

FUELING CHANGE IN TANZANIA: UNCOVERING WHAT DRIVES WOMEN'S WILLINGNESS TO PAY FOR COOKING GAS

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ABSTRACT

Aim: This study examines the determinants of women's willingness to pay for cooking gas in Kilimanjaro, Tanzania, using household utility theory and the energy ladder theory. **Methods:** The study adopted a quantitative research approach with a cross-sectional design, and employed the contingent valuation method (CVM) using a payment scale format. The study was conducted with a sample of 150 women, selected through a multi-stage sampling process to ensure representation across the target population. The data source was primary data collected using a structured questionnaire. Descriptive analysis and a probit model were employed to analyze the data. **Results:** The study finds that women's willingness to pay (WTP) for cooking gas is positively and significantly influenced by household size, average monthly household income, awareness of liquefied petroleum gas (LPG) availability, the presence of a gas plant within the community, and proximity to selling points within a distance of 1–3 km. Conversely, affordability challenges and the frequency of cooking gas purchases have a negative, significant effect on WTP, indicating that high costs and frequent refills discourage consistent use and willingness to pay for cooking gas among women. **Conclusion:** Policies should focus on improving LPG infrastructure, raising awareness, expanding income opportunities, and providing targeted subsidies to address affordability and reduce purchase – frequency barriers for women.

Key words: willingness to pay, cooking gas, woman, probit model, Tanzania

JEL codes: D1, Q4, Q42

INTRODUCTION

Globally, the promotion of the use of clean and renewable energy has been prioritized through various interventions that focus on strengthening energy security, expanding access to renewable energy, advancing energy-efficient technologies, and improving overall energy use efficiency (Bersisa et al., 2021; Kitole et al., 2023; Chanda et al., 2025; Kebele et al., 2025).

Moreover, Sustainable Development Goal 7 (SDG 7) underscores this commitment by aiming to ensure universal access to affordable, reliable, sustainable, and modern energy by 2030 (United Nations [UN], 2015; Bai et al., 2023; Kitole et al., 2023; Afriyie et al., 2024; Dunga & Goswami, 2025; Zhao et al., 2025). Access to clean and affordable energy remains limited for many households, with only 17% of African households having access to clean cooking fuels

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(International Energy Agency [IEA], 2022; Kitole et al., 2023; Dumga & Goswami, 2025; Tornel-Vázquez et al., 2025). Globally, about 2.6 billion people rely on traditional biomass, coal, or kerosene, posing serious health and environmental risks that hinder progress toward SDG 7 (Bakhsh et al., 2020; IEA, 2020; Bersisa et al., 2021; Kitole et al., 2023; Bawakyillenuo et al., 2025; Zhao et al., 2025). Households that adopt clean energy show willingness to allocate part of their monthly budget, making WTP a key factor in transitioning from biomass to cleaner fuels (Sievert & Steinbuks, 2020; Dumga & Goswami, 2025).

In Africa, especially where wood and charcoal dominate, understanding WTP is essential for promoting sustainable energy, improving health outcomes, and reducing environmental degradation (Dumga & Goswami, 2025). In Tanzania, particularly the Kilimanjaro region, assessing women's WTP for cooking gas informs policies on clean energy adoption, gender empowerment, and the mitigation of indoor air pollution, deforestation, and greenhouse gas emissions (World Bank [WB], 2022; Ministry of Energy of the United Republic of Tanzania [URT], 2024).

Globally, high upfront costs, limited infrastructure, and low awareness slow both the willingness to pay for and the adoption of cooking gas (IEA, 2021). In Africa, poverty, weak distribution networks, and cheaper alternatives such as charcoal further hinder uptake despite the health and environmental benefits (World Health Organization [WHO], 2022). In Tanzania, including the Kilimanjaro region, low household incomes, limited subsidies, high distribution costs, rural remoteness, and cultural preferences reduce women's willingness to pay for liquefied petroleum gas (LPG) (URT, 2015). Only 7.9% of Tanzanian households are willing to use and pay for cooking gas, highlighting extremely low adoption. Traditional fuels dominate, with over 80% of the population relying on firewood (58.6%), charcoal (27.1%), and kerosene (1.2%), while LPG (9.2%) and electricity (2.5%) remain limited (URT, 2024). This reliance reflects broader adoption challenges, including limited awareness, poor access to efficient cookstoves, affordability constraints, and inadequate knowledge on using and maintaining clean cooking solutions (URT, 2024).

To address the challenges, global efforts emphasize expanding access to clean cooking, offering affordable

financing, and reducing environmental harm from traditional fuels (Clean Cooking Alliance [CCA], 2021). Across Africa, governments are introducing subsidies, improving infrastructure, and raising awareness to encourage the shift from biomass to gas (Aikins & McLachlan, 2020; Gafa & Egbendewe, 2021; Twumasi et al., 2021). In Tanzania, initiatives led by the government and NGOs focus on LPG promotion subsidies, education, and private sector partnerships, especially in regions including Kilimanjaro (URT, 2023), through providing tax relief to stimulate the use of LPG in the country (URT, 2015). Also, in 2023, the Tanzania LPG Association (TZLPGA) was established, bringing together six major companies involved in the household gas cylinder trade, including Cam-Gas, O-Gas, Lake Gas, Taifa Gas, Oryx Gas, Manji Gas, and Puma Energy to promote the use of LPG for cooking (URT, 2023). Additionally, the enactment of the Rural Energy Act of 2005 (URT, 2005), National Energy Policy of 2015 and Rural Energy Fund (URT, 2015), Rural Energy Agency (REA) as well as National Renewable Energy Strategy, 2024–2034 (URT, 2024), and increased budget allocations aim to promote greater use of LPG (URT, 2023). Over the past decade, the supply of LPG for household cooking has grown significantly (URT, 2015). However, the success of any policy intervention largely depends on consumers' preferences and their willingness to pay for clean energy, including cooking gas (Bersisa et al., 2021). Fostering willingness to pay for cooking gas requires an understanding of the drivers and obstacles to it.

The existing studies primarily examine the determinants of adoption of improved cookstoves, willingness to pay for electricity connections, and the use of various fuel types in countries (Numata et al., 2012; Sievert & Steinbuks, 2020; Bersisa et al., 2021; Chindarkar et al., 2021; Onyekuru et al., 2021; Das et al., 2022; Wen et al., 2022; Dumga & Goswami, 2025). In Tanzania, research has largely been confined to studying the drivers of cooking energy choice. Scanty studies (Rosenbaum et al., 2015; Bersisa et al., 2021) in developing countries, including Tanzania, have been conducted on drivers of willingness to pay for cooking gas, such as LPG for cooking. The recent existing studies (Osiolo, 2017; Pyzalska-Kowalska, 2019; Ayodele et al., 2021; Das et al., 2022; Ma

et al., 2022; Nketiah et al., 2022; Janghorban et al., 2024; Chishimba & Muchapondwa, 2025; Dumga & Goswami, 2025; Kebele et al., 2025; Tornel-Vázquez et al., 2025) on determinants of willingness to pay for cooking energy focused much on cooking electricity, household electricity, renewable electricity, green electricity, and improved cookstoves, including biomass and gas stoves as well as ICSs, traditional fuels such as firewood and charcoal, and solar cookers. For example, Kebele et al. (2025) studied solar cookers in peri-urban Tigray, Ethiopia. Bersisa et al. (2021) investigated improved cookstoves, including biomass and gas stoves, in rural Ethiopia, and Dumga and Goswami (2025) analyzed electricity use for cooking in rural Southern Ethiopia. Osiolo (2017) assessed firewood, charcoal, and electricity for households and enterprises in Kenya, whereas Rosenbaum et al. (2015) evaluated improved cookstoves in Bangladesh. Janghorban et al. (2024) examined household and SME electricity connections in Nigeria, and Das et al. (2022) examined firewood use in the peri-urban Kathmandu Valley, Nepal. Pyzalska-Kowalska (2019) studied residential consumers' willingness to pay for green electricity in Poland, Ayodele et al. (2021) explored renewable electricity in Nigeria, and Nketiah et al. (2022) analyzed renewable green electricity in Ghana.

Limited studies (Chindarkar et al., 2021; Das et al., 2022) focused on cooking gas such as LPG. For instance, Chindarkar et al. (2021) focused on households' willingness to pay for LPG for cooking in rural India, while Das et al. (2022) study focused on LPG in the peri-urban Kathmandu Valley, Nepal. This issue remains underexplored in the context of cooking gas in rural areas, where most households in developing countries, including Tanzania, reside and have markedly different livelihood conditions. Studies show that willingness to pay (WTP) for clean energy is primarily influenced by socio-economic factors such as income, education, household size, and gender (Sievert & Steinbuks, 2020; Ayodele et al., 2021; Bersisa et al., 2021; Chindarkar et al., 2021; Das et al., 2022; Tornel-Vázquez et al., 2025). Behavioral factors, including awareness of health and environmental benefits, community influence, and government involvement, also increase WTP (Das et al., 2022; Nketiah et al.,

2022). However, structural barriers such as price sensitivity, income instability, and limited infrastructure constrain adoption (Pyzalska-Kowalska, 2019; Bersisa et al., 2021; Dumga & Goswami, 2025). Nevertheless, these studies often overlooked fully examining factors such as the frequency of purchasing cooking gas, time savings relative to traditional fuels, and training in the use of clean cooking energy that influence women's willingness to pay for cooking gas. Furthermore, existing studies have largely overlooked women, even though in rural households they bear primary responsibility for collecting and transporting cooking energy sources, devoting a significant portion of their time and effort to these tasks (Dumga & Goswami, 2025). This study addresses these gaps by including the influence of the above-overlooked factors to offer an understanding of the drivers of women's willingness to pay for cooking gas in Kilimanjaro, Tanzania.

LITERATURE REVIEW

The energy ladder theory

The energy ladder theory, developed by Leach (1992), proposes that as household income increases, fuel use transitions from traditional fuels such as firewood and dung to transitional fuels like charcoal and kerosene, and ultimately to modern fuels including LPG and electricity (Bensch et al., 2021; Pangaribowo & Iskandar, 2022). The theory assumes that fuel choice follows a linear progression with rising income, that modern fuels are universally preferred when affordable, and that fuel decisions are largely driven by income, affordability, and accessibility (Pangaribowo & Iskandar, 2022). The fuel choice implies the willingness to pay for cooking gas. In the context of this study, women, based on income increase, can be willing to pay for cooking gas, such as LPG, as a transition from traditional fuels.

The energy ladder theory offers several strengths. It provides a clear conceptual framework for understanding socio-economic transitions in household energy use, explains patterns of fuel switching, and supports planning for energy infrastructure and clean energy policies (Kitole et al., 2023). The theory is particularly relevant to this study as it aligns

with the analysis of key determinants of willingness to pay for cooking gas, including income, affordability, and price. It also offers a theoretical basis for understanding the economic transition from traditional fuels to cooking gas such as LPG.

Despite its usefulness, the theory has notable limitations. It oversimplifies household energy behavior by assuming a linear transition and failing to account for fuel stacking, the simultaneous use of multiple fuels. It also neglects cultural, behavioral, and contextual factors that shape energy choices and willingness to pay. Furthermore, it assumes rational decision-making while overlooking concerns such as safety perceptions, time savings, and preferences for specific energy sources. As such, non-income determinants of household energy decisions, which are omitted in this framework, are more adequately captured within household utility theory.

Household utility theory

Household decisions regarding the willingness to pay for cooking energy are grounded in rational choice. According to the theory, households consider both their preferences for cooking energy sources and budget constraints when selecting the energy source that maximizes their perceived utility (Greve & Lay, 2023; Kitole et al., 2023). Willingness to pay for cooking energy, particularly modern fuels such as LPG, is influenced by a range of socio-economic characteristics that vary across households. In this study, willingness to pay for cooking gas is considered the dependent variable. For a household that expresses a willingness to pay, the corresponding utility function can be represented as follows:

$$U_j = \beta'x_j + \epsilon_j, j = 1, 2 \quad (1)$$

when the household choice j is made, the underlined assumption (U_j) achieves the maximum value among the available set of utilities. That is, j is chosen when $U(\text{alternative } j) > U(\text{alternative } k)$, $k \neq j$ is a vector of explanatory variables that affect the willingness to pay (WTP) for cooking gas, D^* is a latent variable that indicates the willingness to pay (WTP) for cooking gas, β' is a vector of unknown parameters, ϵ_j and is a disturbance term.

Empirical literature on the drivers of willingness to pay for cooking energy

The literature on households' willingness to pay (WTP) for clean cooking energy and renewable electricity highlights consistent patterns and challenges across diverse geographic and socio-economic contexts. Across India, Ethiopia, Nepal, Nigeria, Ghana, Poland, and Bangladesh, socio-economic factors such as income, education, household size, and gender emerge as strong predictors of WTP (Ayodele et al., 2021; Bersisa et al., 2021; Chindarkar et al., 2021; Das et al., 2022). Wealthier and more educated households consistently exhibit higher WTP, reflecting both greater financial capacity and greater awareness of the health, time-saving, and environmental benefits of adopting clean energy. Similarly, household composition, including the number of productive-age members, affects WTP by influencing labor availability and energy needs (Kebele et al., 2025). Behavioral and awareness factors also play a critical role. Studies show that recognition of health advantages, environmental impacts, and community adoption increases WTP (Chindarkar et al., 2021; Das et al., 2022; Nketiah et al., 2022). Tornel-Vázquez et al. (2025) examined the adoption of nature-based solutions for energy transition among rural households in Northern Nigeria using a two-stage Heckman selection model. Their analysis of willingness to pay (WTP) indicated that several factors were positively associated with higher WTP, including household size, time spent on food preparation, biomass use, participation in informative workshops, and household income. The Ghana study demonstrates that government involvement and awareness campaigns indirectly enhance WTP by shaping attitudes and subjective norms, while perceived behavioral control alone does not significantly influence payment behavior. Social dynamics can both encourage and constrain adoption; for instance, participation in community organizations was associated with lower WTP in Tigray, possibly due to social norms or shared resource strategies (Kebele et al., 2025). Fuel stacking in Nepal shows households often use traditional fuels alongside LPG, influenced by availability, cost, and convenience (Das et al., 2022). Economic and structural barriers, including price sen-

sitivity and limited ability to pay full market prices, constrain WTP for clean energy (Pyzalska-Kowalska, 2019; Chindarkar et al., 2021; Bersisa et al., 2021). Income instability, cash flow issues, and infrastructure challenges such as distance to distribution points further limit adoption (Bersisa et al., 2021; Das et al., 2022; Dumga & Goswami, 2025). Even in higher-income contexts such as Poland and Nigeria, WTP remains moderate, underscoring the need for subsidies, flexible financing, and targeted interventions to support clean energy adoption (Pyzalska-Kowalska, 2019; Ayodele et al., 2021).

Across studies, various models estimate willingness to pay (WTP) for different energy types, including Probit, Ordered Probit, and double-bounded contingent valuation approaches (Osiolo, 2017; Bersisa et al., 2021; Kebele et al., 2025). Conditional logit and structural equation models capture household and SME preferences, as well as the role of attitudes and social norms in shaping WTP (Nketiah et al., 2022; Janghorban et al., 2024). CVM has been widely applied to assess WTP for renewable and clean energy across countries like Poland, Nigeria, and Nepal (Pyzalska-Kowalska, 2019; Ayodele et al., 2021; Das et al., 2022). Experimental trials and behavioral assessments further reveal adoption patterns and preferences, highlighting methodological diversity in studying energy WTP (Rosenbaum et al., 2015).

Methodologically, studies use contingent valuation, double-bounded CV, discrete choice experiments, and choice modeling to estimate stated preferences and marginal WTP for clean energy (Bersisa et al., 2021; Chindarkar et al., 2021; Janghorban et al., 2024). Structural equation modeling highlights the influence of attitudes and social norms, while discrete choice experiments capture heterogeneity in household and SME preferences (Nketiah et al., 2022; Janghorban et al., 2024). However, comparisons across studies are limited by differences in elicitation methods, samples, and contexts, reducing generalizability. Key gaps include limited evidence from rural and low-income settings, a lack of longitudinal analysis, and a minimal focus on multi-fuel (fuel stacking) decision-making. Overall, WTP is shaped by socio-economic status, awareness, and communi-

ty effects, but high costs, weak infrastructure, and income variability constrain full and sustained clean energy adoption.

DATA AND METHODS

This study employed cross-sectional data collected in the Kilimanjaro region of Tanzania, where many households still rely on traditional cooking fuels such as charcoal and firewood, making it a relevant setting for examining willingness to pay for cleaner energy sources such as cooking gas (URT, 2015; Kitole et al., 2023). The research was conducted specifically in rural areas of Hai District, one of the seven districts in the Kilimanjaro Region (NBS & REA, 2020). A multi-stage sampling strategy was applied. First, Hai District was purposively selected because of its greater reliance on traditional cooking methods than the surrounding districts. Second, two wards, including Machame Magharibi and Machame Uroki, were purposively chosen within the district. Finally, simple random sampling was used to select women-headed households for participation. The sample size was determined using the formula provided by Yamane's formula (1973) as follows:

$$n = \frac{z^2 pq N}{e^2(N-1) + z^2 pq} \quad (2)$$

$$n = \frac{1.96^2 \cdot 0.1117 \cdot 0.888 \cdot 14,254}{0.015(14,254 - 1) + 1.96^2 \cdot 0.1117 \cdot 0.888}, \quad n = \frac{5,212.999}{34.087} = 150$$

where n is a required sample size, N is a total population size, z is a standard normal deviate corresponding to the desired confidence level (e.g., z equals 1.96 for 95% confidence), p is an estimated proportion of the population possessing the characteristic of interest, $q = 1 - p$ (the proportion of the population not possessing the characteristic), and e is an acceptable margin of error (level of precision).

The study surveyed 150 women in 2025 using a structured questionnaire and applied the contingent valuation method (CVM) to estimate women's willingness to pay for cooking gas. CVM requires careful design of WTP questions, as the elicitation format significantly influences respondents' answers (Hanemann, 1984; Pyzalska-Kowalska, 2019). The literature

identifies four main WTP elicitation formats: bidding/bargaining, payment scale, open-ended, and dichotomous choice (Oerlemans et al., 2016). Each format varies in structure and response burden, affecting the reliability and validity of WTP estimates (Yoo & Kwak, 2009; Zoric & Hrovatin, 2012; Ntanos et al., 2018; Dumga & Goswami, 2025). The study applied the contingent valuation method using a payment scale format to estimate women's willingness to pay for cooking gas, selected for its simplicity and practicality (Ntanos et al., 2018). Monetary ranges were defined from pre-tests and market prices: below TZS 20,000; TZS 20,000–50,000; TZS 50,001–100,000; and above TZS 100,000, with a zero WTP option included. Women selected the maximum monthly amount they were willing to pay, and households perceiving higher benefits from LPG showed a higher likelihood of willingness to pay.

$$\text{mean WTP} = \frac{\beta(\text{number of respondents} \times \text{midpoint of category})}{\text{total respondents}} \quad (3)$$

For the top category (“Above TZS 100,000”), the study involved assigning a reasonable assumed value (TZS 120,000) based on context (Ntanos et al., 2018). The binary dependent variable indicates whether a household is classified as a high-cooking-gas expenditure user. The threshold of TZS 100,000 was selected because it represents the upper expenditure class in the survey instrument. For respondents reporting expenditure in the category (“Above TZS 100,000”), an assumed representative value of TZS 120,000 was assigned to approximate actual expenditure, following the common practice for handling open-ended expenditure classes, as recommended by Ntanos et al. (2018). The dependent variable for each household is dichotomous: a response of “yes” (1) if the women's WTP exceeds the market price of cooking gas (small or big size), and “no” (0) if it does not. In other words, a respondent answers “yes” (1) when their WTP is greater than the market price of cooking gas (refilling), and “no” (0) otherwise. The WTP model can be formally expressed as shown in Equation (1),

$$WTP_i(x_i, \epsilon_i) = y_i(x_i, \epsilon_i) = x_i\beta + \epsilon_i \quad (4)$$

where x_i is a vector of explanatory variables, β is a vector of parameters, and ϵ_i is an error term. The probability of observing a “yes” response given the values of is given by:

$$P(x_i = 1|x_i) = P(y_i > t_j) = P(x_i\beta + \epsilon_i > t_j) = P(\epsilon_i > t_j - x_i\beta) \quad (5)$$

A probit model was used to estimate the binary decision of whether a woman is willing to pay more than TZS 100,000 for cooking gas (1 = yes, 0 = no). The model, estimated using maximum likelihood, is appropriate for probability analysis with a normally distributed error term (Berkson, 1944; Becker & Waldman, 1987). Its suitability for socio-economic binary choice analysis, as shown in studies such as Kebele et al. (2025), justifies its application in this study.

The general form of the probit model is expressed as follows:

$$D_i^* = \beta'x_i + u_i \quad (6)$$

$$D_i = \begin{cases} 1 & \text{if } D_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

where D_i is an observed dummy variable that indicates whether a woman is willing to pay (WTP) for cooking gas, and subscript i indicates a woman. x_i is a vector of explanatory variables that affect the willingness to pay (WTP) for cooking gas, D^* is a latent variable that indicates the willingness to pay (WTP) for cooking gas, β' is a vector of unknown parameters, and $u \sim N(0, 1)$ is a disturbance term. The marginal effects derived from the model show how a unit change in each independent variable affects the probability of willingness to pay, holding other factors constant. It can be specified as:

$$\frac{\delta(Y = 1|X)}{\delta X_i} = \phi(X\beta)\beta_i \quad (7)$$

where $\phi(\cdot)$ is a probability density function (PDF) of the standard normal distribution, β_i is a coefficient of the explanatory variable. The marginal effect (ME) shows the change in the probability that $Y = 1$ for a one-unit increase in X_i , holding other variables constant. ME is interpreted as average marginal effects (AME). The explanatory variables included age, marital status, education, household size, average household income per month, frequency of purchasing cooking gas, health concerns on use of traditional energy, time

saving relative to traditional fuels, environmental impact on using firewood/charcoal, safety in using cooking gas, awareness on availability of LPG, training on use of clean cooking energy, the presence of gas plant within the community, distance from home to the selling point and affordability. The selected explanatory variables (characteristics and factors) were specifically chosen to examine farmers' responses based on insights from the theoretical framework (household utility theory and energy ladder theory), a review of similar literature, and the local situation.

RESULTS AND DISCUSSION

Descriptive results

Tables 1 and 2 provide the descriptive characteristics of respondents and their willingness to pay (WTP) for cooking gas. Most respondents are over 40 years old, indicating that older household heads mainly influence LPG decisions and may prioritize health and safety benefits. Limited participation of younger households could affect future adoption trends, suggesting a need for age-inclusive LPG promotion strategies. Most respondents are married (67.33%), meaning LPG decisions are largely made at the family level, while widowed households (27.33%) may face financial constraints. Targeting household decision-makers is key to increasing LPG adoption. Over 85% have secondary or higher education, which supports awareness of LPG safety, health, and environmental benefits. However, lower-educated households need training and awareness to reduce fear and misinformation. Medium-sized households (4–7 members) dominate, while larger households face higher LPG costs that may limit adoption. Household size directly affects fuel demand and affordability.

About 74.67% of households are willing to pay for cooking gas, with the largest share (32.67%) able to pay above TZS 100,000, indicating strong demand among higher-income households. However, 25.33% are unwilling to pay, and many can only afford lower amounts, showing that affordability remains a key barrier to wider LPG adoption. The mean willingness to pay for cooking gas is about TZS 58,867 per month,

indicating moderate affordability and readiness to adopt cleaner energy. However, many households may still struggle to use LPG consistently if prices rise above this level. Cooking gas is the most used fuel (39.33%), followed by electricity (27.33%), charcoal (22.67%), and firewood (10.67%). This shows progress toward cleaner energy, though reliance on traditional biomass fuels remains significant. Nearly three-quarters earn

Table 1. Demographic characteristics

Category	Frequency	Percentage [%]
Education		
No formal education	9	6.00
Primary education	13	8.67
Secondary education	50	33.33
College/University	78	52.00
Total	150	100.00
Household size		
1–3	55	36.67
4–6	77	51.33
7–8	0	0.00
Above 8	18	12.00
Total	150	100.00
Age [years]		
Less than 18	1	0.67
18–30	14	9.33
31–40	34	22.67
41–50	49	32.67
Above 50	52	34.60
Total	150	100.00
Marital status		
Single	7	4.67
Married	101	67.33
Divorced	1	0.67
Widow	41	27.33
Total	150	100.00

Source: author's research.

Table 2. Descriptive results

Category	Frequency	Percentage [%]
Willingness to pay (WTP) for cooking gas		
Yes	112	74.67
No	38	25.33
Total	150	100.00
Amount relating to WTP for cooking gas [TZS]		
0	38	25.33
Below 20,000	7	4.67
20,000–50,000	33	22.00
50,001–100,000	23	15.33
Above 100,000	49	32.67
Total	150	100.00
Type of cooking fuel currently used by women		
Firewood	16	10.67
Charcoal	34	22.67
Cooking gas	59	39.33
Electricity	41	27.33
Total	150	100.00
Average household income per month [TZS]		
Below 100,000	10	6.67
100,000–500,000	32	21.33
500,001–1,000,000	72	48.00
Above 1,000,000	36	24.00
Total	150	100.00
Frequency of purchasing cooking gas		
Weekly	3	2.00
Bi-weekly	27	18.00
Monthly (once every month)	59	39.33
Occasionally (no fixed schedule/sometimes)	61	40.67
Total	150	100.00
Health concerns on the use of traditional energy		
Strongly disagree	0	0.00
Disagree	1	0.67
Neutral	19	12.67
Agree	50	33.33
Strongly agree	80	53.33
Total	150	100.00
Time-saving relative to traditional fuels		
Strongly disagree	0	0.00
Disagree	3	2.00
Neutral	24	16.00

Category	Frequency	Percentage [%]
Agree	45	30.00
Strongly agree	78	52.00
Total	150	100.00
Perception on negative environmental impact of using firewood/charcoal		
Strongly disagree	0	0.00
Disagree	2	1.33
Neutral	18	12.67
Agree	48	32.00
Strongly agree	81	54.00
Total	150	100.00
Safety in using cooking gas		
Strongly disagree	1	0.67
Disagree	6	4.00
Neutral	20	13.33
Agree	49	32.67
Strongly agree	74	49.33
Total	150	100.00
Awareness on availability of LPG		
Yes	122	81.3
No	28	18.7
Total	150	100.00
Training on use of clean cooking energy		
Yes	51	34.00
No	99	66.00
Total	150	100.00
The presence of gas plant within the community		
Yes	58	38.67
No	54	36.00
Not sure	38	25.33
Total	150	100.00
Distance from home to the selling point		
Less than 1 km	34	22.67
1–3 km	64	42.67
Above 3 km	52	34.67
Total	150	100.00
Affordability (ability to pay the price of LPG)		
Yes	69	46.00
No	66	44.00
Not sure	15	10.00
Total	150	100.00

Source: author's research.

above TZS 500,000, making LPG more affordable for higher-income groups, while low-income households face cost barriers. Income strongly determines consistent LPG use and adoption.

Most households purchase LPG occasionally or monthly, indicating partial adoption and continued reliance on biomass. Cost and supply constraints limit regular LPG consumption. A strong majority recognize the health risks of traditional fuels, making health benefits a major driver of LPG adoption. Public health messaging can further strengthen this motivation. Most respondents agree LPG saves time compared with biomass fuels, especially benefiting women and working households. Convenience is a strong incentive for adoption. High awareness that biomass fuels harm the environment supports positive attitudes toward LPG. Environmental messaging can reinforce clean cooking transitions. Most households perceive LPG as safe, reducing a key barrier to adoption. Targeted training can address remaining safety concerns. Less than half of respondents are aware of LPG availability, limiting uptake despite willingness to pay. Improving market visibility and distribution information is essential.

Only 34% of households have received training, while most lack guidance on safe LPG use. Expanding training programs can reduce safety concerns and support sustained adoption. Less than 40% report having a gas plant nearby, with many uncertainties or lacking access. Weak or unclear infrastructure limits the reliable use of LPG and requires investment and better information. Over one-third of households live more than 3 km from LPG outlets, increasing refill costs and inconvenience. Closer distribution points would encourage more frequent and consistent use. Opinions are evenly split on affordability, showing cost remains a major barrier for many households. Subsidies and flexible payment options are critical for wider LPG adoption.

Results on the drivers of willingness to pay for cooking gas

Table 3 presents the findings on the socio-economic determinants of women's willingness to pay for cooking gas. The study identified several key factors, including affordability, household size, average household income per month, awareness of the availability of LPG,

infrastructure availability (gas plants), distance from home to the selling point between 1 km and 3 km, and frequency of purchasing cooking gas (once every month). The willingness to pay for cooking gas among women is found to be positively and significantly influenced by household size, average household income per month, awareness of the availability of LPG, infrastructure availability (gas plants), and distance from home to the selling point between 1 km and 3 km. Negative and significant influences come from factors such as affordability and the frequency of purchasing cooking gas.

Household size is positively and significantly associated with women's willingness to pay (WTP) for cooking gas at the 10% level. This implies that women from larger households (with more than eight members) are 22.8 percentage points (pp) more likely to be willing to pay for cooking gas compared with those from smaller households, holding other factors constant. Similarly, household income per month shows a positive and statistically significant relationship with WTP at the 5% level, indicating that women from households earning more than one million Tanzanian shillings monthly are 23.5 pp more likely to pay for cooking gas, reflecting the role of income capacity in adopting cleaner energy sources. Awareness of LPG availability is also positively and significantly related to WTP at the 10% level, suggesting that women who know where LPG can be accessed are 17.4 pp more likely to pay for it than those who lack such awareness. Moreover, the presence of gas plants within the community is highly significant (at the 1% level), increasing the probability of women's WTP by 22.2 pp, which underscores the importance of infrastructure in facilitating energy access. Distance to the selling point between 1 km and 3 km is positively significant at the 5% level, showing that women within this range are 24.2 pp more likely to pay for LPG than otherwise – possibly due to improved accessibility without excessive travel burden. Conversely, affordability exhibits a negative and significant effect at the 5% level, meaning that women who perceive LPG as affordable are paradoxically 11.3 pp less likely to be willing to pay than women who perceive LPG is not affordable, possibly due to expectations of subsidized prices or prior access through informal means. Finally,

Table 3. Results of the probit model of socio-economic factors influencing willingness to pay for cooking gas among women

Variable	Coefficient	SE	$P > z $	ME
Age above 50 years	0.322	0.261	0.218	0.109
Education level (university/college)	0.321	0.251	0.202	-0.106
Household size	0.622	0.375	0.098	0.228
Awareness of the availability of LPG (yes)	0.602	0.347	0.083	0.174
Household average income per month	0.657	0.271	0.015	0.235
Frequency of purchasing cooking gas (yes)	-0.448	0.264	0.090	-0.143
Time saving relative to traditional fuels (yes)	-0.283	0.341	0.407	-0.098
Perception of the negative environmental impact of using firewood/charcoal (yes)	-0.029	0.387	0.941	-0.010
Health concerns on use of traditional energy (yes)	0.574	0.408	0.159	0.163
The presence of gas plants within the community (yes)	0.651	0.253	0.010	0.222
Received training on the use of clean coking energy (yes)	0.145	0.264	0.583	0.049
Affordability of cooking gas (yes)	-0.590	0.256	0.021	-0.191
Safety in using cooking gas	0.212	0.351	0.546	0.067
Distance from home to the selling point (less than 1 km)	0.398	0.326	0.222	-0.139
Distance from home to the selling point of 2–3 km	0.719	0.315	0.023	0.242
Number of observations = 150	Wald chi ² (16) = 42.09	prob>chi ² = 0.0004	pseudo R ² = 0.2345	y = Pr(WTP) 0.271

Notes: $p < 0.10$ is significant at 10% level; $p < 0.05$ is significant at 5% level, and $p < 0.01$ is significant at 1% level. ME is marginal effect interpreted as average marginal effects (AME).

Source: author's research.

the frequency of purchasing cooking gas is negatively and significantly associated with WTP at the 10% level, indicating that women who buy gas monthly are 14.3 pp less likely to pay for it than women who do not buy gas monthly, likely due to the financial strain of frequent expenditures or limited liquidity.

DISCUSSION

The positive and significant relationship between household size and willingness to pay (WTP) for cooking gas suggests that larger families tend to have

higher energy needs and therefore place greater value on adopting LPG for cooking. Bigger households are also more likely to recognize the time and health benefits of clean energy, which leads to higher WTP than in smaller households. The finding is in line with household utility theory and studies of Bersisa et al. (2021), Onyekuru et al. (2021), Kebele et al. (2025), and Tornel-Vázquez et al. (2025). The weakness here is that the relationship may also reflect economies of scale rather than genuine preference, meaning smaller households might still adopt if other barriers, such as price, were addressed.

Higher household income increases the capacity and likelihood of paying for LPG. This aligns with the energy ladder hypothesis, which posits that as income rises, households shift from traditional fuels (such as firewood and charcoal) to cleaner alternatives, such as LPG. Thus, income directly influences affordability and preference for modern energy sources (Kulindwa et al., 2018). The findings are in line with energy ladder theory and household utility theory. Also, the findings concur with the studies of Ayodele et al. (2021), Bersisa et al. (2021), Chindarkar et al. (2021), Tornel-Vázquez et al. (2025). Household income may not capture households that prioritize traditional fuels due to cultural preferences or fuel stacking behavior, limiting the generalizability of the findings.

Awareness plays a critical role in shaping perceptions and trust in LPG as a safe, accessible, and efficient cooking fuel. Households that are well-informed about LPG availability and benefits are more willing to pay, indicating that information campaigns and public sensitization can effectively boost demand. The findings are consistent with theoretical expectations and with the studies of Chindarkar et al. (2021) and Nketiah et al. (2022). Information alone may not translate into actual adoption if financial or infrastructure constraints persist, highlighting a gap between knowledge and behavior.

The presence of gas plants within the community positively influences WTP by reducing supply barriers and ensuring reliable access to refilling services. Adequate infrastructure not only enhances convenience but also builds consumer confidence in sustained availability, encouraging adoption and higher willingness to pay. The finding is consistent with theoretical expectations and previous studies (Das et al., 2022; Dumga & Goswami, 2025). This finding may overestimate effects in regions where supply reliability is inconsistent or where transport costs still pose barriers, limiting applicability to all areas.

A moderate distance to LPG selling points (1–3 km) positively influences WTP, as it represents convenient access without excessive transportation costs or effort. However, distances beyond this range could discourage adoption due to the time and cost burdens of fuel

procurement. The finding is consistent with theoretical expectations and with previous studies of Das et al. (2022) and Dumga and Goswami (2025). However, this measure ignores other contextual factors such as road quality, transportation availability, or safety concerns, which may reduce accessibility in practice.

Affordability has a negative, significant effect on WTP, suggesting that higher LPG prices or limited financial capacity reduce women's willingness to adopt or consistently use cooking gas. This underscores the importance of targeted subsidies, flexible payment schemes, and financing options to lower cost barriers for low-income households. The finding is consistent with theoretical expectations. The measure may not account for households' access to credit, subsidies, or informal sharing arrangements, which can mitigate cost constraints and influence actual behavior.

The negative, statistically significant relationship between the frequency of purchasing cooking gas and willingness to pay (WTP) suggests that women who buy gas more frequently, such as once per month, are less willing to pay higher prices for it. This may be due to the recurring financial burden of frequent refills, which increases sensitivity to price changes and reduces disposable income available for energy expenditure. It may also reflect liquidity constraints or income instability, in which regular payments are perceived as less manageable than infrequent bulk purchases. The finding highlights the importance of promoting affordable refill options, flexible payment systems, or smaller cylinder sizes to reduce the financial strain associated with frequent purchases. The finding is based on theoretical expectations. The negative effect of frequent purchases on WTP highlights financial strain, but it may not consider differences in household storage capacity or consumption patterns, which could moderate the relationship.

Time savings relative to traditional fuels were not significant because many women may not perceive LPG as substantially reducing cooking time compared with charcoal or kerosene, especially when other household chores consume most of their daily time (Chindarkar et al., 2021; Das et al., 2022). Training

on the use of clean cooking energy was not significant because awareness and basic operational knowledge of LPG are already widespread, making additional training less influential in shaping willingness to pay (Bersisa et al., 2021; Nketiah et al., 2022).

CONCLUSIONS AND POLICY IMPLICATIONS

The study concludes that women's willingness to pay for cooking gas increases with household size, income, awareness, and accessibility to LPG infrastructure. Proximity to selling points within 1–3 km also enhances WTP. However, affordability issues and frequent gas purchases reduce it. These findings highlight the need for improved access, affordability measures, and awareness to promote wider LPG adoption. The study findings suggest several key policy implications. First, because larger households show a higher willingness to pay (WTP), policymakers could prioritize awareness-raising and promotional programs targeting smaller households to encourage broader LPG adoption. Second, the positive influence of household income highlights the need for income-enhancing initiatives, such as women's economic empowerment programs, to improve the affordability of clean cooking energy. Third, awareness of LPG availability significantly increases WTP, indicating that public campaigns and community outreach on LPG's benefits and safety are essential. Fourth, improved infrastructure – such as expanding gas plants and distribution networks – can enhance accessibility and reliability, further encouraging adoption. Fifth, shorter distances to selling points increase WTP; thus, policies should promote decentralized LPG retail outlets within 1–3 km of residential areas. Conversely, the affordability challenge underscores the importance of targeted subsidies or installment payment schemes to reduce upfront costs. Lastly, frequent purchasing discourages WTP, implying that policies encouraging larger, cost-effective cylinder refills or bulk-purchase options could enhance consistent LPG use.

LIMITATIONS OF THE STUDY AND AREA FOR FURTHER RESEARCH

Despite its contributions, this study faced several limitations. First, the sample was restricted to selected districts in Kilimanjaro, limiting the generalizability of the findings to other regions or the national level. Second, reliance on self-reported data introduces the possibility of response bias, as participants may over- or under-report their willingness to pay. Future studies should expand to other regions of Tanzania to enable comparative analysis and a broader understanding of determinants across different contexts. In-depth qualitative research is recommended to explore how cultural beliefs, norms, and household power dynamics shape willingness to pay for cooking gas. Additionally, longitudinal studies could track changes over time to assess how shifts in income levels, policy frameworks, and infrastructure development influence households' willingness to pay for cooking gas.

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NAPĘDZANIE ZMIAN W TANZANII: IDENTYFIKACJA CZYNNIKÓW DETERMINUJĄCYCH SKŁONNOŚĆ KOBIEC DO ZAPŁATY ZA GAZ DO GOTOWANIA

STRESZCZENIE

Cel: Celem badania jest identyfikacja determinantów skłonności do zapłaty za gaz do gotowania wśród kobiet zamieszkujących region Kilimandżaro w Tanzanii z zastosowaniem teorii użyteczności gospodarstwa domowego oraz koncepcji drabiny energetycznej. **Metody:** W badaniu zastosowano podejście ilościowe z użyciem przekrojowego schematu badawczego oraz metody wyceny warunkowej (CVM) w formacie skali płatności. Próba badawcza obejmowała 150 kobiet, wytypowanych w wieloetapowym procesie doboru próby w celu zapewnienia reprezentatywności badanej populacji. Wykorzystano dane pierwotne zebrane za pomocą ustrukturyzowanego kwestionariusza ankietowego. Do analizy danych zastosowano statystykę opisową oraz model probitowy. **Wyniki:** Wyniki wskazują, że skłonność do zapłaty (WTP) za gaz do gotowania wśród kobiet jest dodatnio i statystycznie istotnie determinowana przez wielkość gospodarstwa domowego, przeciętny dochód miesięczny gospodarstwa domowego, poziom świadomości dostępności skroplonego gazu ropopochodnego (LPG), obecność infrastruktury gazowej w społeczności lokalnej oraz bliskość punktów sprzedaży (w odległości 1–3 km). Jednocześnie czynniki takie jak ograniczenia dochodowe (przystępność cenowa) oraz częstotliwość zakupu gazu wywierają istotny, negatywny wpływ na WTP, co sugeruje, iż wysokie koszty oraz konieczność częstego uzupełniania zapasów ograniczają skłonność do regularnego korzystania z gazu do gotowania. **Wnioski:** Implikacje dla polityki publicznej wskazują na potrzebę rozwoju infrastruktury LPG, zwiększania poziomu świadomości, wzmacniania możliwości dochodowych gospodarstw domowych oraz wdrażania ukierunkowanych subsydiów w celu ograniczenia barier związanych z przystępnością cenową i częstotliwością zakupu.

Słowa kluczowe: skłonność do zapłaty (WTP), gaz do gotowania, kobieta, model probitowy, Tanzania