

Household Energy Transition and Environmental Security: Strategies for Scaling Up Liquefied Petroleum Gas (LPG) Adoption in Dar Es Salaam, Tanzania

Mrs. Catherine Venance Mwamunyange, Col (Dr) Emmanuel Psongol Kondoltiony, PhD, Dr.
Caroline Gatobu

National Defence University-Kenya

DOI: <https://doi.org/10.47772/IJRISS.2026.100600861>

Received: 18 June 2026; Accepted: 23 June 2026; Published: 07 July 2026

ABSTRACT

The continued use of charcoal and firewood as the main household cooking fuel is problematic both in the environment and public health as the region of Dar es Salaam is rapidly urbanising. Although household uptake of LPG is relatively low, the government's efforts to encourage the use of clean cooking technologies are having only a limited impact, resulting in deforestation, indoor air pollution, and greenhouse gas emissions. Drawing inspiration from the Energy ladder theory and the Theory of Technology Acceptance (TAM), the following issues were identified as a means of improving the adoption of household LPG to boost environmental security in the city of Dar es Salaam. A mixed methodology research was adopted and took a stratified random sampling of 400 households and 18 key informants, officials from the Ministry of Energy, LPG merchants and community leaders. The data obtained were quantitative, which were analysed with descriptive statistics and binary logistic regression in SPSS Version 29, and qualitative data, which were analysed thematically. Household LPG adoption was associated with a regression model, which was statistically significant ($\chi^2 = 81.64$, $p < 0.001$) and accounted for 47% of the variation in household LPG adoption. The results showed that 10.4% of the respondents were familiar with the LPG policy of the government. LPG affordability emerged as the strongest predictor of adoption ($\beta = 0.91$, $OR = 2.48$, $p < 0.001$), followed by proximity to refill stations ($\beta = 0.84$, $OR = 2.32$, $p < 0.001$) and policy awareness ($\beta = 0.68$, $OR = 1.97$, $p = 0.001$). Also, public awareness campaigns, the participation of government and the private sector and policy enforcement played significant roles in boosting the adoption of LPGs by households ($p < 0.05$). The results validate the Energy Ladder Theory which indicates that affordability and infrastructure are important in influencing adoption and TAM is important because of the role of policy awareness and perceived benefits. The study findings call for an appropriation of financial, institutional, infrastructural and behavioural interventions as key enabling tools for fast-tracking clean cooking transitions and improving long-term environmental security in the city of Dar es Salaam, Tanzania.

Keywords: Liquefied Petroleum Gas (LPG), Household Energy Transition, Environmental Security, Energy Ladder Theory, Technology Acceptance Model, Binary Logistic Regression, Tanzania.

INTRODUCTION

Environmental security has increasingly become a global concern due to rapid urbanization, population growth, and unsustainable household energy practices that threaten ecological systems and human health. Traditional biomass fuels, like charcoal and firewood, are still very much a part of the lives of households in many developing nations, particularly for household cooking and heating, despite their increasing availability in some areas. Household air pollution caused by solid fuel use is responsible for around 3.2 million premature deaths every year globally, especially for women and children who are often held closest to the fire during cooking, and therefore most likely to be exposed to the smoke (WHO 2023). Likewise, in the case of urban areas, the dependence on biomass contributes to deforestation and to the emission of greenhouse gases in these places (UNEP, 2022). These issues bring to the fore the centrality of clean household energy and its relevance to environmental sustainability and public health protection.

The drive to promote clean cooking technologies has been a global phenomenon where governments and international development organizations have been pushing for the shift. The switch to clean cooking technologies has been a worldwide activity, driven by the need to combat environmental degradation and enhance the welfare of households. Liquefied Petroleum Gas (LPG) is considered as one of the most widely used clean kitchen energy sources as it is efficient, less polluting and does not require wood as a source. Energy efficiency and massive usage of modern cooking fuels have decreased indoor air pollution and energy-use in developed nations like U.K and U.S. (International Energy Agency, 2022; U.S. Energy Information Administration, 2023). In addition, Smith et al. (2021) found a reduction in exposure to harmful particles amongst LPG users versus charcoal and firewood users. Therefore, there is an increasing recognition of clean cooking transitions as a critical path towards achieving sustainable cities and cities adapted to climate change.

In Asia, there are examples of wide-scale clean cooking initiatives, for example, China and India which has imposed massive initiatives to curb environmental and health hazards caused by biomass fuel usage. Both LPG policy and technology progress, such as subsidization, infrastructure building, and public awareness campaigns, have helped increase LPG access for the benefit of millions of urban households, away from coal, and biomass fuels (Li et al., 2023; World Bank, 2022). On the same note, India's Pradhan Mantri Ujjwala Yojana has ensured that subsidized LPG connections reach vulnerable groups and boosted access to LPG connections for low-income families of rural households (Government of India, 2022; IEA, 2022). These interventions helped curb indoor air pollution, deforestation, and carbon emissions, and enhance household health results. In fact, international experiences show that supportive policies at the government level and the availability of energy infrastructure at low costs is essential to facilitate the transition to clean cooking.

In spite of growing awareness among the citizens in Sub Saharan Africa on the climate and health risks from biomass fuels, most households are still using charcoal and firewood for cooking. Over 900 million people in Africa still rely on traditional biomass for cooking purposes (IEA 2023). This reliance plays a major role in the continent's deforestation, biodiversity depletion and air pollution. To promote LPGs in urban areas, governments in Kenya implemented tax reductions and subsidy programmes to boost domestic LPG consumption in the nation in the last ten years (Kenya Ministry of Energy, 2022; Kenya Forest Service, 2023). In the same way, Uganda facilitated roll out of LPG infrastructure and distribution systems to enhance access for urban households (Uganda Bureau of Statistics, 2022; Uganda National LPG Project, 2023). Regional activities are reflective of an increasing understanding of clean cooking energy as an environmental security concern.

The situation around spreading use of biomass fuels and the various consequent environmental and public health problems are still serious in Tanzania. About 90% of Tanzanians use charcoal and firewood for cooking, only a few households use modern clean energy solutions, like LPG, and electricity (Ministry of Energy Tanzania, 2024; World Bank, 2023). Such continued reliance leads to deforestation, soil erosion, biodiversity loss and greenhouse gas emissions, posing a risk to environmental sustainability. Biomass fuels are the major contributor of indoor air pollution that causes over 30,000 premature deaths each year in Tanzania (WHO, 2021). Furthermore, the report on National Forest Resources Monitoring and Assessment shows that Tanzania is losing forest land of thousands of hectares every year because of charcoal burning (URT, 2022). These are worrisome circumstances that underline the urgent need for cleaner household energy alternatives in the country.

The government of Tanzania is aware of the environmental and health risks of biomass fuels and has released the National Clean Cooking Strategy (2024 – 2034) to work towards speeding up the uptake of modern cooking technologies in Tanzania. The goal of the strategy is to expand the LPG infrastructure and financial incentives, while promoting awareness campaigns, to achieve 80% clean cooking coverage for Tanzanians by 2034 (Ministry of Energy Tanzania, 2024; World Bank, 2023). The government has also been offering tax break on LPG cylinders and LPG cooking stove to make it affordable for poor people. Given all these efforts, household LPG use is in a relatively low state caused by problems including high initial cost of the LPG, inconsistent LPG supply chain, and lack of awareness and cultural preference for traditional cooking methods (Annelise et al., 2022; Jamilaldin, 2025). This shows that challenges in implementing policy still impact the effectiveness of clean cooking programme in Tanzania.

Dar Es Salaam, the biggest commercial city and the fastest growing cities in Tanzania are under growing environmental stress with increased urbanization and also the rising need for household energy needs. National

Bureau of Statistics (2022), UN-Habitat (2022) indicated that the city has a population of over 5 million people and still has an essential population growth rate, and there are informal settlements in the city that are growing. Despite being increasingly recognized as more expensive and/or less available options than LPG most homes in the city continue to use charcoal for their cooking needs. Although LPG is recognized as a cleaner fuel, the use of charcoal in most homes of the city is still looked down on as being cheaper and more readily available than LPG. However, as urban Africans adopt charcoal consumption, it has also been found to be a major contributor of the environmental degradation and generation of greenhouse gas which affects health and urban air quality (World Bank, 2023; Ministry of Energy Tanzania (MET), 2024). As a result, cooking fuel use in Dar es Salaam has increasingly become a critical security issue for the environment that needs immediate policy deliberations and long- and medium-term action strategies.

The use of LPG in Dar es Salaam has enormous environmental and health benefits as it replaces use of charcoal and firewood within households. LPG emits less smoke, less CO and less PM2.5 which is harmful to the environment and human health, when compared to biomass fuels emitting when burned. Aamaas and Grimsby (2024) studied the potential impact of increased use of LPG in urban Tanzania and concluded that this had some positive effect on the reduction of indoor air pollution and pressure on forest ecosystems. Likewise, Shayo and Bintabara (2022) found that exposure to biomass fuels among children living in biomass fuel households more likely to experience respiratory infections as compared to biomass free fuel households. Moreover, LPG use helps to cut down carbon emissions and enhance urban environmental conditions. Thus, expanding LPG's use in households could assist with the protection of the environment as well as the health of the people.

In spite of the known advantages of LPG, a number of socio-economic and demographic factors are still important in explaining household adaption in Dar es Salaam. Household readiness and readiness for changing to clean cooking technologies is influenced by their level of income, education, ease with which LPGs can be obtained, gender divisions, cultural attitudes and affordability of fuel for the household. (Lasisi, 2021; Azuwike et al., 2023). Even after knowing the harmful environmental and health effects of charcoal, there are many households, especially those living in poverty, who can't afford LPG cylinders, stoves and refilling costs or simply choose to have charcoal as fuel. However, some households opted not to use LPG extensively due to concerns about reliability and safety of LPG supplies (Mainimo et al., 2022; Biririza, 2024; IEA, 2023). Household energy choices are both a response to economic situations and shaped by socio-cultural attitudes towards clean cooking technologies.

This study aimed to examine the use of Liquefied Petroleum Gas (LPG) in households and the implications for environmental security in the City of Dar es Salaam in Tanzania. The study specifically aims at identifying the socio-economic and demographic determinants of LPG adoption, surfacing the connection between LPG use and environmental security, and exploring how ways to make the shift from biomass to clean cooking technology better in households' future. The results will be useful for policy formulation, Environment sustainability, and planning of clean energy in the urban context of Tanzania (Ministry of Energy Tanzania, 2024). The study will also offer actionable solutions that can aid the effective implementation of Tanzania's National Clean Cooking Strategy and promotes Sustainable Household Energy Transitions in Dar es Salaam.

THEORETICAL FRAMEWORK

This study is based on the energy ladder theory proposed by Hosier and Dowd (1987) which describes the energy transitions in household energy use as related to the degree of socio-economic development and the rise in household income. The theory is that as the economic situation improves over time, the transition of a household from traditional biomass fuels, such as firewood and charcoal, to transitional fuels, such as kerosene, to later become modern and cleaner fuel, such as LPG or electricity. It assumes that households make choices of cleaner, efficient and convenient energy services when removal of financial, structural and institutional prohibitions is minimized. As a result, invariably, an increase in household income along with affordability and availability of fuels coupled with supportive government policies are likely to ensure the gradual shift away from traditional fuel usage to cleaner alternatives.

The Energy Ladder Model is suitable to explain causes behind household adoption of LPG use in Dar es Salaam. Despite the nationwide growing awareness of LPG as a clean, environmentally friendly source of cooking fuel,

in a large number of family's charcoal and firewood are still important due to a number of various factors, including low cost, poor availability of refill stations, delivery issues and socio-cultural preferences. This theory implies that household income isn't the only variable that influences the adoption of cleaner energy; modern energy infrastructure and policy environments also play a role. Hence, the study focuses on factors that affect the household's decision to switch to LPG including government-private sector partnership, policy awareness and public awareness campaign, district awareness and public awareness campaign, policy enforcement, availability of LPG stations, and comparability of cost of LPG.

The study also is based on the Davis (1989) Technology Acceptance Model (TAM) which state that users are mainly affected by their perceptions of usefulness and ease-of-use of a new technology before adopting it. Perceived usefulness in the field of aspect of household cooking energy: the environmental, health, economic and time-saving advantage of LPG fuel over the traditional biomass fuels. Perceived ease of use is associated with accessibility, affordability, safety, availability and convenience of LPG acquisition and utilization. Additionally, messaging to the public, education and policy can impact these perceptions favorably, thus enhancing the mass uptake of clean cooking technologies and its continued use.

The Energy Ladder Theory and TAM offer a complete theory to explain the uptake of LPGs in the household sector of Dar es Salaam. The energy ladder theory focuses on socio-economic factors, the growth of incomes, and energy transition, but TAM adds a dimension of the behavioral and perceptual aspect of how household decisions are made about clean cooking technologies. These theories can be integrated for a better understanding of economic and institutional factors which shape the adoption of LPG. Thus, the joint theoretical approach offers a solid conceptual basis for discussion of strategies that facilitate individual household adoption of LPG, biomass fuel reduction and enhancement of environmental security through sustainable individual household energy transition in Tanzania.

METHODOLOGY

The adopted research design was mixed-method research design that incorporated quantitative and qualitative data collection methods in this study which was aimed at examining household adoption of Liquefied Petroleum Gas (LPG) and implications on environmental security in Dar es Salaam city, Tanzania. Quantitative component used descriptive cross-sectional survey design, collecting statistical data on household energy use, affordability, accessibility and perceptions on LPG adoption. At the same time, a phenomenological approach was used in collecting the qualitative data to get in-depth information from key informants such as energy officials, LPG distributors, and community leaders. Ilala, Kinondoni, Temeke, Ubungo and Kigamboni districts were selected for the study due to their high levels of rapid urbanization and high biomass fuel dependency (NBS, 2022; Ministry of Energy Tanzania, 2024). Thus, methodological triangulation helped achieve a level of reliability, validity and contextual understanding.

The districts of interest were located in the five districts of Dar es Salaam, as identified by the National Bureau of Statistics (2022) and the target population consisted of 1,549,051 households. The sample included 18 key informants (purposive sampling) and 270 household respondents (strategically random sampling) according to the required sample size. The sample included 18 key informants and 270 household respondents which was stratified random sampling on the basis of the required sample size. The sample size was determined using Yamane's (1967) formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

- n_0 = required sample size
- N = population size (total number of households in Dar es Salaam)
- e = margin of error (5% or 0.05)

Where: n = sample size, N = target population, and e = margin of error.

$$n_0 = \frac{1,549,051}{1 + 1,549,051(0.05)^2}$$

$$n_0 = \frac{1,549,051}{3,080.91}$$

$$n_0 \approx 400$$

Therefore, the required sample size is 400 households. The collected quantitative data were analyzed using the software SPSS Version 29. The data was summarized using descriptive statistics (frequencies, percentages, means and standard deviations) and analyzed for the influence of policy awareness, affordability, number of LPG refill stations, public awareness campaigns, private sector and government collaboration and policy enforcement on household LPG adoption, through binary logistic regression analysis. The level of 5% ($p < 0.05$) was taken as the statistical significance.

FINDINGS

The primary aim of this study was to evaluate strategies for enhancing household LPG adoption to strengthen environmental security in the Dar es Salaam Region. To address this objective, structured questions were asked and results were as demonstrated in the following subsections;

Awareness of Government or Local Policies Promoting LPG Use

Respondents were asked to indicate if they are awareness of government or local policies promoting LPG use. Results were as presented in the Figure;

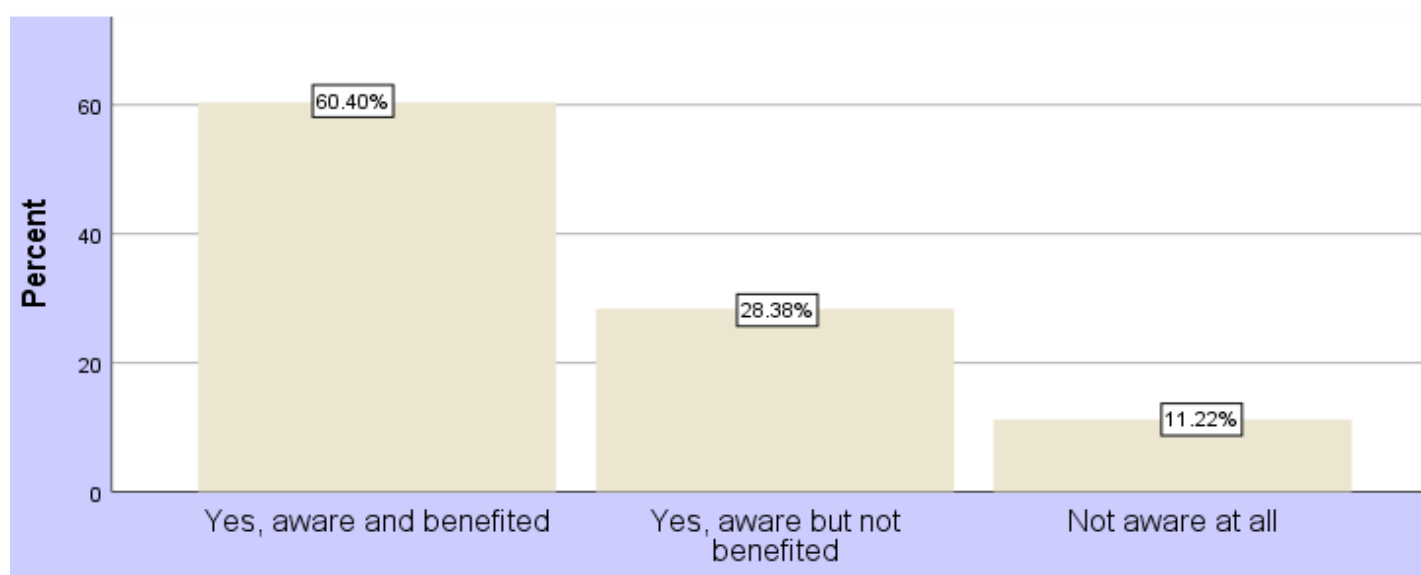


Figure 1: Awareness of Government or Local Policies Promoting LPG Use

(Source: Researcher, 2026)

Figure 1 demonstrate that majority (60.4%) of respondents did know that there are also government or local policies that encourage the use of LPG and have enjoyed them. Moreover, 28.4% had heard of such policies but had not personally received the benefit, and 11.2% had never heard of such policies. These findings indicate that there is a relatively high policy consciousness among metropolitan households. However, there is still a disconnect between the awareness level and practical benefits, meaning that dissemination of information is successful, although the access to political incentives including subsidies is still limited.

Qualitative and secondary data agrees with this state of awareness-impact. The government has put in place some priority programs such as the elimination of VAT on LPG cylinders, stoves, and other accessories in 2015, the National LPG Master Plan (2016-2025) to deal with the lack of reliance on biomass fuels (Africa Energy Portal, 2024). Such initiatives are consistent with the National Clean Cooking Strategy (2024-2034) that is aiming at the 80% adoption of clean cooking by 2034. In spite of these efforts, the LPG consumption rate is still fairly low, with an adoption level in Dar es Salaam calculated at less than 20% (MECS, 2022). The continued use of charcoal that supplies more than half of the household cooking energy in Dar es Salaam (Ministry of Energy, 2024) is another indicator of chronic socio-economic and cultural obstacles that restrict the successful implementation of policy actions. One of the key informants described it in the following way:

“The government subsidy scheme gives households a 50 percent discount on the 6kg LPG cylinder kit though not all eligible households are yet covered by the distribution.” (KII-MOE, 2026)

Also, a distributor emphasized implementation challenges:

“The 6kg cylinder is priced at 36,000 TZS, with the government contributing half, although other low-income families are still finding it difficult to dispose of their 18,000 TZS.” (KII-DIS, 2026)

These understandings imply that policy awareness may not necessarily be measured as universal access or benefit. The results are in line with previous research that showed that policy solutions like subsidies and promotional activities raise awareness, but obstacles to structural barriers may restrain successful adoption (Mainimo *et al.*, 2022; Oduka *et al.*, 2025). The studies on clean cooking transitions indicate that awareness is a contingent prerequisite to long-term adoption, yet it is not a sufficient factor; the affordability, availability, and efficiency in implementing clean cooking are also determinants. Based on a perspective of Innovation Diffusion (Rogers, 2003) information distribution through communication channels might be effective, but will not be adopted unless there is perceived relative advantage and practical access. Consequently, the development of useful policy agendas and inclusive implementation systems is imperative in order to achieve maximum environmental and social advantages of reforms on LPG promotion.

Proximity to the Nearest LPG Refill or Exchange Station

Respondents were asked to indicate the nearest LPG refill or exchange station from their home and their responses were as demonstrated below;

Table 1: Proximity to the Nearest LPG Refill or Exchange Station

	Frequency	Percent
Less than 500 meters	113	39.0%
500 meters – 2 kilometers	65	22.4%
More than 2 kilometers	56	19.3%
No refill station in my area	56	19.3%
Total	290	100.0%

(Source: Researcher, 2026)

Table 1 reveals that 39.0% of the households are less than 500 meters away to an LPG refill or exchange station suggesting that the physical access of a sizeable portion of respondents remains relatively good. Nonetheless, 22.4% moved 500 meters to 2 kilometers and 19.3% moved over 2 kilometers. It is worth noting that 19.3% of them stated that there was no refill station in their locality. These results indicate that even with sufficient accessibility of many urban households, the existence of spatial inequalities in the distribution systems could imply inability to fully depend on LPG in some regions.

The qualitative results support the value of proximity. One distributor noted:

“We are establishing additional refill points to facilitate the distance yet all the neighborhoods are not equipped with a nearby location of regular LPG change.” (KII-DIS, 2026)

On the same note, a ministry official noted:

“Distribution coverage is also to be enhanced, as more households are likely to be reliant on LPG in case refill services are easily accessible in their communities.” (KII-MOE, 2026)

These findings demonstrate that physical access is a highly significant factor in establishing long-term LPG use. The findings coincide with the earlier researches that demonstrated that the distance to refill stations is an important variable that predetermines the exclusive use of LPG (Kowsari and Zerriffi, 2011; Grimsby *et al.*, 2024). The study on urban Africa has shown that distance to shop increases the cost of transactions and is an incentive to fuel stacking, particularly between the households with low income. Both distribution infrastructure and market density are considered to be significant aspects of clean cooking changes, in terms of the energy access. Therefore, the introduction of the refill networks and the fair spatial coverage is a significant contribution to the strengthening of the LPG sustainability and environmental safety in Tanzania.

Policies and Initiatives that Promote LPG use

This sub-section aimed at assessing respondent’s perception on policies and initiatives that promote LPG use. Respondents were asked to rate their level of agreement whereby 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree. Results were as presented below;

Table 2: Enhancement Strategies for Promoting LPG Adoption and Environmental Security

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean ± SD
Government subsidies or tax exemptions make LPG more affordable	11.4% (35)	14.0% (43)	12.4% (38)	35.2% (108)	27.0% (83)	3.52 ± 1.33
Expanding LPG refill stations would increase adoption	2.7% (8)	6.4% (19)	17.6% (52)	43.9% (130)	29.4% (87)	3.91 ± 0.98
Public awareness campaigns improved knowledge	6.8% (20)	10.9% (32)	13.9% (41)	28.6% (84)	39.8% (117)	3.84 ± 1.25
Private sector incentives encourage LPG use	4.5% (13)	5.9% (17)	14.8% (43)	39.7% (115)	35.2% (102)	3.95 ± 1.07
Government–private collaboration is essential	5.5% (16)	7.3% (21)	18.0% (52)	35.3% (102)	33.9% (98)	3.85 ± 1.14
Policy enforcement ensures safe and sustainable use	6.5% (19)	9.5% (28)	13.3% (39)	38.1% (112)	32.7% (96)	3.81 ± 1.18
Promoting LPG reduces deforestation and improves environmental security	7.1% (21)	5.4% (16)	11.9% (35)	36.4% (107)	39.1% (115)	3.95 ± 1.17
Average (Enhancement Strategy Index)						3.83 ± 1.16

(Source: Researcher, 2026)

According to Table 2, the household members believe in institutional, infrastructural, and regulatory interventions that enhance the adoption of LPG and the environment security. Indicatively, 74.9% (Agree + Strongly Agree) respondents believed that incentives in the private sector stimulate LPG, and 75.5% said increasing LPG encourages deforestation and enhances environmental security. On the same note, 73.3 percent favored the expansion of LPG refill stations to promote its adoption. The 68.4% agreed that there should be public awareness and 69.2% agreed that there should be government-private collaboration. The majority of 70.8% of the respondents supported policy enforcement. Despite the time that 62.2% respondents supported subsidies and tax exemptions, this was relatively low, which implied that interventions such as financial ones are not enough by themselves. The Enhancement Strategy Index (Mean = 3.83 +- 1.16) has an overall picture of support of multi-sectoral approach.

“The government is now underway to implement the National Clean Cooking Strategy (2024-2034), VAT workload on LPG devices as well as design-specific subsidies on 6kg cylinders to enhance urban household access.” (KII-MOE, 2026)

This case complies with the National Clean Cooking Strategy (2024-2034), initiated by the Ministry of Energy in 2024, and in which 80% clean cooking access is set by 2034. The Tanzania Ministry of Energy (2024) notes that the LPG penetration is less than 40% in the country, and higher in the urban cities like Dar es Salaam. The policy framework also entails VAT exemptions on LPG cylinders and burners, partial subsidies on starter kits, and regulatory reform to be used in attracting the private investment. The high level of survey support of subsidy and policy implementation indicates that the community is informed about these programs, though moderate scores indicate insufficient implementation in the program of equal benefits to the public.

“The 50 percent subsidy on the 6kg cylinder package has made first time adoption higher, however the long term usage remains on whether refill costs can be reasonably allocated, and whether there is a stable supply.” (KII-MOE, 2026)

The findings illustrate a destructive policy-performance chasm. Although the Ministry of energy (2024) has reported introduction of subsidized 6kg cylinders to reduce barriers of entry, it is a challenge to afford refills. Government statistics show that more than 1.2 million improved cook stoves and LPG packages have been allocated under clean cooking programs but constant usage requires the repetition of refill expenditure. This helps to reinforce the regression data in which improvement measures proved effective and ineffective at the same time. The findings indicate that subsidy programs can raise the initial uptake, but the additional steps, like price stabilization and payment model contingent on income are required to achieve long-term environmental security benefits.

“The increase in refill stations, enhanced storage, and the security of supply chains is necessary to make households rely on LPG anytime.” (KII-DIS, 2026)

The Clean Cooking Strategy focuses on the infrastructure development; its emphasis is on strengthening the distribution network and the storage investment led by the private sector (Tanzania Ministry of Energy, 2024). Governmental accounts reveal that the number of LPG distribution points in urban centers has significantly risen over the last five years, but still there are spatial inequalities. Table 2 shows that the refill station expansion had a high mean score (3.91), indicating that physical accessibility is regarded as very important by households. The literature available before also indicates that insufficient supply infrastructure compromises sole use of LPG even in places where affordability interventions are in place (Kowsari and Zerriffi, 2011). Thus, infrastructure growth has a direct contribution to adoption as well as environmental results.

“Home delivery services, flexible payment methods, and programs to replace the cylinders, which minimize inconvenience to the household can be adopted by private companies.” (KII-DIS, 2026)

According to the Ministry of Energy (2024), one of the fundamental blocks of transition to clean cooking is considered to be public-private partnerships. The policy promotes the proliferation of home delivery systems, the provision of micro-finance facilities as well as cylinder replacement plans by the suppliers of LPG to make them more affordable and convenient. The high scoring of Table 2 (Mean = 3.95) in respect of incentives in the private sector portrays confidence in the market-driven techniques. This model is empirically justified, and it shows that both the efficiency in privately distributing the springs of clean cooking and financial innovation increase the rate of clean cooking transition (Grimsby *et al.*, 2024). Therefore, joint governance between the government and industry seems the key to scaling adoption and enhancing environmental security goals.

The results of Table 2 is in line with the National Clean Cooking Strategy (2024-2034) of the Tanzania Ministry of Energy, which identifies five pillars of the work such as affordability mechanisms, system expansion, enforcement of regulations, involvement of the private sector, and communication of behavior change (Tanzania Ministry of Energy, 2024). Government statistics show that over 60% of cooking energy use in urban areas is charcoal consumption that has led to deforestation and carbon emissions. The policy lowers the reliance of biomass and state the adoption of LPG as a clean fuel transitioning to LPG. The alignment between household

perceptions, interview evidence, regression findings, and national policy targets indicate that there is need to enhance the strategies multi-dimensionally. The private-sector innovation, regulation enforcement, and financial incentives, and infrastructure investment would have to act in tandem to result in sustainable LPG adoption and sustainable environmental security in the long term in Dar es Salaam.

Regression Analysis of Factors Influencing Household LPG Adoption

A binary logistic equation analysis was used to get the strength and direction of the link between LPG adoption and factors. Household LPG adoption was considered as dependent variable (1 = adopted LPG as cooking fuel; 0 = otherwise) whereas policy awareness, accessibility to LPG refill stations, pricing, public awareness, cooperation with the private sector and policy enforcement was included as independent variable.

Table 3: Binary Logistic Regression Results for Factors Influencing Household LPG Adoption

Variable	β	SE	Wald	Odds Ratio (Exp β)	p-value
Policy awareness	0.68	0.21	10.48	1.97	0.001**
Proximity to refill station	0.84	0.24	12.13	2.32	<0.001***
LPG affordability	0.91	0.19	22.94	2.48	<0.001***
Public awareness campaigns	0.52	0.18	8.41	1.68	0.004**
Government-private collaboration	0.43	0.20	4.63	1.54	0.031*
Policy enforcement	0.39	0.18	4.41	1.48	0.036*
Constant	-2.17	0.64	11.51	—	0.001

Model Statistics

- Model Chi-square = 81.64, $p < 0.001$
- Nagelkerke $R^2 = 0.47$
- Hosmer–Lemeshow Test = 0.61
- Classification Accuracy = 82.5%

The statistics show that the binary logistic regression model was statistically significant ($\chi^2 = 81.64$, $p < 0.001$), suggesting that the combined effect of the explanatory variables selected was capable of predicting the adoption of LPG by the households. Overall the model was able to explain nearly 47% of the variation in LPG adoption (Nagelkerke $R^2 = 0.47$) and correctly classified 82.5% of the households, a result of good predictive ability. The independent variables that showed the strongest association included LPG affordability ($\beta = 0.91$, OR = 2.48, $p < 0.001$), suggesting that households that perceived LPGs as affordable were more likely to adopt this energy source than those in which it was not affordable. Additionally, living close to LPG refueling stations had a positive significant effect on the adoption of LPG by the household ($p < 0.001$, $\beta = 0.84$ and OR = 2.32), as did awareness of policy ($p = 0.001$, $\beta = 0.68$ and OR = 1.97).

Additionally, all types of public awareness activities, partnership development between government and private companies, and policies had a statistically significant positive association with the adoption of household LPGs (at the $p < 0.05$ level). The results imply that the implementation of solid policies, behavioral change interventions and institutional support are good indicators of the promotion of households' shift away from traditional biomass fuel towards clean fuel for cooking energy needs. The regression further suggests that socio-economic and institutional factors influence household energy choices more than a single factor. Hence, interventions to boost the affordability of LPGs, boost infrastructure for replenishment, boost awareness-raising campaigns, boost public–private partnerships, and introduce supportive policies, will likely lead to greater LPG adoption, improved environmental security and sustainable transition towards more LPG use in household energy provision in Dar es Salaam.

DISCUSSIONS

The findings indicated that there is a significant effect of policy awareness on the use of Liquefied Petroleum Gas (LPG) by the households in Dar es Salaam. While the largest proportions of respondents (60.4%) knew of government policies that encourage LPG use, qualitative evidence suggested that many households did not have access to the full benefits of the policies due to limited availability and cost. The binary logistic regression analysis also showed that policy awareness had significant impacts on uptake of LPG technology ($\beta = 0.68$, OR = 1.97, $p = 0.001$); this meant that the likelihood of adoption of LPG is almost two times higher among households that have acquired awareness of policy on clean cooking technologies promoted by the government than among those that are not aware of the policy. The observed findings are consistent with those of Mainimo et al. (2022) who found that awareness leads to positive change in attitude of household members towards CCTs, but the outcome does not necessarily result to adoption of CCTs without favorable socio-economic factors. The results further corroborate the Technology Acceptance Model (TAM) (Davis, 1989) that asserts the perceived usefulness and ease of use affect technology adoption. Government awareness campaign in this way contributes to the better understanding of the environmental, health and economic gains from LPG and promoting their uptake by households.

The research also demonstrated that the physical accessibility is a significant determinant on household LPG adoption rate. Almost two-fifths said they did not have an LPG refill station in their locality while 39.0% said they travel more than 2 kilometres to get to an LPG refill station. The regression analysis results showed that the likelihood of LPG adoption was significantly higher if they were located in areas with LPG refill stations compared to those further away ($\beta = 0.84$, OR = 2.32, $p < 0.001$). The result founds the work done by Kowsari and Zerriffi (2011) who found that domestic fuel source use, especially traditional biomass fuels, is encouraged by longer travel distances, the higher the cost of transactions. Similarly, Grimsby et al. (2024) noted that a lack of LPG distribution infrastructure continues to represent some of the main challenges to continued uptake in urban Africa. The finding is also found to be consistent with the Energy Ladder Theory developed by Hosier & Dowd (1987) which posits that the success of the transition to modern household energy requires not the household income alone, but the access to reliable energy infrastructure.

The results also indicated widespread support for institutional, infrastructural and policy measures promoting LPG use and environmental safety. Slightly over 70% agreed to the expansion of refill stations, improve policies to be enforced, increase incentives for private sector, and facilitate partnership between government and private sector. Incremental analysis of regression also showed that four other factors—public awareness campaign ($\beta = 0.52$, OR = 1.68, $p = 0.004$), government–private sector collaboration ($\beta = 0.43$, OR = 1.54, $p = 0.031$), and policy enforcement ($\beta = 0.39$, OR = 1.48, $p = 0.036$)—significantly and positively influenced household LPG adoption. The results are consistent with Biririza, (2024)’s conclusion that there is a need for integrated institutional, infrastructural, and financial solutions for successful clean energy transitions. They also endorse the National Clean Cooking Strategy (2024-2034), calling for coordinated investments in infrastructure, regulatory enforcement, behavioral change communication, and private sector involvement for improved access to clean cooking technologies in Tanzania.

Lastly, the regression model had a good explanatory power; its chi squared value was 81.64 with a corresponding p value of < 0.001 , which points towards an approximate 47% explanation of the household adoption of LPGs (Nagelkerke $R^2 = 0.47$); 82.5% of households were correctly classified. However, LPG affordability was the most significant predictor of adoption (adoption rate 0.91, OR 2.48, $p < 0.001$) meaning that households that perceived LPG to be affordable were two and a half times more likely to take up LPG than those that perceived it to be unaffordable. While the initial access for a refill is provided with the assistance of government subsidies (subsidized LPG starter packs), refill prices are still a challenge for lasting use, especially for low income groups. The results have great implications for the Energy Ladder Theory, which states that the transition to modern household energy sources is strongly driven by the economic capacity of the household. The results were also consistent with those reported by Azuwiki et al., (2023), who noted that among the strongest determinants of persistent LPG uptake in urban Africa was their affordability.

Study Limitations

This study provides valuable insights into the factors influencing household Liquefied Petroleum Gas (LPG) adoption in Dar es Salaam; however, several limitations should be acknowledged. First, the mixed methods used strengthened the findings of the study, but the qualitative part involved interviewing 18 key informants; it is possible that the range of informant viewpoints in the study area was not fully represented. Second, respondents were drawn from the five districts of Dar es Salaam but did not involve a systematic comparative (across districts) analysis of the differences in LPG adoption. As a result, insights about the spatial and socio-economic inequities of LPG access, costs and/or policy implementation may have been missed. Further studies should involve more in-depth qualitative sample size and comparative district level analysis for understanding variations in household clean cooking transitions by geography and socio-economic level.

CONCLUSION

The results of this work indicate that, the improvement of household LPG usage is extremely important in Dar es Salaam region, Tanzania from the point of view of improving the environmental security of the households. The results showed that policy awareness, LPG affordability, access to LPG refill stations, public awareness program, public-private sector partnerships, and enforcement of LPG policies have positive impact on LPG adoption rate; in which LPG affordability was the strongest factor, while using binary logistic regression, the findings indicate that LPG affordability was the most influential factor in determining LPG adoption pattern. These results align with the Energy Ladder Theory which suggests the importance of socio-economic conditions in household energy transition and Technology Acceptance Model which emphasizes on the importance of perceived usefulness and ease of use in technology acceptance. Hence, strengthening affordability mechanisms, expanding LPG distribution network, strengthening policy implementation and promotion of behaviour change programmes are critical for smoothing out LPG transitioning, mitigating biomass fuel vulnerability and ensuring environmental sustainable security.

RECOMMENDATIONS

The Government of Tanzania should scale up the use of subsidy programmes covering LPG starter kits, as well as create income-sensitive financing alternatives addressing the low-income groups in urban and peri-urban population to implement the 'National Clean Cooking Strategy (2024-2034)'. This would lower financial costs of acquiring LPG equipment and LPG refill services and make adoption of clean cooking technologies easier and less costly from a financial perspective, which would encourage the sustained uptake of clean cooking technologies by households. Furthermore, the government should also step up monitoring and policy enforcement to guarantee equal access to subsidies and accountability in the implementation of clean cooking programmes.

The Ministry of Energy is required to scale up LPG distribution network infrastructure, and create more refill and exchange stations in poorly-serviced areas of Dar es Salaam with the active participation of its private sector partners. Ease of access and access proximity to LPG would decrease transportation costs, enhance convenience and decrease dependence on charcoal and firewood across the households. In addition, investment in local sites and the storage and transport infrastructure must be focused to guarantee a reliable and continuous provision of LPG all over the region.

Society education and awareness programmes of LPG should be strengthened in houses, mass media, radio, television, social media and other mediums highlighting LPG's environmental, economic and health benefits. Special attention should be given to the communities where smoking of biomass fuel is prevalent such as low-income community and informal settlement. Second, LPG-related education and awareness-raising initiatives should be bolstered to reflect the anxieties and misconceptions related to using and handling LPG which persist and continue to deter some households from using clean cooking technologies.

The government needs to be more pro-active in strengthening the public-private partnerships for greater innovation and better services to households for accessing LPG services. There is a need to adopt some flexible policies and flexible payment mechanisms in the private sector to provide affordable and convenient services to

consumers by introducing home delivery and cylinder exchange systems. Such integrated initiatives may facilitate the long-term transition of households to clean energy and help mitigate deforestation as well as operating level air quality and environmental security situation in Dar es Salaam Region.

REFERENCES

1. Aamaas, B., & Grimsby, L. K. (2024). Clean cooking transitions and environmental sustainability in urban Africa. *Energy for Sustainable Development*, 78(2), 115–128.
2. Africa Energy Portal. (2024). Tanzania clean cooking and LPG policy reforms. <https://africa-energy-portal.org>
3. Annelise, G., Mushi, P., & Temu, A. (2022). Household energy transitions and barriers to LPG adoption in Tanzania. *Journal of Energy in Southern Africa*, 33(4), 45–59.
4. Azuwiki, D. O., Chikowore, T., & Mbewe, S. (2023). Socio-economic determinants of clean cooking fuel adoption in urban Africa. *Energy Policy*, 174, 113–126. <https://doi.org/10.1016/j.enpol.2023.113126>
5. Biririza, J. (2024). Institutional interventions and clean energy transitions in developing countries. *Renewable Energy Journal*, 12(1), 66–81.
6. Government of India. (2022). Pradhan Mantri Ujjwala Yojana annual implementation report. Ministry of Petroleum and Natural Gas.
7. Grimsby, L. K., Aamaas, B., & Zerriffi, H. (2024). LPG accessibility and household fuel transitions in urban Africa. *Energy Research & Social Science*, 109, 103425. <https://doi.org/10.1016/j.erss.2024.103425>
8. Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources and Energy*, 9(4), 347–361. [https://doi.org/10.1016/0165-0572\(87\)90003-X](https://doi.org/10.1016/0165-0572(87)90003-X)
9. International Energy Agency. (2022). World energy outlook 2022. <https://www.iea.org>
10. International Energy Agency. (2023). Africa energy outlook 2023. <https://www.iea.org>
11. Jamilaldin, M. (2025). Challenges affecting household adoption of clean cooking technologies in Tanzania. *East African Journal of Environmental Studies*, 9(1), 88–101.
12. Kenya Forest Service. (2023). Annual forest conservation and biomass energy report. Government Printer.
13. Kenya Ministry of Energy. (2022). Kenya clean cooking strategy 2022–2028. Government Printer.
14. Kowsari, R., & Zerriffi, H. (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. *Energy Policy*, 39(12), 7505–7517. <https://doi.org/10.1016/j.enpol.2011.06.030>
15. Lasisi, T. T. (2021). Behavioral determinants of household clean cooking fuel adoption in Sub-Saharan Africa. *Energy Policy*, 156, 112–124. <https://doi.org/10.1016/j.enpol.2021.112124>
16. Li, X., Zhang, Y., & Chen, H. (2023). Urban clean cooking transitions and air pollution reduction in China. *Environmental Science and Policy*, 145, 56–68. <https://doi.org/10.1016/j.envsci.2023.03.011>
17. Mainimo, T., Ndlovu, S., & Banda, K. (2022). Policy awareness and adoption of clean cooking technologies among urban households in Africa. *Journal of Sustainable Energy*, 14(3), 201–219.
18. Ministry of Energy Tanzania. (2024). National clean cooking strategy 2024–2034. Government of Tanzania.
19. Modern Energy Cooking Services (MECS). (2022). Tanzania clean cooking market assessment report. <https://mecs.org.uk>
20. National Bureau of Statistics Tanzania. (2022). 2022 population and housing census report. Government Printer.
21. Oduka, J., Mwangi, P., & Mutesi, R. (2025). Policy incentives and household LPG adoption in East Africa. *African Journal of Environmental Policy*, 11(2), 77–94.
22. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.
23. Shayo, E. H., & Bintabara, D. (2022). Household air pollution and respiratory infections among children in Tanzania. *Annals of Global Health*, 88(1), 1–12. <https://doi.org/10.5334/aogh.3650>

24. Smith, K. R., Bruce, N., & Balakrishnan, K. (2021). Clean household energy and health outcomes in developing countries. *The Lancet Planetary Health*, 5(7), e452–e460. [https://doi.org/10.1016/S2542-5196\(21\)00102-4](https://doi.org/10.1016/S2542-5196(21)00102-4)
25. Uganda Bureau of Statistics. (2022). Uganda energy access statistical report. Government Printer.
26. Uganda National LPG Project. (2023). Annual LPG infrastructure development report. Ministry of Energy and Mineral Development.
27. United Nations Environment Programme. (2022). Global environmental outlook report. <https://www.unep.org>
28. United Nations Human Settlements Programme (UN-Habitat). (2022). World cities report 2022. <https://unhabitat.org>
29. United Republic of Tanzania (URT). (2022). National forest resources monitoring and assessment report. Ministry of Natural Resources and Tourism.
30. U.S. Energy Information Administration. (2023). International energy statistics report. <https://www.eia.gov>
31. World Bank. (2022). Clean cooking transitions in developing economies. <https://www.worldbank.org>
32. World Bank. (2023). Tanzania energy sector overview report. <https://www.worldbank.org>
33. World Health Organization. (2021). Household air pollution and health in Tanzania. <https://www.who.int>
34. World Health Organization. (2023). Household air pollution and health. <https://www.who.int>
35. Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper and Row.