Determinants of the Liquefied Petroleum Gas among household in Muheza District, Tanga

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Abstract

The transition to clean energy is critical for environmental sustainability and public health, particularly in rural areas where biomass remains the dominant source of household energy. This study investigates the determinants influencing household decisions toward the adoption of Liquefied Petroleum Gas (LPG) in Muheza District, Tanga Region. Employing a cross-sectional research design, data were collected from 100 households using structured questionnaires and analyzed using a ordered logistic regression model. The findings reveal that receiving an LPG subsidy significantly increases the likelihood of both medium (0.4245, $p<0.05$) and high (0.5723, $p<0.05$) energy consumption, indicating the effectiveness of subsidies in promoting clean fuel use. Household income, gender, age, education level, household size, and access to infrastructure also influence adoption patterns. Specifically, female-headed households and those with secondary education are more likely to adopt LPG, while larger households are more inclined toward high consumption if resources allow. These results highlight the importance of not only financial incentives but also complementary factors such as education, infrastructure, and gender-responsive policies to achieve broader and sustained adoption of clean energy in rural Tanzania.

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1. Introduction

In recent years, the global focus on clean energy adoption has gained significant momentum, driven by the urgent need to combat climate change, reduce health risks associated with indoor air pollution, and achieve universal energy access as outlined in Sustainable Development Goal 7 (SDG 7). In developing countries like Tanzania, where a majority of the population continues to depend on traditional biomass fuels such as firewood and charcoal for cooking and heating, the transition to cleaner alternatives is both a challenge and a necessity. According to the World Bank (2020), approximately 85 percent of households in Tanzania still rely on biomass for their daily energy needs. This situation is particularly prevalent in rural districts like Muheza in the Tanga Region, where limited infrastructure, low household income, and deep-rooted cultural practices contribute to the continued use of traditional fuels. The consequences of this dependence are far-reaching. Deforestation, environmental degradation, and adverse health outcomes—particularly among women and children—are common. Indoor air pollution from burning biomass contributes to over 20,000 premature deaths annually in Tanzania, according to the World Health Organization (2021). Furthermore, women in rural areas often spend more than three hours each day collecting firewood, which limits their opportunities for education and economic advancement (Doggart et al., 2020).

To address these challenges, the Government of Tanzania has taken deliberate steps to promote the use of Liquefied Petroleum Gas (LPG) as a cleaner and more sustainable cooking fuel. One of the key strategies has been the provision of subsidies under the National Strategy for Clean Cooking Energy (NSCCE) for the period 2024 to 2034. In Muheza District, the government has already distributed more than 3,200 subsidized gas cylinders by early 2025 (The Citizen, 2025). These efforts aim to make LPG more accessible and affordable, particularly for low-income households, and to encourage a gradual shift away from traditional biomass fuels. However, while subsidies are a critical enabler of clean energy adoption, they represent only one part of a much larger puzzle. The success of LPG adoption depends on a variety of interrelated factors. These include household income, education levels, availability and reliability of LPG supply, cultural preferences, safety concerns, and awareness of the benefits of clean cooking technologies. Without addressing these underlying determinants, the uptake of LPG may remain limited despite financial incentives.

Studies from other countries provide valuable insights into these complexities. In India, for example, the Pradhan Mantri Ujjwala Yojana program successfully distributed over 80 million subsidized LPG connections, yet many rural households reverted to traditional fuels due to the high cost of refills and inconsistent supply chains (Kar et al., 2019). In Kenya, subsidies increased LPG use by 25 percent in peri-urban areas, but adoption in rural regions was hindered by cultural preferences and limited infrastructure (Lee et al., 2021). Similar trends have been observed in Tanzania. Research by Msuya and Kessy (2020) revealed that while urban households responded positively to LPG price reductions, rural households remained constrained by low awareness, distribution challenges, and concerns over safety.

Recognizing the importance of a multifaceted approach, the Tanzanian government allocated 455.7 million Tanzanian shillings in 2024 specifically for LPG subsidies in the Tanga Region (Rural Energy Agency, 2024). In Muheza, this initiative has led to a 50 percent reduction in the cost of gas stoves, with the remaining cost borne by the household. While this model shows

promise, it has yet to be tested at scale in remote rural settings where economic and cultural conditions differ significantly from urban areas. A recent study by Choumert-Nkolo et al. (2023) in northern Tanzania demonstrated that subsidies could reduce biomass use by up to 30 percent in targeted pilot areas, but also emphasized that adoption plateaus without continuous community engagement, education, and support infrastructure. Muheza District's inclusion in the NSCCE reflects a broader national ambition to reach 80 percent clean energy usage by 2034. However, for such goals to be achieved, it is essential to understand how different factors interact to influence household decisions around energy use. These factors which ranges from affordability and accessibility to cultural attitudes and knowledge that must be considered in designing interventions that can lead to sustained adoption of clean cooking technologies. This study aims to explore the determinants influencing the adoption of Liquefied Petroleum Gas among households in Muheza District, Tanga Region. By examining the role of government subsidies alongside socio-economic, infrastructural, and behavioral factors, the study seeks to provide evidence-based insights that can guide more effective policy implementation and support the broader transition to clean and sustainable energy in rural Tanzania.

2. Review of Literature review

The global push for clean energy adoption has gained momentum as part of efforts to mitigate climate change, reduce health risks associated with traditional biomass fuels and achieve sustainable development goals (SDGs), particularly SDG 7 (Affordable and Clean Energy). In Sub-Saharan Africa, where access to modern energy remains limited, households predominantly rely on biomass such as firewood and charcoal, contributing to deforestation, indoor air pollution and economic inefficiencies. Tanzania, a country with a predominantly rural population, exemplifies these challenges, with over 80% of its households depending on biomass for cooking and lighting Aslam et al (2021). Clean energy subsidies financial incentives designed to lower the cost of modern energy alternatives like liquefied petroleum gas (LPG), solar power, and electricity have emerged as a policy tool to shift household energy consumption patterns. This literature review explores the role of clean energy subsidies in shaping household energy consumption, drawing from studies in Tanzania and Sub-Saharan Africa, with a focus on socioeconomic, environmental, and policy dimensions relevant to Muheza District, Tanga Region.

Tanzanian households exhibit a strong reliance on traditional biomass driven by availability, affordability and cultural preferences. Lusambo (2016) noted that firewood and charcoal account for over 90% of total energy consumption in rural areas, with urban households also maintaining significant usage despite greater access to electricity. A study by Hosier and Kipondya (1993) on urban household energy use in Tanzania highlights a transition from firewood to kerosene and electricity over time, influenced by income levels and electrification efforts. However, even wealthier households tend to "stack" fuels combining modern and traditional sources due to reliability issues and cost considerations. In rural settings like Muheza District, this reliance on biomass is exacerbated by limited grid connectivity and the high upfront costs of clean energy technologies.

Recent studies underscore persistent inequalities in clean energy access. Ntegwa and Olan'g (2023) found that only 6.9% of Tanzanian households use clean cooking fuels, with adoption concentrated among affluent urban populations. Rural urban disparities, economic status, and education levels of household heads are key determinants of this gap. These findings suggest that subsidies could play a pivotal role in bridging access disparities, particularly in underserved rural districts like Muheza.

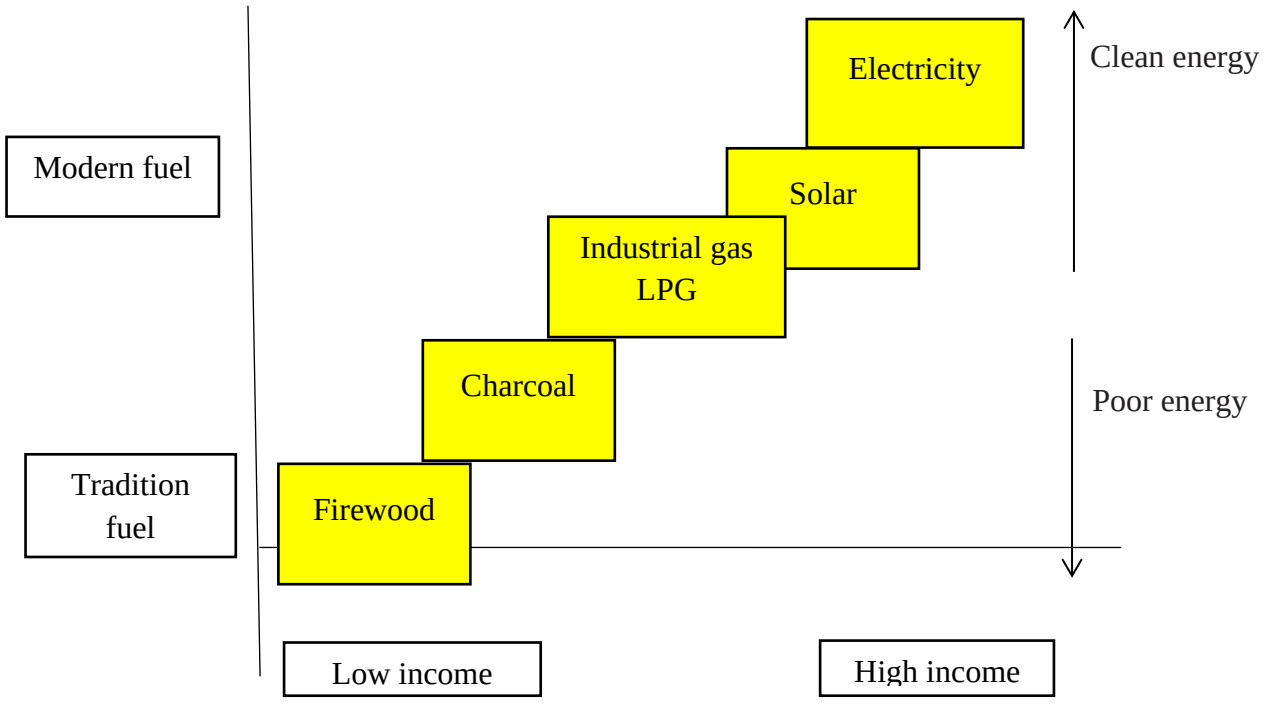
The socioeconomic factors influencing energy consumption are well-documented. Rahut et al. (2017) argue that household income, education, and gender of the household head significantly affect the adoption of clean energy in Sub-Saharan Africa. Female-headed households, for instance, are more likely to adopt renewable sources due to heightened awareness of health risks from biomass smoke. In Tanzania, Choumert-Nkolo et al. (2019) found that wealthier and more educated households are more likely to transition to electricity and LPG, while poorer households face a "poverty trap" due to higher per-unit costs of small quantity fuel purchases.

Environmentally, the overuse of biomass has led to deforestation and land degradation in Tanzania, particularly in regions like Tanga with high forest cover (Omari et al., 2020). Clean energy subsidies could mitigate these impacts by reducing reliance on wood fuel. However, studies caution that subsidies alone are insufficient without complementary measures like awareness campaigns and infrastructure development (Bishoge et al 2018). In Muheza, where agricultural and forestry residues are abundant, integrating subsidies with biomass to energy technologies like biogas could offer a dual benefit of waste management and energy access.

3. Theory

The Energy Ladder Theory posits that household energy consumption follows a hierarchical progression from traditional, inefficient fuels (e.g., firewood, dung) to modern, cleaner alternatives (e.g., LPG, electricity) as socioeconomic status improves (Hosier & Dowd, 1987). This progression is driven by income, education, and access to infrastructure, with households "climbing" the ladder as these factors align. In Tanzania, where over 80% of rural households rely on biomass (Lusambo, 2016), the theory suggests that subsidies could accelerate this transition by reducing the cost barrier to modern fuels.

Figure 1 Energy ladder theory



Source: Adopted from Kitole et al., (2024)

Figure 1 illustrates the transition from tradition to modern fuel as income increases. Low income household rely on firewood and charcoal (high pollution fuels) while wealthier household use cleaner energy source like LPG, solar and electricity. This shift highlights the link between economic status and access to cleaner, more efficient energy. However, empirical evidence highlights a limitation many households engage in "fuel stacking," using multiple energy sources simultaneously rather than fully transitioning (Masera et al., 2000). In Muheza District, where forest resources are abundant and cultural practices favor biomass, subsidies may not eliminate traditional fuel use but rather diversify the energy mix. Thus, the theory is adapted to hypothesize that subsidies lower the rungs of the energy ladder, making clean energy more accessible without necessarily displacing biomass entirely.

Diffusion of Innovations Theory

Proposed by Rogers (1962), the Diffusion of Innovations Theory explains how new technologies or practices such as clean energy solutions spread through a population. Adoption depends on five stages (knowledge, persuasion, decision, implementation, confirmation) and is influenced by factors like relative advantage, compatibility, complexity, trialability and observability. In the context of Muheza, clean energy technologies (e.g., subsidized LPG cylinders) represent innovations whose uptake hinges on awareness, affordability and perceived benefits over biomass.

Subsidies enhance the "relative advantage" by lowering costs, while government campaigns (like Tanzania's 2024 gas cylinder program) address the knowledge and persuasion stages. However, compatibility with local cooking practices and the complexity of maintaining modern appliances may slow diffusion in rural areas. This theory frames subsidies as a catalyst for adoption, predicting that early adopter's wealthier or educated households will influence broader community uptake over time.

Above all, The Energy Ladder Theory and Diffusion of Innovations Theory provide insight into how gas LPG subsidies impact household energy use in Muheza District, Tanzania. The Energy Ladder Theory suggests that subsidies lower the cost of cleaner fuels like LPG, encouraging a shift from traditional biomass, though cultural preferences may result in fuel stacking rather than a complete switch. Meanwhile, the Diffusion of Innovations Theory explains how subsidies boost the affordability and visibility of clean energy, promoting adoption through community influence. Together, they show subsidies can drive partial energy transitions in rural settings like Muheza.

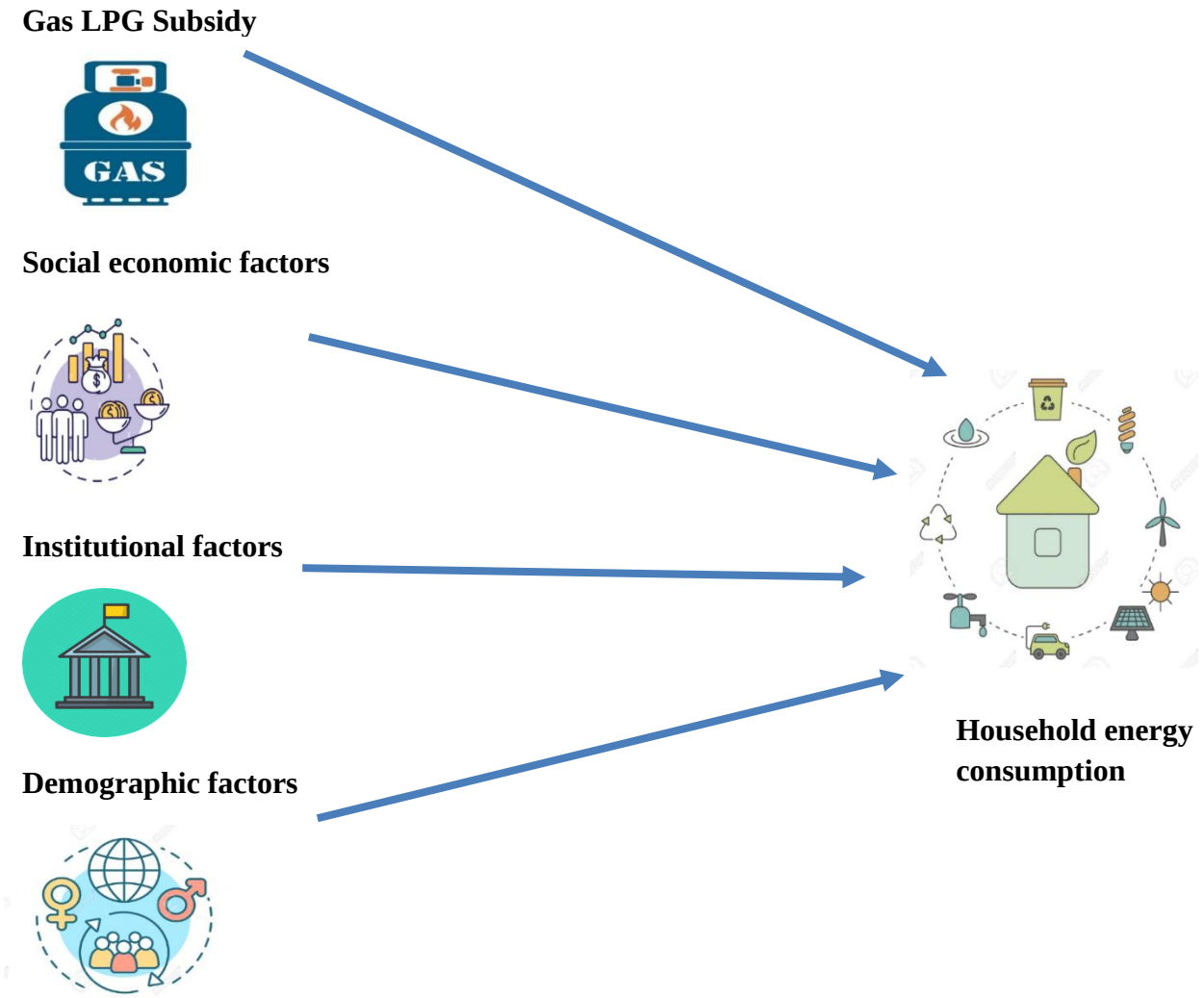


Figure 2 Conceptual framework
Source: Author's construction 2025

3. Study area

Muheza District, located in northeastern Tanzania in Tanga Region, covers 1,498 km², bordered by Mkinga District to the north, the Indian Ocean and Tanga City to the east, Pangani and Handeni Districts to the south and Korogwe District to the west. The 2022 Tanzania National Census reported a population of 238,260, predominantly rural, with agriculture as the main economic activity, including crops like rice, maize, cassava, citrus, cocoa, and cashews, and fishing along the coast. The district's topography ranges from coastal lowlands to the Usambara Mountains, with a tropical climate (20°C–30°C, 1,000–2,000 mm annual rainfall) (Emidi et al 2017). Energy use is biomass-dominated, with wood and charcoal common for cooking reflecting national trends where 72% of rural households use wood (Lusambo 2016). Recent NSCCE initiatives, including distributing 3,255 subsidized gas cylinders in February 2025, aim to promote LPG use. Energy-saving stove projects, like those by TaTEDO, have reduced biomass reliance in villages like Sakale, supervised by Muheza District authorities. This rural, agricultural setting faces challenges in energy access, making it ideal for studying subsidy impacts.

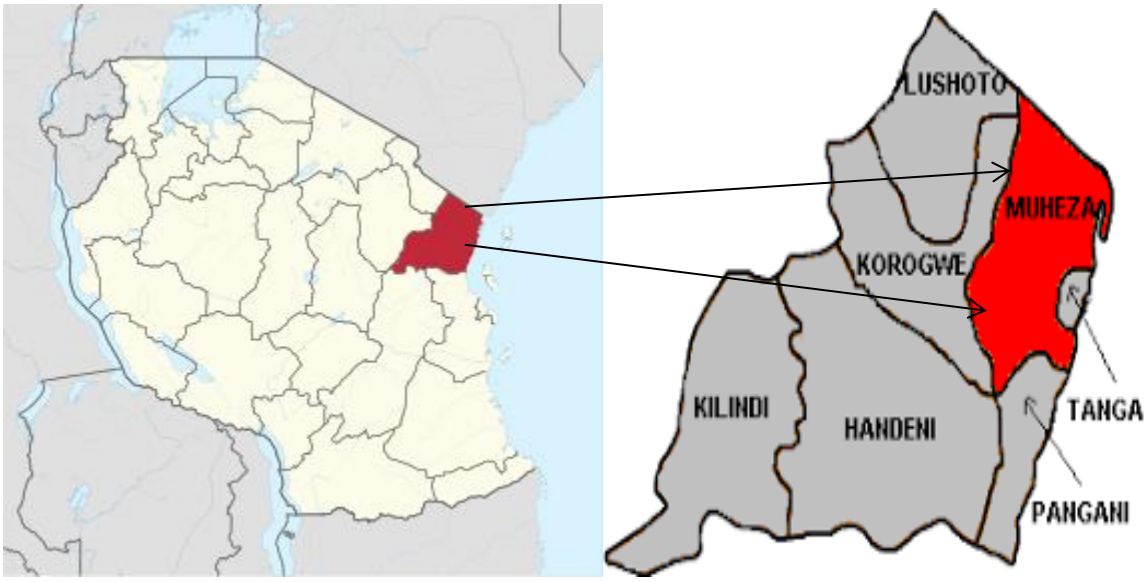


Figure 3 Map of Muheza District
Source: Muheza district (2025)

3.1 Methodology

The study utilized a cross-sectional design to evaluate the impact industrial gas LPG subsidies on household energy consumption in Muheza District, Tanzania, with data collected in March 2025. A sample of 100 households across four wards selected for their socioeconomic and geographic diversity was determined using Yamane's (1967) formula for a representative sample with a 10% margin of error commonly used for large populations, based on a total population of households in the selected wards. This method ensured that the sample size was both efficient and reliable, allowing for the generalization of findings to the broader household population with confidence (Creswell, 2014; Cohen et al., 2018). Simple random sampling chose 25 households per ward, and data was collected through face-to-face interviews using a structured questionnaire covering energy sources, subsidy awareness, and socioeconomic factors. Analysis was performed in Stata, using descriptive statistics and inferential statistics

3.2 Analytical model

This study employs the ordered logit model, which is appropriate for analyzing ordinal dependent variables such as household energy consumption levels categorized as low, medium, and high. The model uses the cumulative logistic distribution to estimate the probability of a household falling into a specific energy consumption category based on various explanatory variables. It is particularly effective in capturing the influence of factors like income, education, household size, and access to subsidies on ordered outcomes (Kitole et al., 2023; Jamaldin & Laurent, 2025; Jamaldin, 2024; Kitole & Sesabo, 2022). The model provides a structured framework for assessing how these factors affect the likelihood of transitioning to higher levels of clean energy use. The ordered logit formulation is used here to explain the extent to which LPG subsidies and other household characteristics shape energy consumption behavior.

$$log\left[\frac{\pi_j(x_i)}{\pi_k(x_i)}\right] = \alpha_{0i} + \beta_{ij}x_{1i} + \beta_{2j}x_{2i} + \cdots \ldots \ldots \ldots + \beta_{pj}x_{pi}$$

Whereas $j = 1,2, \ldots \ldots k$

Additionally, the reduced form of the equation is expressed as:

$$\log\left(\pi_j(x_i)\right) = \frac{\exp\left(\alpha_{0i} + \beta_{ij}x_{1i} + \beta_{2j}x_{2i} + \cdots \ldots \ldots + \beta_{pj}x_{pi}\right)}{1 + \sum_{j=1}^{k-1} \exp\left(\alpha_{0i} + \beta_{ij}x_{1i} + \beta_{2j}x_{2i} + \cdots \ldots \ldots + \beta_{pj}x_{pi}\right)}$$

For $j = 1,2, \ldots, (k-1)$, and the parameters α and β will be estimated by the use of maximum likelihood. This Model was Chosen because the dependent variable has more than two ordered categories: low, medium and high was preferred due to its straightforward computational process and its enhanced predictive capability. On the other hand, variables that have been used in this study have been presented at Table 1.

Table 1 Variables and measurements

Variables	Types of variables	Measurements
Dependent variable		
Household energy consumption	Categorical	Categories of household energy consumption 0= low 1=medium 3=high
Independent variables		
Gas subsidy	Categorical	Binary indicator (1=does not receive subsidy 1= receive subsidy
Household Income	Continuous	Amount
Age	Continuous	Age of household head
Gender	Categorical	Gender of the household head
Household size	Continuous	Total number of person in household
Education level	Categorical	Education and awareness on household head
Infrastructure access	Categorical	Availability of Gas (0=has no access 1= has access

Source: Author's design (2025)

4. Results

The descriptive statistics reveal significant variation among households in Muheza District. The average monthly household income is TZS 240,600, with a wide range (TZS 110,000–460,000) and high standard deviations (TZS 115,975), indicating income disparities that may affect gas LPG affordability. The mean age of household heads is 44.76 years (SD = 8.41), suggesting that most decision makers are middle aged, which may influence their willingness to adopt new energy technologies. Household sizes average 4.98 members (SD = 1.43), with larger households likely having higher energy demands. These findings highlight the need for targeted policies that consider economic diversity, household composition, and demographic factors to enhance the effectiveness of Gas LPG subsidies in rural communities.

Table 2 Descriptive statistics of continuous variables

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
Household income	100	240600	115974.7	110000	460000
Age	100	44.76	8.406491	32	62
Household size	100	4.98	1.428286	3	8

Source: field research (2025)

Table 3 presents the characteristics of respondents in terms of gender, education level, infrastructure access, and ward location. The majority of respondents are female (60%), while males make up 40%. In terms of education, most have attained a secondary level (52%), followed by tertiary education (30%), and a smaller portion with only primary education (18%). Infrastructure access is relatively high, with 69% of respondents having access, while 31% do not. Regarding geographical distribution, the highest proportion of respondents comes from Genge (36%), followed by Majengo (27%), Mbaramo (20%), and Kilulu (17%). These statistics provide insights into the demographic and socio-economic distribution of the surveyed households, which could influence household energy consumption patterns in Muheza District.

Table 3 Characteristics of respondents

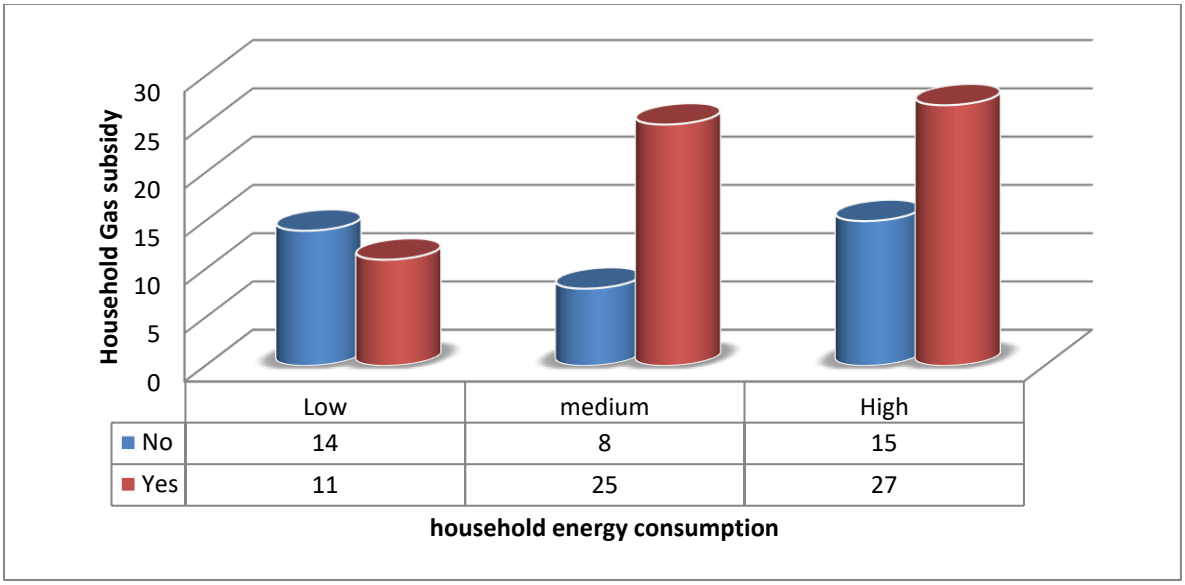
	Categories	Frequency	Percentage
Gender	Male	40	40%
	Female	60	60%
	Total	**100**	**100%**
Education level	Primary	18	18%
	Secondary	52	52%
	Tertiary	30	30%
	Total	**100**	**100%**
Infrastructure access	No	31	31%
	Yes	69	69%
	Total	**100**	**100%**
Location(ward)	Kilulu	17	17%
	Genge	36	36%
	Mbaramo	20	20%
	Majengo	27	27%
	Total	**100**	**100%**

Source: Field research (2025)

Figure 4 illustrates the relationship between gas (LPG) subsidies and household energy consumption levels. It shows that households receiving gas LPG subsidies (Yes) are more likely to be in the high energy consumption category (27) compared to those without subsidies (15). Conversely, among low energy consumers, more households do not receive subsidies (14) compared to those that do (11). This suggests that clean energy subsidies encourage higher energy

consumption likely by increasing access to modern energy sources such as LPG and electricity. However, a notable number of households without subsidies still fall into the high consumption category, indicating that factors beyond subsidies such as income levels and infrastructure also play a role in energy consumption patterns. These findings emphasize the importance of complementary policies alongside subsidies to ensure sustainable and equitable energy access.

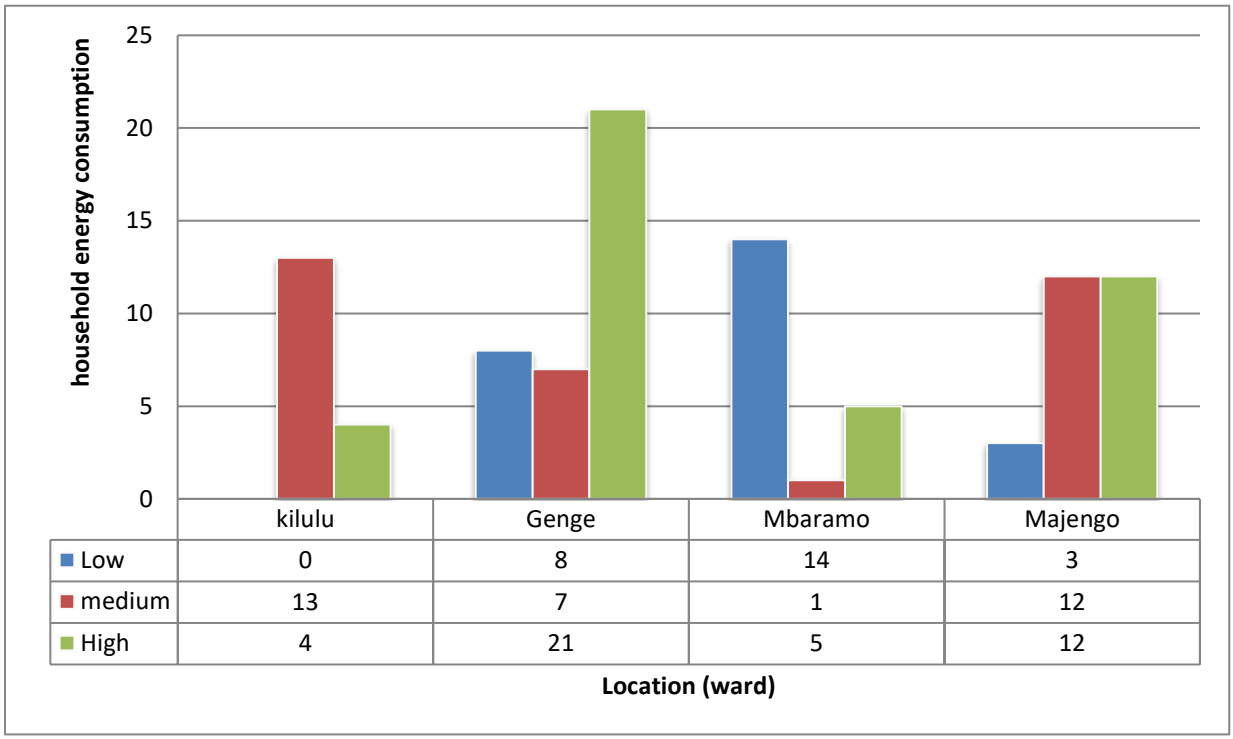
Figure 4 Relationship between Gas (LPG) subsidy and household energy consumption



Source: Field data (2025)

Figure 5 shows the relationship between household energy consumption and respective wards in Muheza District reveals significant variations in energy use patterns. Kilulu has no low-energy consumers, with most households falling into the medium 13 and high 4 consumption categories, suggesting greater reliance on modern energy. Genge shows a more balanced distribution across all levels, indicating moderate energy accessibility. Mbaramo has the highest number of low-energy consumers 14 and very few in the medium 1 and high 5 categories, reflecting potential barriers to Gas LPG access. Majengo has a relatively even distribution, with medium 12 and high 12 consumption levels being dominant. These differences highlight the impact of local infrastructure, economic conditions and access to clean energy sources, emphasizing the need for targeted interventions to promote equitable energy distribution across all wards.

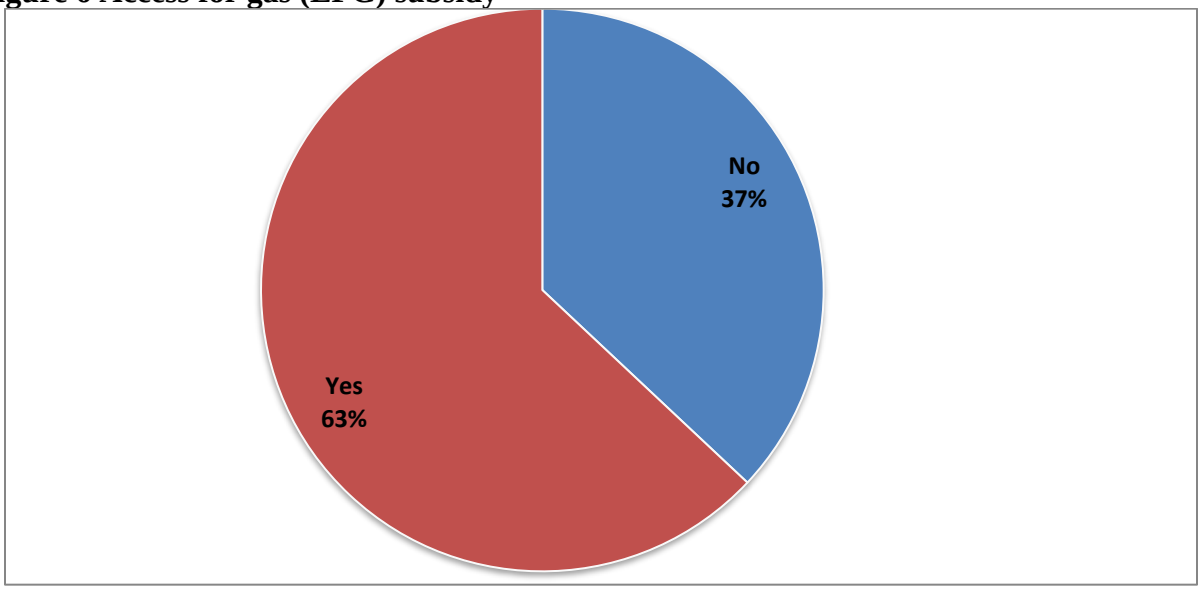
Figure 5 Relationship between household energy consumption with respective wards



Source: Field data (2025)

Figure 6 illustrates access to gas (LPG) subsidies among households. It shows that 63% of households receive gas LPG subsidies, while 37% do not. This indicates that a majority of households benefit from government or organizational support for cleaner energy sources, which can promote the adoption of modern energy alternatives. However, the 37% without subsidies suggests that a significant portion of households may still face financial or structural barriers to accessing clean energy, highlighting the need for expanded subsidy programs and awareness initiatives to ensure broader adoption.

Figure 6 Access for gas (LPG) subsidy



Source: Field data (2025**)**

Determinants of household energy consumptions levels

The Ordered logit model shows that receiving a gas LPG subsidy increases the likelihood of a household being in the Medium or High energy consumption category compared to Low, with coefficients of 0.424527 ($p < 0.05$) for Medium and 0.5722895 ($p < 0.05$) for High. This translates to odds ratios of approximately 0.654 and 0.564, respectively, indicating that subsidized households are 34.6% more likely to adopt medium consumption and 43.6% more likely to adopt high consumption than those without subsidies.

Household income has a contrasting effect on energy consumption likelihood. For "Medium" with "Low," the coefficient of -0.0000987 ($p < 0.05$) yields an odds ratio of about 0.9999, suggesting that a TZS 1,000 increase in monthly income slightly reduces the likelihood of medium consumption by 0.01%, possibly due to initial costs deterring partial adoption. Conversely, for High with Low, the coefficient of 0.0000318 ($p < 0.05$) gives an odds ratio of 1.000032, indicating a 0.0032% increase in the likelihood of high consumption per TZS 1,000, reflecting that wealthier households are more inclined to fully adopt cleaner energy options.

Table 4 Ordered logistic regression of Household energy consumption

Variables	Household energy consumption	
	Medium	**High**
Gas (LPG) subsidy		
Yes	0.424527	0.5722895
	(1.436549)**	(0.7828315)
Household income Tzs month	-0.0000987	0.0000318
	(0.0000422)**	(0.0000184)**
Age	-0.3392761	0.0072179
	(0.1573354)**	(0.0727749)
Gender		
Female	0.678147	0.9855772
	(2.002261)**	(0.931029)
Household size	-0.448406	0.310939
	(2.111518)***	(0.755478)*
Education level		
Secondary	0.652651	0.0673744
	(2.200584)**	(0.7918393)
Tertiary	0.42697	0.103424
	(3565.67)	(3565.668)
Infrastructure access		
Yes	0.857824	0.415929
	(1.378084)	(0.8172817)*
Location (ward)		
Genge	-0.07957	-0.087218
	(4645.982)	(4645.982)
Mbaramo	-0.06584	-0.060764
	(4645.982)	(0.0982)
Majengo	-0.25843	-0.028666
	(4645.982)	(4645.982)
Observation	100	
LR ch2 (40)	134.27	
Prob>Chi 2	0.0000	
Pseudo R2	0.6235	

Standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

The age of the household head influences the likelihood of energy consumption, particularly for Medium and Low where a coefficient of -0.3392761 ($p < 0.05$) results with coefficient of 0.712,

meaning a one year increase in age reduces the likelihood of medium consumption by 28.8%. This suggests younger heads are more open to partial clean fuel use. For High and Low, the coefficient of 0.0072179 ($p > 0.1$) with an odds ratio of 1.007 shows a slight, insignificant 0.7% increase, indicating that age has little impact on full adoption, possibly due to cultural resistance among older heads favoring biomass.

Female headed households are more likely to adopt higher energy consumption levels. The coefficient of 0.678147 ($p < 0.05$) for Medium and Low gives an odds ratio of 1.97, a 97% higher likelihood, while 0.9855772 ($p < 0.1$) for High and Low yields an odds ratio of 2.68, a 168% higher likelihood. This significant effect ($p < 0.05$ for Medium, $p < 0.1$ for High) aligns with the study's observation that women, aware of health risks from biomass that is 20,000 premature deaths annually, WHO, 2021 are more likely to shift to cleaner fuels as of LPG.

Household size affects the likelihood of energy consumption differently across categories. For Medium and Low a coefficient of -0.448406 ($p < 0.01$) results in an odds ratio of 0.639, a 36.1% lower likelihood per additional person, suggesting larger households stick to biomass due to cost or demand. For High and Low, a coefficient of 0.310939 ($p < 0.1$) gives a coefficient of 1.36, a 36% higher likelihood, indicating that larger households may adopt high consumption if resources allow, reflecting diverse energy needs.

Education level impacts the likelihood of energy consumption, with secondary education showing a notable effect. For Medium and Low a coefficient of 0.652651 ($p < 0.05$) yields an odds ratio of 1.92, a 92% higher likelihood, suggesting that secondary education encourages partial clean fuel use. For high and low the coefficient of 0.0673744 ($p > 0.1$) with an odds ratio of 1.07 is insignificant as is tertiary education (odds ratios 1.53 and 1.11, $p > 0.1$), likely due to the small sample of tertiary educated heads limiting its influence on full adoption.

Access to gas LPG infrastructure increases the likelihood of higher consumption, particularly for High and Low where a coefficient of 0.415929 ($p < 0.1$) gives an odds ratio of 1.52, a 52% higher likelihood. For Medium and Low the coefficient of 0.857824 ($p > 0.1$) with an odds ratio of 2.36 is not significant, suggesting that infrastructure is more critical for full adoption, supporting the document's emphasis on the need for rural electrification to boost gas LPG use.

5. Discussion

The ordered logit results indicate that receiving a gas LPG subsidy is associated increase in likelihood of being in the medium and high energy consumption categories. This finding aligns with global evidence suggesting that while subsidies reduce the upfront cost of clean energy, sustained adoption remains a challenge due to ongoing expenses such as LPG refills (Kar et al., 2019; Lee et al., 2021). In Tanzania, previous studies have shown that LPG adoption increased in urban areas following subsidies (Msuya & Kessy, 2020), yet rural households still lag behind due to supply chain issues and cultural factors. In Muheza, the results suggest that while subsidies improve access to gas LPG, they do not necessarily translate into higher overall consumption. This may be due to the persistence of fuel stacking**,** where households use both biomass and modern fuels instead of fully transitioning to clean energy (Masera et al., 2000).

Household income shows a mixed effect, slightly decreasing the likelihood of medium consumption but increasing the likelihood of high consumption reflecting socioeconomic disparities. This finding resonates with the literature review, where Choumert-Nkolo et al. (2019)

found that wealthier Tanzanian households are more likely to transition to electricity and LPG, while poorer households face a poverty trap due to higher per-unit costs of small-quantity fuel purchases. Ntegwa and Olan'g (2023) further support this, noting that only 6.9% of Tanzanian households use clean cooking fuels, with adoption concentrated among affluent urban populations, highlighting rural-urban disparities that persist in Muheza. The slight positive effect on high consumption aligns with the Energy Ladder Theory (Hosier & Dowd, 1987), suggesting that income improvements can facilitate a shift to cleaner fuels, but the negligible magnitude indicates that income alone is insufficient without addressing rural-specific barriers.

Female headed households were found to have a significantly higher likelihood of medium and high energy consumption compared to male headed households. This finding aligns with research by Rahut et al. (2017), who argued that female headed households are more likely to adopt clean energy due to increased awareness of indoor air pollution risks. Women, as primary household energy managers, tend to prioritize cleaner energy sources when affordability permits (WHO, 2021).This result is also supported by studies on gender and clean energy transitions**,** which suggest that targeted interventions such as awareness campaigns for women can enhance the effectiveness of clean energy subsidies (Choumert-Nkolo et al., 2019). The finding underscores the importance of gender sensitive energy policies in Tanzania's clean energy transition efforts.

The negative effect of age on the likelihood of medium consumption indicates that younger household heads are more likely to adopt partial clean fuel use, while the insignificant effect on high consumption suggests limited influence on full adoption. This finding is consistent with the literature review's emphasis on cultural preferences for biomass in rural Tanzania, as Lusambo (2016) noted that over 90% of rural energy consumption relies on firewood and charcoal, driven by availability and tradition. Hosier and Kipondya (1993) observed a transition to modern fuels in urban Tanzania over time, influenced by socioeconomic factors, but in rural Muheza, older household heads may resist change due to entrenched practices, supporting the Diffusion of Innovations Theory (Rogers, 1962) where compatibility with local practices slows adoption among older demographics

Larger households are less likely to adopt medium consumption but more likely to adopt high consumption reflecting diverse energy needs. This finding partially aligns with where Hosier and Kipondya (1993) noted that even wealthier households in Tanzania tend to stack fuels due to reliability and cost issues, a practice prevalent in rural Muheza where larger households may require more energy and thus rely on biomass. However the positive effect on high consumption suggests that some larger households possibly with more resources can adopt cleaner fuels, a nuance not directly addressed in the literature but consistent with the study's observation of resource availability influencing adoption.

Secondary education significantly increases the likelihood of medium consumption but its effect on high consumption is insignificant as is tertiary education. This supports Rahut et al. (2017) in the literature review, which found that education significantly affects clean energy adoption in Sub-Saharan Africa, as educated households are more aware of environmental and health benefits. Ntegwa and Olan'g (2023) also highlight education as a determinant of clean fuel adoption in Tanzania, though concentrated among urban populations. In Muheza, secondary education's impact on partial adoption aligns with the Diffusion of Innovations Theory (Rogers, 1962), where

knowledge and persuasion stages are critical, but the lack of effect on high consumption suggests additional barriers like cost or infrastructure.

Households with access to clean energy infrastructure had a higher likelihood of high energy consumption.. This finding is consistent with Diffusion of Innovations Theory (Rogers, 1962), which suggests that accessibility and visibility play a crucial role in the adoption of new technologies and Bishoge et al. (2018) caution that subsidies alone are insufficient without infrastructure development, as rural areas like Muheza face limited grid connectivity (only 5% use modern fuels, IEA, 2022). The study's emphasis on the need for complementary measures like infrastructure aligns with this, as households with access are more likely to fully adopt clean energy, supporting the Energy Ladder Theory's focus on access as a driver of transition.

6. Conclusion

This study has examined the relationship between Gas (LPG) subsidies and household energy consumption, as well as the factors influencing access to clean energy. The findings indicate that households with access to gas LPG subsidies tend to consume more gas LPG compared to those without subsidies. Furthermore, the study highlights key socioeconomic factors, such as gender, education level, infrastructure access, and geographical location, which play a crucial role in determining household energy choices. The results emphasize that government intervention, such as subsidies and infrastructure development, significantly impact household energy consumption patterns and the transition to cleaner energy sources.

Enhancing gas LPG Subsidies The government should expand gas LPG subsidies to reach more low-income households, ensuring that affordability is not a barrier to adoption. These subsidies should cover the initial costs of clean energy technologies such as solar panels, biogas systems, and energy-efficient appliances. Special attention should be given to rural and underserved communities, where financial constraints often limit the transition to clean energy. Additionally, subsidy programs should be structured to reduce dependency on traditional biomass fuels which are associated with environmental degradation and health risks.

Energy Infrastructure as major barrier to clean energy adoption is the lack of adequate infrastructure, particularly in remote areas. The government should prioritize investments in energy infrastructure, including expanding electricity grids, supporting decentralized renewable energy projects, and improving energy distribution networks. Off-grid renewable energy solutions, such as mini-grids and standalone solar home systems, should be promoted to ensure that communities without direct grid access can still benefit from clean energy. Improved infrastructure will not only increase access but also enhance the reliability and efficiency of energy supply.

Education and Awareness Campaigns this because the study suggest that many households are unaware of the benefits and availability of clean energy solutions. To address this, the government and stakeholders should implement nationwide awareness campaigns to educate citizens on the advantages of clean energy, subsidy programs, and available financing options. Schools, local community organizations, and media outlets should be engaged in promoting energy literacy. Additionally, practical training on the installation and maintenance of clean energy systems should be provided to empower communities with the necessary skills to adopt and sustain clean energy technologies.

Gender Inclusive Energy Policies, The findings suggest that gender plays a role in energy access and consumption patterns. Women, particularly in rural households, often play a central role in managing household energy needs. Therefore, energy policies should be designed to ensure equal access to gas LPG subsidies for both men and women. Targeted programs should be developed to empower women through financing schemes, capacity-building initiatives, and business opportunities in the clean energy sector. Women-led cooperatives and enterprises focused on renewable energy solutions should be supported to increase their participation in the energy transition.

References

Aslam, Z., Li, H., Hammerton, J., Andrews, G., Ross, A., & Lovett, J. C. (2021). Increasing Access to Electricity: An Assessment of the Energy and Power Generation Potential from Biomass Waste Residues in Tanzania. *Energies*, *14*(6), 1793. https://doi.org/10.3390/en14061793

Bishoge, O., Zhang, L., & Mushi, W. (2018). The Potential Renewable Energy for Sustainable Development in Tanzania: A review. *Clean Technologies*, *1*(1), 70–88. https://doi.org/10.3390/cleantechnol1010006

Choumert-Nkolo, J., et al. (2023). Clean energy transitions in rural Tanzania: Evidence from LPG subsidies. Energy Policy, 172, 113321.

Dimoso, R. L., & Andrew, F. (2021). Rural Electrification and Small and Medium Enterprises' (SMEs) performances in Mvomero District, Morogoro, Tanzania. J. Bus. Sch., 4(1), 48–69.

Doggart, N., et al. (2020). The cost of cooking: Biomass dependency in Tanzania. Environmental Management, 66(4), 567-579.

Emidi, B., Kisinza, W. N., Mmbando, B. P., Malima, R., & Mosha, F. W. (2017). Effect of physicochemical parameters on Anopheles and Culex mosquito larvae abundance in different breeding sites in a rural setting of Muheza, Tanzania. *Parasites & Vectors*, *10*(1). https://doi.org/10.1186/s13071-017-2238-x

Heltberg, R. (2004). Fuel switching: Evidence from eight developing countries. Energy Economics, 26(5), 869-887. https://doi.org/10.1016/j.eneco.2004.04.018

Hosan, S., Sen, K. K., Rahman, M. M., Karmaker, S. C., Chapman, A. J., & Saha, B. B. (2023). Evaluating the mediating role of energy subsidies on social well-being and energy poverty alleviation in Bangladesh. *Energy Research & Social Science*, *100*, s103088. https://doi.org/10.1016/j.erss.2023.103088

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe. Resources and Energy, 9(4), 347-361. https://doi.org/10.1016/0165-0572(87)90003-X

Hosier, R., & Kipondya, W. (1993). Urban household energy use in Tanzania. *Energy Policy*, *21*(5), 454–473. https://doi.org/10.1016/0301-4215(93)90035-e

International Energy Agency (IEA). (2022). Energy Access Outlook 2022. Paris: IEA.

Jamaldin, S & Laurent, M.F (2025) The role of multiple income sources of Household income in improving livelihoods in Western Tanzania. *Academicus Magazine*, 3(1), 59-73. https://doi.org/10.4314/academicus.v3i1.5

Jamaldin, S. (2024). The influence of seed selection on coffee production and farmers' livelihood in Kagera region. *Journal of Policy and Development Studies,* 17(1), 152-167 https://dx.doi.org/10.4314/jpds.v17il.13

Kapinga, J. (2025). Tanzania ups clean cooking drive with subsidised gas cylinders. *The Citizen.*

Kar, A., et al. (2019). LPG subsidies and household energy use in India. Energy Policy, 134, 110987.

Kitole, F. A., Tibamanya, F. Y., & Sesabo, J. K. (2023). Cooking energy choices in urban areas and its implications on poverty reduction. *International Journal of Sustainable Energy, 42*(1), 474–489. https://doi.org/10.1080/14786451.2023.2208680

Kitole, F.A., & Sesabo, J.K. (2022). Smallholder Livestock Keepers' Breeding Choices and Its Implication on Poverty Reduction in Developing Countries: Empirical Evidence from Tanzania. Glob Soc Welf 9, 241–251 (2022). https://doi.org/10.1007/s40609-022-00252-9

Kitole, F. A., Sesabo, J. K., Adesiyan, O. F., Ige, A. O., Ojo, T. O., Emenike, C. U., Khumalo, N. Z., Kassem, H. S., & Elhindi, K. M. (2024). Greening the Growth: A Comprehensive Analysis of Globalization, Economic Performance, and Environmental Degradation in Tanzania. Sustainability, 16(24), 10983. https://doi.org/10.3390/su162410983

Lambe, F., et al. (2015). Can carbon finance transform household energy markets? A review of cookstove projects and programs in Kenya. *Research & Social Science*, 5, 55-62. http://dx.doi.org/10.1016/j.erss.2014.12.012

Lee, K., et al. (2021). Subsidies and clean cooking adoption in Kenya. Renewable Energy, 168, 104-115.

Lusambo LP. (2016). Household energy consumption patterns in Tanzania. *Journal of Ecosystem & Ecography*, *01*(s5). https://doi.org/10.4172/2157-7625.s5-007

Mhagama, G., & Heriel, E. (2023). Determinants of household energy use for cooking in Tanzania. *Rural Planning Journal*, *25*(2), 44. https://doi.org/10.59557/rpj.25.2.2023.44

Msuya, N., & Kessy, F. (2020). Urban energy transitions in Tanzania: The role of LPG subsidies. Journal of Energy in Southern Africa, 31(3), 45-58.

Ntegwa, M. J., & Olan'g, L. S. (2023). Explaining the rise of economic and rural-urban inequality in clean cooking fuel use in Tanzania. *Heliyon*, *10*(1), e23910. https://doi.org/10.1016/j.heliyon.2023.e23910

Omari, N. D. a. M., Sarakikya, N. H., & Tesha, N. J. (2020). Energy Generation from Biomass in Tanzania Impacts and Challenges: An Overview. *International Journal of Engineering Research And*, *V9*(05). https://doi.org/10.17577/ijertv9is050371

Rahut, D. B., Behera, B., & Ali, A. (2017). Factors determining household use of clean and renewable energy sources for lighting in Sub-Saharan Africa. *Renewable and Sustainable Energy Reviews*, *72*, 661–672. https://doi.org/10.1016/j.rser.2017.01.080

Rogers, E. M. (2003). Diffusion of Innovations (5th ed.). New York: Free Press.

Rural Energy Agency (REA). (2024). Annual Report on Clean Energy Access. Dar es Salaam: REA.

The Citizen. (2025, February 27). Tanzania ups clean cooking drive with subsidised gas cylinders. Retrieved from www.thecitizen.co.tz

Timilsina, R. R., Rahut, D. B., Gautam, M. S., Mishra, R., & Sonobe, T. (2023). Are households shifting toward cleaner cooking fuel? Empirical evidence from India during 2005–2021. *Frontiers in Environmental Economics*, *2*. https://doi.org/10.3389/frevc.2023.1137248

Utouh, H. M. L., & Kitole, F. A. (2024). Forecasting effects of foreign direct investment on industrialization towards realization of the Tanzania development vision 2025. *Cogent*

Economics & Finance, 12(1). https://doi.org/10.1080/23322039.2024.2376947
World Bank. (2020). Tanzania Energy Sector Review. Washington, DC: World Bank.
World Health Organization (WHO). (2021). Indoor Air Pollution and Health in Tanzania. Geneva: WHO
Yamane, T. (1967). Statistics: An Introductory Analysis (2nd ed.). New York: Harper and Row