small and others being large. In terms of marital status, 58.77% of household heads were either married or living together, while the rest were either never married (28.2%), widowed (6.1%), or divorced (6.9%) (Marital status of whether married or not). A majority of households (74.1%) were located in rural areas, while the rest were in urban areas (25.9%). Finally, the majority of households' head (80.6%) were multidimensionally energy poor, whereas the remaining households (19.4%) were not. These results suggest that energy poverty was a significant issue in Tanzania, with the majority of households being classified as multidimensional energy poor.

**Table3: Characteristics of respondents**

| Variable name | Observation | Mean | Std. deviation | Maximum | Minimum |
|---|---|---|---|---|---|
| Sex of household head | 64,880 | | | | |
| Male | 51,622 (79.57%) | | | | |
| Female | 13,258 (20.43%) | | | | |
| Age of household head | 64,880 | 47.171 | 14.422 | 12 | 95 |
| Number of households | 64,880 | 7.005 | 3.92 | 1 | 48 |
| Marital status of whether married or not Married | 35,223 | | | | |
| Never married | 9,937 (28.21%) | | | | |
| Widowed | 2,158 (6.13%) | | | | |
| Divorced | 2,426 (6.89%) | | | | |
| Married or living together | 20,702 (58.77%) | | | | |
| Type of place residence | 64,880 | | | | |
| Urban | 16,776 (25.86%) | | | | |
| Rural | 48,104 (74.14%) | | | | |
| Status of MEPI for household head | | | | | |
| Energy not poor | 12,593 (19.41%) | | | | |
| Energy poor | 52,287 (80.59%) | | | | |

Source: Researcher (2024)

## 3.2. Inferential Statistics

### 3.2.1. Estimations of multidimensional energy poverty at the national level

The findings in Table 4 provide estimates of multidimensional energy poverty in Tanzania using the Alkire-Foster methodology, where a household is considered energy poor if they lack access to energy in at least one-third of the dimensions being measured, and the threshold for energy poverty was set at 33.3% (K) because it is a standard cut used to construct global MPI (Alkire and foster, 2011; Alkire at el., 2023). The study found that approximately 81 percent of all households in Tanzania were multidimensionally energy-poor with an average intensity of 71.66 percent. This indicated that, majority persons in Tanzania are deprived by 71.66 percent energy deprivation level from all indicators being assessed. Additionally, the Multidimensional Energy Poverty Index (MEPI), which combines information on the incidence and intensity of poverty, was estimated to be 0.582. The researchers also calculated the confidence interval (95%) for the MEPI, which ranges from 0.5794 to 0.5841, indicating that the estimate is statistically reliable within a 95% confidence level

**Table4: National Multidimensional energy poverty index with its components**

| Energy Poverty Cut-off (K) K=33.3% | **Multidimensional energy poverty Indices** | | **Conf. Interval (95%)** |
|---|---|---|---|
| | Incidence of energy poverty | 81.1867 | [80.8860 81.4874] |
| | intensity energy poverty | 71.6550 | [71.5501 71.7599] |
| | Multidimensional Energy Poverty Index | 0.5817 | [0.5794272 0.5841] |

Source: Researcher (2024)

According to these findings, Tanzania needs to invest in human capital and skills development of its current and future workforce while increasing job generation in key sectors that drive growth. This needs to be coupled with a better enabling environment that fosters small firms' growth and survival chances, furthers agricultural transformation, and reduces vulnerability to negative

domestic and international economic and weather shocks.

### 3.2.2. Estimation of Multidimensional Energy Poverty Indices by Zone

The findings in Table 5 show that the Central zone has the highest MEPI of 0.693, followed by the Western zone with an MEPI of 0.658. This means that the Central and Western zones in Tanzania have the highest levels of multidimensional energy. The Northern and Southern Highland zones also have relatively high MEPIs of 0.512 and 0.583, respectively, indicating a notable level of multidimensional energy poverty in these regions. The Southern and South West Highland zones have MEPIs of 0.644 and 0.637, respectively, while the Lake zone has an MEPI of 0.635. On the other hand, the Eastern zone and Zanzibar have the lowest MEPIs of 0.389 and 0.372, respectively, indicating a lower level of multidimensional energy poverty compared to other zones. The Northern and Southern Highland zones also have relatively high MEPIs of 0.512 and 0.583, respectively, indicating a notable level of multidimensional energy poverty in these regions. These findings help policymakers and researchers identify areas in need of immediate attention and design effective strategies to alleviate energy poverty and improve the well-being of people in different regions. It is crucial to understand the geographical distribution of multidimensional energy poverty in Tanzania and evaluate the impact of policies and interventions over time.

**able5: Multidimensional Energy Poverty Index (MEPI) Level by Zone**

| Zone | MEPI |
|---|---|
| Western | 0.658 |
| Northern | 0.512 |
| Central | 0.693 |
| Southern Highland | 0.583 |
| Southern | 0.644 |
| South West Highland | 0.637 |
| Lake | 0.635 |
| Eastern | 0.389 |
| Zanzibar | 0.372 |
| **Total** | **0.5817** |

Source: Researcher (2024)

### 3.2.3. Estimation of Multidimensional Energy Poverty Index by Place of Residence

The findings in Table 6 indicate households living in rural areas in Tanzania have a higher deprivation level of multidimensional energy poverty (94 percent) than those living in urban areas (50.1 percent) with an average, intensity of energy deprivation of 72.2 percent and 69 percent respectively. Moreover, the multidimensional energy poverty index is higher in rural areas (0.6807 percent) than in urban areas (0.346). These results are similar to a study by Ashagi-digbi *et al*. (2020) in Nigeria and Ang'u *et al*. (2023) conducted in Kenya who found that the majority of households living in rural areas are multidimensional energy poorer than in urban areas. The findings show that there are significant gaps in living standards that persist between rural and urban areas. Rural households lag considerably behind their urban counterparts in almost all monetary and non-monetary dimensions of poverty. These statistical differences reveal that there is an urgent need for policies and interventions to address energy poverty in rural areas. Targeted strategies and resource allocation based on these findings can improve energy access and help reduce poverty in these regions.

**Table 6: Multidimensional Energy Poverty Rates by Place of Residence (Rural and Urban)**

| Index s (%) | Urban | Rural | Total |
|---|---|---|---|
| Multidimensional energy poverty incidence (H) | 50.092 | 94.233 | 81.187 |
| Multidimensional energy poverty intensity (A) | 69.069 | 72.232 | 71.655 |
| Multidimensional Energy Poverty (MEPI) | 0.346 | 0.6807 | 0. 5817 |

Source: Researcher (2024)

### 3.2.4. Estimation of Multidimensional Energy Poverty by Sex of Household Head

The findings in Table7 shows that female headed households have a higher multidimensional energy incidence index (84.0 percent) than male-headed households (80.4 percent) with an energy deprivation intensity of (71.5 percent) and (66.3 percent) respectively. Furthermore, the MEPI values for female-headed households and male-headed households are 0.635 and 0.568, respectively. Therefore, female-headed households (0.635) have more multidimensional energy poverty than male-headed households (0.568). This result is similar to the study by Bersisa (2019) in Ethiopia who showed that the probability of a female-headed household being multidimensional energy poor is higher compared to a male-headed household. Addressing this disparity requires gender-sensitive policies and interventions. Therefore, it is crucial to prioritise targeted support and initiatives to address the specific needs of female-headed households and alleviate their energy poverty.

**Table 7: Multidimensional energy poverty indices by Sex of Headed Household**

| Index (%) | Male-headed | Female-headed | Total |
|---|---|---|---|
| Multidimensional energy poverty incidence, H | 80.4 | 84.0 | 81.2 |
| Multidimensional energy poverty intensity, A | 66.3 | 71.5 | 67.4 |
| MEPI | 0.568 | 0.635 | 0.58 |

Source: Researcher (2024)

### 3.3. Contribution of Multidimensional Energy Poverty by Dimension

The findings in Table 8 provide information on the Multidimensional Energy Poverty Index (MEPI), which consists of three dimensions: Fig.1 indicates that the "Modern Fuel" dimension (43.6 percent) contributes the most to the MEPI, than the Asset dimension (17.9 percent) and The "Education" dimension (38.5 percent) to an overall Multidimensional Energy Poverty Index,

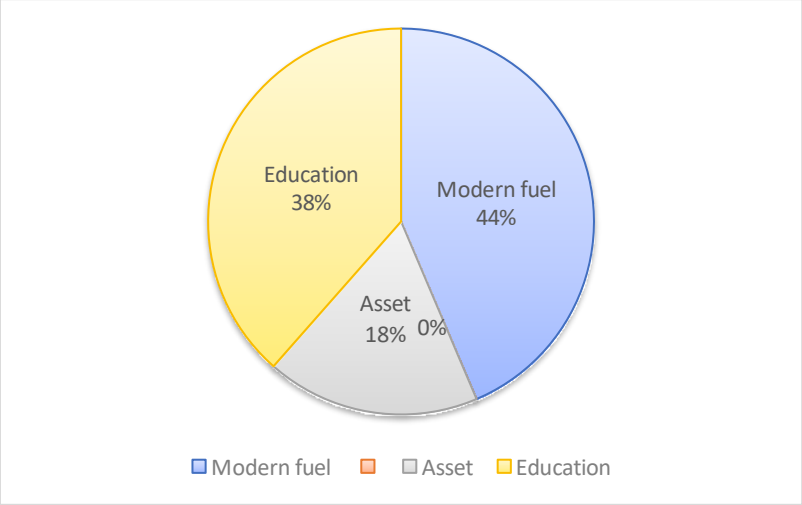


**Figure1: Contribution of Multidimensional Energy Poverty by Dimension (%)**

Therefore, the findings in Fig.1 provide valuable insights into the relative contributions of different dimensions to the Multidimensional Energy Poverty Index (MEPI). It highlights the importance of factors related to modern fuel access, asset ownership, and education in understanding and addressing energy poverty.

**Table 6: Contribution multidimensional energy poverty by dimension and indicators**

| Dimensions | MEPI (%) | Indicators | MEPI (%) |
|---|---|---|---|
| Modern fuel | 43.6 | Cooking fuel | 23.14 |
| | | Electricity | 22.44 |
| Asset | 17.9 | Asset's ownership | 15.96 |
| Education | 38.5 | Years of schooling | 4.16 |
| | | Education Attainment | 34.30 |

Source: Researcher (2024

## 4. Conclusion and Recommendations

### 4.1. Conclusion

The primary objective of the study was to estimate the deprivation level of energy among households in Tanzania from a multidimensional perspective. The study focuses on addressing two primary research questions:

i. What was the level of deprivation of multidimensional energy poverty among households in Tanzania?
ii. What was the contribution of each dimension to multidimensional energy poverty among households in Tanzania?

This was accomplished by examining the Multidimensional Energy Poverty Index (MEPI) using the Alkire and Foster methodology. The key findings of the study showed the highest levels of multidimensional energy poverty in Tanzania, particularly in rural areas and among female-headed households. Moreover, significant regional disparities in the incidence of multidimensional energy poverty were observed, with the Eastern and Zanzibar regions experiencing the highest incidence. This suggests policies and interventions to address multiple dimensions of energy poverty.

### 4.2. Recommendations

#### 4.2.1. Recommendation for Policy Implications

The study has revealed that Tanzania is highly affected by multidimensional energy poverty, with over 80% of households experiencing it. The study recommends that all stakeholders take urgent action to improve access to modern energy sources, especially in rural areas and for female-headed households. The government and other stakeholders should prioritise energy access as a fundamental need for poverty reduction and economic development. The study identified the lack of access to modern cooking fuels, electricity, and assets as the main contributing factors to multidimensional energy poverty in Tanzania. Therefore, policies and programmes that prioritise increasing access to modern energy sources, particularly in rural areas, could help to reduce multidimensional energy poverty. It is strongly recommended that policymakers to take a regional approach to addressing multidimensional energy poverty, tailored to the specific needs and challenges of each region

#### 4.2.2. Areas for Future Research

Previous studies in Tanzania used a uni-dimension of monetary indicator (income/consumption) to estimate the deprivation level of energy poverty. This study used many dimensions of non-monetary indicators to construct the Multidimensional Energy Poverty Index (MEPI) in estimating deprivation level of multidimensional energy poverty among households in Tanzania. Therefore, future research needs to consider dimensions of both monetary and non-monetary indicators so as to get a clear picture of the deprivation level of multidimensional energy among households in Tanzania. Moreover, this study focuses on estimations of

multidimensional energy poverty, so future research work should consider estimating determinants and spatial variations of multidimensional energy poverty in Tanzania.

## References


Alkire, S., and Foster, J. (2007). *Counting and multidimensional poverty measurement*. OPHI Working Paper 7, Oxford Poverty and Human Development Initiative, University of Oxford.

Alkire, S., and Foster, J. (2011). Counting and multidimensional poverty measurement. *Journal of Public Economics,* 95(7–8), 476–487.

Alkire, S., Foster, J., Seth, S., Santos, E., Roche, M. and Ballon, P. (2015). Multidimensional Poverty Measurement and Analysis. United Kingdom, New York, NY 10016, United States of America: Oxford University Press 198 Madison Avenue.

Alkire, S., Kanagaratnam, U., and Suppa, N. (2023). The global Multidimensional Poverty Index (MPI) 2023 country results and methodological note. anchorbooks.com

Ang'u, C., Muthama, N. J., Mutuku, M. A. and M'IKiugu, M. H. (2023). Analysis of energy poverty in Kenya and its implications for human health. Energy Policy, 176, 113506. https://doi.org/10.1016/j.enpol.2023.113506.

Ashagidigbi, w. M., Babatunde, B. A., Ogunniyi, A. I., Olagunju, K. O. and Omotayo, A. O. (2020). Estimation and determinants of multidimensional energy poverty among households in Nigeria. Sustainability (Switzerland), 12(18), 1–13. https://doi.org/10.3390/su12187332

Bersisa, M. (2019). *Multidimensional measure of household energy poverty and its determinants in Ethiopia 1. In Economic Transformation for Poverty Reduction in Africa* (pp. 58-83). Routledge.

Drago, C. and Gatto, A. (2023). Gauging energy poverty in developing countries with a composite metric of electricity access. Utilities Policy, 81, 101486.

Floess, E., Grieshop, A., Puzzolo, E., Pope, D., Leach, N., Smith, C. J., ... and Bailis, R. (2023). Scaling up gas and electric cooking in low-and middle-income countries: climate threat or mitigation strategy with co-benefits? *Environmental Research Letters*, *18*(3), 034010.

Halkos, G. E. and Aslanidis, P. S. C. (2023). Addressing Multidimensional Energy Poverty Implications on Achieving Sustainable Development. *Energies*, *16*(9), 3805.https:// doi.org/10.3390/en160938

IEA, IRENA, UNSD, Word Bank and WHO, (2023): *The energy Progress Report*. Available from:/https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report 2023-full_report.pdf (accessed 5 October 2023).

Katoch, O. R., Sharma, R., Parihar, S. and Nawaz, A. (2023). Energy poverty and its impacts on health and education: a systematic review. *International Journal of Energy Sector Management*.

Mendoza Jr, C. B., Cayonte, D. D. D., Leabres, M. S. and Manaligod, L. R. A. (2019). Understanding multidimensional energy poverty in the Philippines. *Energy Policy,* 133(), https://doi.org/10.1016/j.enpol.2019.110886.

Mosses, J. T., Makundi, H. and Hamza, V. (2023). Barriers of solar cooking and policy prescription towards its adoption in Tanzania: The case of Southern Unguja and Kilimanjaro regions. Energy for Sustainable Development, 75, 72-81 https://doi.org/10.1016/j.esd.2023.04.011

Nussbaumer, P., Bazilian, M. and Modi, V. (2012). Measuring energy poverty:

Focusing on what matters. *Renewable and Sustainable Energy Reviews, 16*, 231-243.https:// doi: 10.1016/j.rser.2011.07.150

Okyere, M. A., Essel-Gaisey, F., Zuka, F. M., Christian, A. K. and Nunoo, I. K. (2023). Wading out the storm: Exploring the effect of flooding on energy poverty amidst disaster management strategies in Dar es Salaam. *Environmental Science and Policy,* 150, 103578. https://doi.org/10.1016/j.envsci.2023.103578

Omari, A. M., Tesha, M. J. and Sarakikya, M. H. (2020). Energy Generation from Biomass in Tanzania Impacts and Challenges-An Overview. *International Journal of Engineering Research and Technology,* 9(5), 789-793. https://doi.org/10.17577/ijertv9is050371

Rugaimukamu, K., Shauri, N. E. and Mazigwa, R. C. (2023). The Political Economy Analysis of Institutional Barriers to Rural Electrification in Tanzania. Open Journal of Social Sciences, 11(6), 275-310.https://doi.org/10.4236/jss.2023.116019

Sen, A. (1999), *Development as Freedom. New York: Anchor Books*, A Division of Random House, Inc. Retrieved from: https://www.anchorbooks.com

Sule, I. K., Yusuf, A. M. and Salihu, M. (2022). Impact of energy poverty on education inequality and infant mortality in some selected African countries. Energy Nexus, 5, 100034. https://doi.org/10.1016/j.nexus.2021.100034

Townsend, P. (1979). *Poverty in the United Kingdom: a survey of household resources and standards of living*. University of California Press.