

# Public Awareness and Social Acceptance of Solar Energy as a Strategy for Reducing Energy Poverty in Tanzania

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## Abstract

This study investigates public awareness and social acceptance of solar energy as a strategy for reducing energy poverty in Tanzania, focusing on households, micro, small and medium enterprises (MSMEs), and health and education facilities. Guided by a positivist philosophy and a deductive approach, a cross-sectional survey was administered to 384 respondents. Data were analysed using descriptive statistics, cross-tabulations, Pearson correlations, multiple regression, and moderation analysis. The findings show that general awareness of solar energy is relatively high, yet practical knowledge on maintenance and financing remains limited. Awareness and acceptance vary significantly by stakeholder group, with higher levels among institutional users and MSMEs than households. Mass media is the dominant information source but exhibits the lowest conversion from awareness to adoption, while community engagement, peer referrals, and formal training achieve higher conversion rates. Regression results indicate that social acceptance, service availability, and financing options are the strongest predictors of sustained solar energy use, jointly explaining 64% of the variance. Moderation analysis reveals that reliable after-sales services and flexible financing significantly strengthen the link between awareness and sustained use, while gender-inclusive decision-making enhances acceptance and continuity at the household level. Longitudinal perceptions among adopters indicate improving attitudes over time when systems perform reliably and maintenance support is accessible. The study concludes that solar energy can meaningfully reduce energy poverty in Tanzania when deployed through people-centred, service-enabled, and gender-responsive approaches. Policy implications emphasise practical energy literacy, community-based outreach, strengthened service ecosystems, inclusive financing mechanisms, and monitoring frameworks that prioritise sustained use over installations.

**Keywords:** Solar Energy; Energy Poverty; Public Awareness; Social Acceptance; Renewable Energy Policy; Tanzania.

## I. INTRODUCTION

Energy poverty (the persistent lack of access to affordable, reliable, and modern energy services) remains one of the most enduring structural constraints to socio-economic development in many developing countries. In recent years, the global energy transition discourse has increasingly emphasized renewable energy as a dual solution for expanding energy access while addressing climate change and sustainability goals. Among renewable options, solar energy has attracted particular attention due to its decentralised nature, rapidly declining costs, and suitability for off-grid and underserved contexts (Okika *et al.*, 2025; Lyanda & Mwakitalima, 2025; Olaniyi *et al.*, 2025; Halder & Sethi, 2025; Thapa *et al.*, 2025). However, evidence from developing regions suggests that the transformative potential of solar energy is shaped not only

by technological availability, but also by social acceptance, public awareness, institutional support, and long-term user engagement.

In Tanzania, energy poverty continues to affect households, enterprises, and social institutions despite sustained reforms in the electricity sector. While grid expansion and generation capacity have increased, access remains uneven across rural, peri-urban, and island communities, where extending conventional infrastructure is often economically and technically prohibitive (Biririza, 2024; Mnzava *et al.*, 2022; Mwampashi, 2024; Poncian & Pedersen, 2023; Mpapalika & Mmari, 2023). As a result, solar energy has emerged as a central pillar in Tanzania's energy transition strategies, offering a practical pathway to decentralised electrification, enhanced energy security, and inclusive development (Okika *et al.*, 2025; Kyaruzi *et al.*, 2021; Ndaki *et al.*, 2022).

Solar energy contributes to socio-economic development and poverty reduction through multiple interrelated channels. At the household level, access to solar electricity improves lighting, communication, and indoor air quality, while reducing expenditure on traditional and polluting energy sources. At the enterprise level, solar power enables productive uses such as refrigeration, irrigation, processing, and digital services, which enhance incomes and reduce operational costs for micro, small and medium enterprises (Akter & Bari, 2022; Lyakurawa, 2023; Akinbamiwa *et al.*, n.d.). In the social sector, solar energy supports service delivery in health facilities and schools, particularly in remote areas where grid reliability remains limited (Mhando, 2022; Ferrall *et al.*, 2021). At a broader scale, solar deployment reduces dependence on fossil fuel imports, contributes to climate change mitigation, and stimulates employment and entrepreneurship in installation, maintenance, and supply chains (Olaniyi *et al.*, 2025; Mulopo, 2022; Mangwiro & Apata, 2025).

Despite these benefits, empirical evidence from Tanzania demonstrates that solar energy does not automatically translate into sustained poverty reduction. Adoption and long-term use are shaped by a complex interplay of awareness, acceptance, affordability, service availability, policy stability, and socio-cultural dynamics (Malima *et al.*, 2025; Aly *et al.*, 2019; Mandari, 2021; Mwampashi, 2024). Public awareness of solar energy has increased over time, yet studies indicate that knowledge remains uneven and often superficial, particularly regarding system performance, maintenance requirements, financing options, and long-term cost–benefit implications (Lyanda & Mwakitalima, 2025; Biririza, 2024; Mnzava *et al.*, 2022). This gap between general awareness and actionable understanding limits informed decision-making and constrains adoption among low-income users.

Social acceptance further mediates the relationship between awareness and adoption. Trust in technology providers, perceived reliability of systems, visibility of successful installations, and social norms within communities strongly influence willingness to adopt solar technologies (Standal *et al.*, 2024; Poncian & Pedersen, 2023; Ferrall *et al.*, 2021). In addition, gendered decision-making processes play a critical role at the household level. While women are often the primary users and managers of household energy, financial authority frequently rests with men, shaping adoption outcomes and the sustainability of benefits (Standal *et al.*, 2024; Lyakurawa, 2023).

Recent Tanzanian studies have contributed valuable insights into solar energy policy, market dynamics, and energy transition pathways. Okika *et al.* (2025) outline a strategic roadmap for sustainable solar electricity generation, emphasising policy coherence and institutional coordination. Lyanda and Mwakitalima (2025) review advancements in solar photovoltaic applications and highlight uneven adoption across sectors. Malima *et al.* (2025) reveal structural barriers faced by solar social enterprises serving low-income markets, including weak

consumer awareness and inadequate after-sales services. Biririza (2024) and Mwampashi (2024) further demonstrate how governance challenges and policy volatility shape energy sector outcomes in Tanzania. While these studies are critical, they tend to prioritise technical, policy, or market perspectives, often treating public awareness and social acceptance as secondary factors.

Consequently, a clear research gap emerges. There is limited empirical evidence in Tanzania that systematically examines how public awareness and social acceptance of solar energy influence adoption and sustained use across different user groups, including households, MSMEs, and health and education facilities. Moreover, few studies evaluate the comparative effectiveness of outreach channels such as mass media, community engagement, formal training, and peer referrals in converting awareness into adoption. The moderating roles of after-sales service availability, financing mechanisms, and gendered decision-making processes remain underexplored, and longitudinal evidence tracking perception and usage dynamics over time is largely absent (Biririza, 2024; Malima *et al.*, 2025; Lyanda & Mwakitalima, 2025; Ferrall *et al.*, 2021; Mwampashi, 2024).

Against this backdrop, the central research problem addressed in this study is that, despite widespread promotion of solar energy as a strategy for reducing energy poverty in Tanzania, there is insufficient stakeholder-sensitive and longitudinal evidence explaining how public awareness and social acceptance translate into sustained adoption and meaningful poverty reduction outcomes. Without such evidence, solar energy interventions risk remaining fragmented, inefficient, or short-lived, particularly among low-income and underserved populations.

In response to this problem, the general objective of this study is to examine how public awareness and social acceptance of solar energy influence its adoption and sustained use as a strategy for reducing energy poverty in Tanzania. Specifically, the study aims to: (i) measure and compare awareness levels, information sources, and acceptance across households, MSMEs, and health and education facilities in selected mainland and Zanzibar sites; (ii) evaluate which outreach channels (media, community events, formal training, and peer referrals) produce the highest conversion rates from awareness to trial and adoption; (iii) assess the moderating effect of service availability and financing options on sustained use; (iv) analyse gendered decision-making processes and social norms influencing household adoption; and (v) track perception and usage dynamics over a 12–36 month period among solar energy adopters.

The significance of this study is threefold. From a policy perspective, it provides evidence to inform more effective and inclusive solar energy strategies aligned with national energy and development goals. From a practical standpoint, the findings will assist solar developers, social enterprises, and development partners in designing

outreach, financing, and service models that better respond to user realities. Academically, the study contributes to the limited empirical literature on the social dimensions of renewable energy adoption in Tanzania by explicitly linking awareness and acceptance to energy poverty reduction outcomes using a comparative and longitudinal approach.

The remainder of this paper is organised as follows. Section Two reviews relevant theoretical and empirical literature on energy poverty, solar energy adoption, public awareness, and social acceptance. Section Three presents the research methodology. Section Four reports the study's findings in line with the stated objectives. Section Five discusses the results in relation to existing literature and policy frameworks. Section Six concludes the paper and offers recommendations for policy, practice, and future research.

## II. LITERATURE REVIEW

### A. Theoretical Review

This study is grounded in established theories of technology adoption and energy transition that emphasise the social dimensions of innovation uptake. The Diffusion of Innovations Theory explains how new technologies spread through social systems over time, highlighting the roles of awareness, perceived advantages, compatibility with user needs, and social influence. In the context of solar energy, diffusion is shaped not only by technical performance but also by trust, visibility of benefits, and institutional credibility (Okika *et al.*, 2025; Lyanda & Mwakitalima, 2025).

The Technology Acceptance Model (TAM) further explains adoption behaviour by linking usage decisions to perceived usefulness and perceived ease of use. Tanzanian studies indicate that even where solar technologies are technically viable, perceptions of cost, reliability, and maintenance complexity strongly influence acceptance (Lyakurawa, 2023; Malima *et al.*, 2025). These perceptions are shaped by awareness campaigns, prior user experiences, and the availability of after-sales services.

The Energy Justice Framework provides an additional lens by emphasising equity in access, affordability, and decision-making power. This framework is particularly relevant in Tanzania, where energy poverty intersects with rural marginalisation, gender inequality, and uneven service provision (Standal *et al.*, 2024; Biririza, 2024). Energy justice theory highlights that awareness and acceptance are not merely individual choices but are embedded in social structures, policy environments, and power relations.

In general, these theories suggest that solar energy adoption for poverty reduction depends on a progression from awareness to acceptance and sustained use, moderated by institutional support, financing, and socio-cultural factors.

### B. Empirical Review

#### ➤ Awareness, Information Sources, and Acceptance across User Groups

Empirical studies in Tanzania indicate growing awareness of solar energy, driven largely by national policy discourse, donor programmes, and market expansion. However, awareness levels vary significantly across households, MSMEs, and social institutions. Lyanda and Mwakitalima (2025) observe that while households often recognise solar panels as a lighting solution, MSMEs and institutions demonstrate higher awareness of productive-use applications. Biririza (2024) similarly notes that institutional users benefit from structured procurement and technical guidance, leading to higher acceptance levels.

Despite widespread awareness, depth of knowledge remains uneven. Mnzava *et al.* (2022) and Malima *et al.* (2025) report that limited understanding of system capacity, maintenance requirements, and long-term costs constrains informed adoption decisions, particularly among low-income households.

#### ➤ Effectiveness of Outreach Channels

Outreach mechanisms play a critical role in converting awareness into adoption. Evidence from Tanzania suggests that mass media is effective in creating general awareness but less effective in promoting adoption on its own. Community-based engagement, demonstrations, and peer referrals have been shown to generate higher trust and conversion rates (Mangwiro & Apata, 2025; Ferrall *et al.*, 2021). Formal training programmes are particularly effective for MSMEs and institutional users who require technical confidence to integrate solar energy into operations (Mhando, 2022).

#### ➤ Moderating Role of Services and Financing

After-sales service availability and financing options significantly influence sustained use of solar technologies. Malima *et al.* (2025) identify weak maintenance networks and delayed repairs as major barriers undermining long-term acceptance in Tanzania's base-of-the-pyramid solar markets. Financing constraints, including high upfront costs and limited access to credit, further restrict adoption among households and MSMEs (Lyakurawa, 2023; Mandari, 2021). Studies consistently show that instalment-based payment models and subsidies enhance both uptake and continued use (Okika *et al.*, 2025).

#### ➤ Gendered Decision-Making and Social Norms

Gender dynamics are increasingly recognised as central to energy adoption outcomes. Standal *et al.* (2024) demonstrate that women often bear the burden of energy poverty yet have limited influence over investment decisions. In Tanzania, household adoption of solar energy is frequently shaped by male-dominated financial decision-making, even when women manage day-to-day energy use (Biririza, 2024; Lyakurawa, 2023). Where women participate in decision-making, acceptance and sustained use tend to be higher.

### ➤ *Longitudinal Perception and Usage Dynamics*

Most Tanzanian studies adopt cross-sectional designs, offering limited insight into how perceptions evolve over time. However, available evidence suggests that user satisfaction and trust increase with reliable system performance and accessible services, while negative maintenance experiences lead to declining use (Malima *et al.*, 2025; Mwampashi, 2024). The absence of longitudinal studies remains a critical limitation in understanding sustained poverty-reduction impacts.

### *C. Research and Knowledge Gap*

The reviewed literature reveals several interrelated gaps. First, few Tanzanian studies systematically compare awareness and acceptance across households, MSMEs, and social institutions within a single analytical framework (Biririza, 2024; Lyanda & Mwakitalima, 2025). Second, there is limited empirical evaluation of which outreach channels most effectively convert awareness into adoption (Mangwiro & Apata, 2025; Ferrall *et al.*, 2021). Third, the moderating effects of after-sales services and financing mechanisms on sustained use remain underexplored (Malima *et al.*, 2025; Mandari, 2021). Fourth, gendered decision-making processes are acknowledged but insufficiently analysed empirically (Standal *et al.*, 2024). Finally, there is a notable lack of longitudinal evidence tracking perception and usage dynamics over time (Mwampashi, 2024).

### *D. Conceptual Framework*

Grounded in the theoretical and empirical review, this study adopts a conceptual framework in which public awareness of solar energy shaped by information sources and outreach channels acts as a foundational driver of social acceptance. Acceptance, in turn, influences trial and adoption of solar technologies. The relationship between acceptance and sustained use is moderated by service availability (after-sales and maintenance) and financing options, which determine system reliability and affordability over time.

Gendered decision-making processes and social norms intersect with all stages of the framework, influencing awareness access, acceptance, and final adoption decisions, particularly at the household level. Sustained use of solar energy contributes to energy poverty reduction outcomes, including improved household welfare, productive use, and enhanced service delivery in health and education facilities.

This framework reflects a dynamic, socially embedded process rather than a linear adoption pathway, recognising that solar energy's contribution to poverty reduction in Tanzania depends on both technological and socio-institutional conditions.

## **III. METHODOLOGY**

### *A. Research Philosophy*

This study is grounded in the positivist research philosophy, which assumes that social phenomena can be objectively observed, measured, and analysed through

empirical investigation. Positivism is appropriate for this study because public awareness, acceptance, and adoption of solar energy can be quantified and examined using measurable indicators such as knowledge levels, attitudes, usage patterns, and service access. The positivist stance allows for systematic testing of relationships between variables and supports generalisation of findings across different stakeholder groups and geographic contexts within Tanzania (Biririza, 2024; Lyanda & Mwakitalima, 2025). By adopting this philosophy, the study seeks to produce evidence-based conclusions that can inform policy and practice in energy poverty reduction.

### *B. Research Approach*

The study adopts a quantitative and deductive research approach. The deductive approach is used to test theoretically and empirically grounded assumptions regarding the relationships between public awareness, social acceptance, outreach channels, service availability, financing options, and sustained solar energy use. These assumptions are derived from established technology adoption and energy transition literature and are empirically examined within the Tanzanian context (Malima *et al.*, 2025; Okika *et al.*, 2025). A quantitative approach is appropriate because the study aims to measure patterns, compare groups, and examine relationships among variables using numerical data collected from a large sample.

### *C. Research Design*

The study employs a descriptive and explanatory cross-sectional survey design. The descriptive component enables the measurement and comparison of awareness levels, information sources, and acceptance of solar energy across households, micro, small and medium enterprises (MSMEs), and health and education facilities. The explanatory component examines how awareness and acceptance influence adoption and sustained use, as well as the moderating effects of service availability, financing options, and gendered decision-making processes. A cross-sectional design is suitable given the need to capture current perceptions and behaviours across diverse user groups at a specific point in time, consistent with previous renewable energy studies in Tanzania (Ferrall *et al.*, 2021; Mnzava *et al.*, 2022).

### *D. Area of the Study*

The study was conducted in selected mainland and Zanzibar locations in Tanzania, chosen deliberately to reflect the research problem and identified gaps. The selected areas include rural, peri-urban, and island contexts where energy poverty remains pronounced and where solar energy interventions have been actively promoted. These areas were selected to capture variation in infrastructure access, market maturity, and socio-cultural dynamics, which previous studies identify as critical factors shaping solar energy adoption outcomes (Biririza, 2024; Mwampashi, 2024; Lyanda & Mwakitalima, 2025). The inclusion of Zanzibar is particularly relevant due to its distinct energy governance arrangements and reliance on decentralized renewable energy solutions.

### E. Population of the Study

The target population comprised three key stakeholder groups: households using or exposed to solar energy technologies; Micro, small and medium enterprises (MSMEs) operating in sectors such as manufacturing, services, and agro-processing; and health and education facilities utilizing or considering solar energy solutions. These groups were selected because they represent the primary beneficiaries of solar energy in energy-poor contexts and are central to poverty reduction pathways identified in Tanzanian energy transition studies (Mhando, 2022; Malima *et al.*, 2025; Lyakurawa, 2023).

### F. Sample Size Determination

Given that the exact population size of solar-exposed users across the selected areas was unknown, the sample size was determined using Cochran's (1977) formula for an unknown population. Accordingly, a minimum sample size of 384 respondents was considered adequate to ensure statistical reliability and representativeness.

$$n = \frac{Z^2 \times p \times q}{e^2}$$

Where:

- $n$  = sample size

- $Z$  = Z-value at 95% confidence level (1.96)
- $P$  = estimated proportion of the population (0.5)
- $q = 1 - p$  (0.5)

Substituting the values:

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384$$

### G. Sampling Techniques

A hybrid sampling strategy was employed to balance representativeness and feasibility i.e. purposive sampling was used to select study areas and institutions with known exposure to solar energy initiatives. Stratified sampling was applied to categorise respondents into households, MSMEs, and health and education facilities, ensuring proportional representation of each group. Convenience sampling was used at the final stage to select individual respondents within each stratum, particularly where comprehensive sampling frames were unavailable, a common challenge in energy access studies in Tanzania (Ferrall *et al.*, 2021; Mandari, 2021).

### H. Measurement of Variables

Table 1 presents the study variables, measurement indicators, measurement scales, and sources.

Table 1 Measurement of Variables

Variable	Measurement Indicators	Measurement Scale	Source
Public awareness	Knowledge of solar technology, information sources, understanding of benefits	Likert (1–5)	Lyanda & Mwakitalima (2025); Biririza (2024)
Social acceptance	Attitudes, trust, perceived usefulness	Likert (1–5)	Malima <i>et al.</i> (2025); Ferrall <i>et al.</i> (2021)
Outreach channels	Media exposure, community engagement, training, peer referrals	Nominal / Likert	Mangwiro & Apata (2025)
Service availability	Access to maintenance, after-sales support	Likert (1–5)	Malima <i>et al.</i> (2025)
Financing options	Affordability, credit access, payment flexibility	Likert (1–5)	Mandari (2021); Okika <i>et al.</i> (2025)
Gendered decision-making	Household decision authority, participation	Likert (1–5)	Standal <i>et al.</i> (2024)
Sustained use	Duration of use, reliability, satisfaction	Likert (1–5)	Mwampashi (2024)

### I. Data Collection Methods and Instruments

Primary data were collected using structured questionnaires administered to respondents across the three stakeholder groups. The questionnaire comprised closed-ended questions measured on Likert scales to ensure consistency and facilitate quantitative analysis. Data were collected through face-to-face interviews and self-administered questionnaires, depending on respondent literacy and accessibility. This mixed administration approach enhanced response rates and data quality in line with best practices in Tanzanian field research (Mnzava *et al.*, 2022).

### J. Validity and Reliability

To ensure content validity, questionnaire items were derived from established empirical studies and aligned with the study objectives. Face validity was assessed

through expert review by energy and research methodology specialists. A pilot study was conducted to refine wording and structure.

Reliability was assessed using Cronbach's alpha, with a threshold of 0.70 considered acceptable for internal consistency. Constructs that did not meet the threshold were revised prior to full-scale data collection.

### K. Data Analysis

Data were analysed using Descriptive Statistics and Inferential Analysis with the aid of IBM SPSS version 28. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarise awareness and acceptance levels. Inferential analysis, including correlation and multiple regression analysis, was employed to examine relationships among variables and

test moderating effects of service availability, financing, and gendered decision-making. Cross-tabulation was used to compare stakeholder groups.

#### L. Ethical Considerations

Ethical principles were strictly observed throughout the study. Ethical clearance was obtained from the relevant institutional authority. Respondents were informed of the study's purpose and provided informed consent prior to participation. Confidentiality and anonymity were ensured by excluding personal identifiers from data files. Participation was voluntary, and respondents were free to withdraw at any stage without penalty.

## IV. PRESENTATION OF RESULTS

### A. Demographic Profile of Respondents

The study involved 384 respondents drawn from households, micro, small and medium enterprises

(MSMEs), and health and education facilities in selected mainland and Zanzibar sites. Of the respondents, 58.1% were male and 41.9% female, reflecting relatively balanced gender participation. Most respondents were economically active adults, with 57.3% aged between 31 and 50 years, an age group typically responsible for household and enterprise-level investment decisions.

Households constituted 51.6% of the sample, followed by MSMEs (30.2%) and health and education facilities (18.2%). In terms of education, over three-quarters of respondents had attained at least secondary education, suggesting adequate literacy for engagement with energy technologies. This demographic distribution supports meaningful comparison across stakeholder groups and aligns with prior Tanzanian energy studies focusing on productive and social energy use.

Table 2 Demographic Characteristics of Respondents (n = 384)

Variable	Category	Frequency	Percentage (%)
Gender	Male	223	58.1
	Female	161	41.9
Age group (years)	18–30	96	25.0
	31–40	124	32.3
	41–50	98	25.5
	Above 50	66	17.2
Respondent category	Households	198	51.6
	MSMEs	116	30.2
	Health & education facilities	70	18.2
Education level	Primary	87	22.7
	Secondary	168	43.8
	Tertiary	129	33.6

### B. Awareness, Information Sources, and Social Acceptance of Solar Energy

Descriptive analysis indicates that general awareness of solar energy is relatively high ( $M = 3.89$ ,  $SD = 0.91$ ). Respondents were generally familiar with solar technology as a source of lighting and electricity. However, awareness declined when assessed in terms of practical knowledge, particularly regarding maintenance requirements ( $M = 3.21$ ,  $SD = 1.05$ ) and financing options ( $M = 2.98$ ,  $SD = 1.08$ ). This suggests that awareness in Tanzania is often conceptual rather than operational, limiting informed adoption decisions.

Mass media (radio, television, and newspapers) emerged as the dominant source of information (40.1%), followed by peer referrals (19.3%) and community

meetings (18.5%). Formal training and workshops accounted for 15.4% of information dissemination, while government and NGO programmes were the least cited source. Although mass media plays a crucial role in awareness creation, its dominance also reflects a reliance on passive information channels.

Social acceptance of solar energy was generally positive. Respondents expressed favourable attitudes toward solar energy ( $M = 4.02$ ,  $SD = 0.88$ ) and a high willingness to adopt or continue using solar technologies ( $M = 3.81$ ,  $SD = 0.90$ ). However, trust in solar technology and providers was comparatively lower ( $M = 3.67$ ,  $SD = 0.94$ ), indicating lingering concerns about reliability, quality, and service support.

Table 3 Awareness of Solar Energy Technologies

Awareness indicator	Mean	Standard Deviation
General awareness of solar energy	3.89	0.91
Knowledge of solar energy benefits	3.76	0.97
Understanding of maintenance needs	3.21	1.05
Awareness of financing options	2.98	1.08

Table 4 Sources of Solar Energy Information

Source	Frequency	Percentage (%)
Mass media (radio, TV, newspapers)	154	40.1
Peer referrals (friends/family)	74	19.3
Community meetings/events	71	18.5
Formal training/workshops	59	15.4
Government/NGO programmes	26	6.8

Table 5 Social Acceptance of Solar Energy

Acceptance indicator	Mean	Standard Deviation
Positive attitude toward solar energy	4.02	0.88
Trust in solar technology/providers	3.67	0.94
Willingness to adopt or continue use	3.81	0.90

### C. Stakeholder Comparison: Cross-Tabulation Analysis

Cross-tabulation analysis was conducted to compare awareness and adoption across stakeholder groups. The results reveal clear structural differences. Health and education facilities reported the highest levels of awareness (68.6%) and adoption (72.9%), followed by MSMEs (55.2% awareness; 61.2% adoption). Households recorded the lowest awareness (41.4%) and adoption rates (46.0%).

These differences reflect varying access to institutional support, financing arrangements, and technical guidance. Institutional users and MSMEs often benefit from organised procurement processes and targeted programmes, while households face greater financial and informational constraints. The findings underscore that solar energy adoption and its poverty-reduction potential is unevenly distributed and strongly shaped by user context.

Table 6 Awareness and Adoption by Stakeholder Group

Stakeholder group	High awareness (%)	Moderate awareness (%)	Low awareness (%)	Adoption rate (%)
Households	41.4	38.9	19.7	46.0
MSMEs	55.2	31.9	12.9	61.2
Health & education facilities	68.6	24.3	7.1	72.9

### D. Outreach Channels and Conversion from Awareness to Adoption

To assess the effectiveness of outreach channels, conversion rates from awareness to adoption were analysed. While mass media successfully reached a broad audience, it recorded the lowest conversion rate (42%). In contrast, formal training (64%), peer referrals (61%), and community engagement (58%) demonstrated substantially higher conversion rates.

These results highlight that interactive and trust-based outreach mechanisms are more effective in translating awareness into actual adoption. Community demonstrations and peer experiences reduce perceived risk and provide practical knowledge, which is particularly important in low-income and risk-averse settings.

Table 7 Outreach Channels and Conversion Rates

Outreach channel	Awareness (%)	Adoption (%)	Conversion rate (%)
Mass media	100	42	42.0
Community engagement	100	58	58.0
Formal training	100	64	64.0
Peer referrals	100	61	61.0

### E. Relationships among Key Variables: Correlation Analysis

Pearson correlation analysis revealed statistically significant positive relationships among all key variables ( $p < .01$ ). Public awareness was strongly correlated with social acceptance ( $r = .642$ ) and sustained use ( $r = .512$ ). Social acceptance showed the strongest relationship with sustained use ( $r = .674$ ), followed closely by service availability ( $r = .652$ ) and financing options ( $r = .611$ ).

These results confirm that while awareness is important, acceptance, services, and affordability are more decisive for long-term use, reinforcing the argument that solar energy adoption is a socially and institutionally embedded process.

Table 8 Pearson Correlation Matrix (n = 384)

Variable	1	2	3	4	5	6	7
1. Public awareness	1						
2. Social acceptance	.642**	1					
3. Outreach exposure	.518**	.491**	1				
4. Service availability	.437**	.603**	.402**	1			
5. Financing options	.461**	.587**	.398**	.512**	1		
6. Gender-inclusive decision-making	.355**	.468**	.327**	.441**	.389**	1	
7. Sustained use	.512**	.674**	.489**	.652**	.611**	.458**	1

#### F. Determinants of Sustained Solar Energy Use: Multiple Regression Results

Multiple regression analysis was conducted to identify predictors of sustained solar energy use. The model explained 64% of the variance ( $R^2 = .64$ ), indicating strong explanatory power. Social acceptance emerged as the most influential predictor ( $\beta = .294$ ,  $p < .001$ ), followed by service availability ( $\beta = .241$ ,  $p < .001$ ) and financing options ( $\beta = .219$ ,  $p < .001$ ). Public awareness, outreach

channels, and gendered decision-making were also significant predictors, though with smaller effect sizes.

These findings suggest that positive attitudes toward solar energy must be supported by reliable services and accessible financing to achieve sustained use. Awareness alone, while necessary, is insufficient to guarantee long-term adoption.

Table 9 Multiple Regression Results

Predictor	$\beta$	Std. Error	t	p-value
Public awareness	.168	.041	4.10	.000
Social acceptance	.294	.039	7.54	.000
Outreach channels	.132	.036	3.67	.001
Service availability	.241	.038	6.34	.000
Financing options	.219	.040	5.48	.000
Gendered decision-making	.117	.034	3.44	.001
<b>R<sup>2</sup></b>	<b>0.64</b>			

#### G. Moderating Effects of Services, Financing, and Gendered Decision-Making

Moderation analysis further revealed that service availability significantly strengthens the relationship between awareness and sustained use ( $\beta = .143$ ,  $p = .002$ ). This indicates that awareness translates into continued use only when users have access to maintenance and after-sales support.

Similarly, financing options moderated the awareness–use relationship ( $\beta = .158$ ,  $p = .001$ ). Respondents with access to instalment payments or credit facilities were more likely to sustain solar use, particularly among households and MSMEs.

Gender-inclusive decision-making also played a significant moderating role. The interaction between social acceptance and joint household decision-making was positive and significant ( $\beta = .121$ ,  $p = .004$ ), demonstrating that households where women participate in energy investment decisions experience higher acceptance and sustained use. This finding is particularly relevant in the Tanzanian context, where women are primary energy users but often lack decision-making authority.

#### ➤ Moderating Effect of Service Availability

Table 10 Moderation by Service Availability

Interaction term	$\beta$	p-value
Awareness $\times$ Service availability	.143	.002

#### ➤ Moderating Effect of Financing Options

Table 11 Moderation by Financing Options

Interaction term	$\beta$	p-value
Awareness $\times$ Financing options	.158	.001

#### H. Longitudinal Perception and Usage Dynamics

Among respondents who had used solar systems for more than one year, 62.1% reported improved perceptions over time, while 26.4% reported no significant change. Only 11.5% experienced a decline in perception, mainly due to unresolved maintenance issues and unmet performance expectations. This reinforces the importance of post-installation support in sustaining positive user experiences and long-term poverty-reduction benefits.



Table 12 Perception Changes among Long-Term Users

Perception change	Frequency	Percentage (%)
Improved perception	167	62.1
No change	71	26.4
Declined perception	31	11.5

## V. DISCUSSION OF THE FINDINGS

Generally, the results confirm that solar energy adoption in Tanzania is not merely a technical process but a socially embedded transition shaped by outreach quality, service ecosystems, financing structures, and household decision-making norms (Biririza, 2024; Okika *et al.*, 2025; Lyanda & Mwakitalima, 2025; Malima *et al.*, 2025; Mwampashi, 2024).

### A. Awareness, Information Sources, and Acceptance across Stakeholder Groups

The findings show that general awareness of solar energy is relatively high across the study areas, reflecting sustained national policy attention and market penetration. However, this awareness remains uneven in depth, particularly with respect to maintenance requirements and financing options. Similar patterns have been reported in national and sectoral reviews, which note that awareness campaigns in Tanzania have largely focused on promoting visibility of solar technologies rather than building user capacity for informed decision-making (Lyanda & Mwakitalima, 2025; Biririza, 2024; Mnzava *et al.*, 2022; Okika *et al.*, 2025; Mandari, 2021).

Cross-tabulation results further indicate that health and education facilities and MSMEs demonstrate higher awareness and acceptance levels than households. This reflects differences in institutional capacity, access to structured information, and exposure to formal energy planning processes. Studies on renewable energy transitions in Tanzania consistently show that institutional users benefit from clearer procurement frameworks, technical guidance, and external financing support, which enhance both confidence and uptake (Mhando, 2022; Ferrall *et al.*, 2021; Biririza, 2024; Poncian & Pedersen, 2023; Lyakurawa, 2023). In contrast, households particularly those experiencing energy poverty face compounded informational and financial barriers, limiting acceptance even when awareness exists. This reinforces the argument that energy poverty is as much a governance and institutional challenge as it is a technological one (Mwampashi, 2024; Olaniyi *et al.*, 2025).

### B. Outreach Channels and Conversion from Awareness to Adoption

A key contribution of this study lies in demonstrating that outreach channels differ substantially in their ability to convert awareness into adoption. Although mass media remains the dominant source of information, it produces the lowest conversion rate. In contrast, formal training, peer referrals, and community engagement yield significantly higher adoption outcomes. These findings are consistent with Tanzanian and regional evidence emphasising trust, demonstration effects, and social learning as central to renewable energy uptake (Mangwiro

& Apata, 2025; Ferrall *et al.*, 2021; Malima *et al.*, 2025; Biririza, 2024; Okika *et al.*, 2025).

The results suggest that passive information dissemination is insufficient in contexts characterised by risk aversion and capital constraints. Community-based and peer-led outreach mechanisms reduce uncertainty, allow users to observe real-world performance, and facilitate experiential learning. This aligns with broader analyses of solar energy markets serving low-income populations, which caution against overreliance on mass communication without complementary local engagement (Lyanda & Mwakitalima, 2025; Aly *et al.*, 2019; Olaniyi *et al.*, 2025).

### C. Role of Service Availability and Financing in Sustained Use

The regression and moderation analyses clearly demonstrate that after-sales services and financing options are decisive factors in sustaining solar energy use. Service availability not only directly influences continued usage but also significantly moderates the relationship between awareness and sustained adoption. This finding strongly supports evidence from Malima *et al.* (2025), who document how inadequate maintenance networks and delayed repairs undermine trust in solar providers serving Tanzania's base-of-the-pyramid markets.

Similarly, studies examining Tanzania's broader energy transition highlight institutional fragmentation and weak service ecosystems as persistent barriers to renewable energy sustainability (Mwampashi, 2024; Biririza, 2024; Aly *et al.*, 2019; Poncian & Pedersen, 2023). Without reliable post-installation support, initial adoption risks deteriorating into disuse, thereby limiting long-term poverty-reduction benefits.

Financing options also emerge as a critical moderating factor. Respondents with access to instalment payments, credit schemes, or flexible financing were significantly more likely to sustain solar energy use. This aligns with policy-oriented analyses that identify affordability rather than willingness as the principal constraint facing energy-poor households and MSMEs in Tanzania (Mandari, 2021; Okika *et al.*, 2025; Mnzava *et al.*, 2022; Olaniyi *et al.*, 2025; Lyakurawa, 2023). Together, these findings underscore that solar energy markets must be embedded within supportive financial and service infrastructures to achieve durable impacts.

### D. Gendered Decision-Making and Social Norms

The study provides robust empirical evidence that gendered decision-making processes significantly influence solar energy adoption and sustained use at the household level. While women are often the primary users and managers of household energy, investment decisions

are frequently dominated by men. The moderation results show that households characterised by joint or gender-inclusive decision-making exhibit higher acceptance and more sustained use of solar systems.

This finding is consistent with energy justice and gender-focused studies in Tanzania, which argue that excluding women from energy decisions undermines both equity and effectiveness of energy interventions (Standal *et al.*, 2024; Biririza, 2024; Ferrall *et al.*, 2021; Mpapalika & Mmari, 2023; Olaniyi *et al.*, 2025). By quantitatively demonstrating the moderating role of gender inclusion, this study strengthens the empirical case for integrating gender-responsive approaches into solar energy programmes aimed at reducing energy poverty.

#### *E. Perception and Usage Dynamics over Time*

The longitudinal findings reveal that perceptions of solar energy generally improve over time when systems perform reliably and users have access to maintenance support. Conversely, unresolved technical problems and unmet expectations lead to declining perceptions and, in some cases, abandonment of systems. This dynamic highlights the importance of evaluating renewable energy interventions beyond initial adoption metrics.

Previous studies have noted the scarcity of longitudinal evidence in Tanzania's energy sector, with most analyses relying on cross-sectional snapshots (Mwampashi, 2024; Biririza, 2024; Lyanda & Mwakitalima, 2025). The present findings provide empirical support for calls to track user experiences over time, emphasising that sustained use not installation alone is the appropriate benchmark for assessing energy poverty reduction outcomes (Malima *et al.*, 2025; Okika *et al.*, 2025).

#### *F. Integrated Implications for Energy Poverty Reduction*

Taken together, the findings demonstrate that solar energy has significant potential to reduce energy poverty in Tanzania, but only when deployed within an enabling social and institutional environment. Awareness initiates interest, acceptance shapes intention, and sustained use depends on service reliability, financing accessibility, and inclusive decision-making structures. These results reinforce national and regional critiques of technology-centric energy policies and support calls for people-centred, systems-oriented solar energy strategies (Okika *et al.*, 2025; Biririza, 2024; Olaniyi *et al.*, 2025; Malima *et al.*, 2025; Mwampashi, 2024).

## **VI. CONCLUSION AND POLICY RECOMMENDATIONS**

### *A. Conclusion*

This study examined public awareness and social acceptance of solar energy as a strategy for reducing energy poverty in Tanzania, with particular attention to households, micro, small and medium enterprises (MSMEs), and health and education facilities across selected mainland and Zanzibar sites. By integrating descriptive statistics, cross-tabulation, correlation

analysis, multiple regression, and moderation analysis, the study provides robust empirical evidence on the social and institutional conditions under which solar energy delivers sustained poverty-reduction benefits.

The findings demonstrate that general awareness of solar energy in Tanzania is relatively high, reflecting sustained policy attention and market expansion. However, this awareness is often shallow and uneven, especially with regard to practical knowledge on maintenance, financing, and long-term system performance. As a result, awareness alone does not reliably translate into adoption or sustained use. Instead, social acceptance, trust, and perceived reliability emerge as decisive factors shaping long-term outcomes.

Comparative analysis across stakeholder groups reveals that health and education facilities and MSMEs outperform households in both awareness and adoption. This reflects differences in institutional support, access to structured information, financing mechanisms, and technical assistance. Households particularly those experiencing energy poverty remain constrained by affordability concerns, risk aversion, and limited service access, underscoring the need for differentiated, stakeholder-specific intervention strategies.

The study further establishes that outreach quality matters more than outreach reach. While mass media plays a critical role in creating general awareness, interactive and trust-based channels such as community engagement, formal training, and peer referrals are significantly more effective in converting awareness into adoption. These findings challenge technology-centric and media-heavy awareness strategies and point to the importance of social learning and demonstration effects in low-income contexts.

Crucially, the results confirm that service availability and financing options are not peripheral but central to sustained solar energy use. After-sales services and maintenance infrastructure significantly moderate the relationship between awareness and continued use, while flexible financing mechanisms strengthen the pathway from acceptance to long-term adoption. Without these enabling conditions, solar energy interventions risk producing short-lived or abandoned installations.

The study also provides strong empirical evidence that gendered decision-making processes shape solar energy outcomes. Households characterised by joint or gender-inclusive decision-making exhibit higher acceptance and sustained use of solar technologies, highlighting the importance of integrating gender considerations into energy poverty reduction strategies.

Generally, the findings affirm that solar energy can play a transformative role in reducing energy poverty in Tanzania but only when embedded within people-centred, institutionally supported, and socially inclusive systems. Energy poverty reduction is therefore not simply a matter

of technology deployment, but a broader governance and development challenge.

### B. Policy Recommendations

Based on the empirical findings and their implications, the following policy recommendations are proposed to enhance the contribution of solar energy to energy poverty reduction in Tanzania:

#### ➤ Reorient Awareness Campaigns toward Practical Energy Literacy

Government agencies, development partners, and solar market actors should move beyond visibility-focused awareness campaigns and invest in practical energy literacy programmes. These should emphasise system sizing, maintenance requirements, financing options, and realistic performance expectations. Community-level demonstrations and user education initiatives should be prioritised, particularly in rural and peri-urban areas.

#### ➤ Prioritise Interactive and Community-Based Outreach Models

Energy policies and programmes should formally recognise and support community engagement, peer learning, and formal training as core outreach mechanisms. Incentives can be provided to solar enterprises and local governments that integrate demonstration projects, peer ambassadors, and participatory training into their deployment strategies.

#### ➤ Strengthen After-Sales Service and Maintenance Ecosystems

To ensure sustained use, policymakers should support the development of local maintenance and after-sales service networks, particularly in underserved regions. This may include certification of technicians, service performance standards, and integration of maintenance requirements into solar procurement and subsidy schemes.

#### ➤ Expand Inclusive and Flexible Financing Mechanisms

Financial institutions, regulators, and development partners should scale up affordable and flexible financing models, including instalment payments, pay-as-you-go systems, and targeted subsidies for low-income households and MSMEs. Financing schemes should be explicitly linked to service provision to reduce system failure risks and build long-term user confidence.

#### ➤ Integrate Gender-Responsive Approaches into Energy Policy

Energy poverty reduction strategies should explicitly incorporate gender-inclusive decision-making frameworks. This includes designing outreach programmes that target both men and women, supporting women's participation in energy governance, and recognising women as key stakeholders rather than passive beneficiaries of solar interventions.

#### ➤ Adopt Monitoring Frameworks that Emphasise Sustained Use

Finally, national and local energy programmes should move beyond installation-based metrics and adopt monitoring and evaluation frameworks that track sustained use, user satisfaction, and long-term socio-economic impacts. Longitudinal assessment should become standard practice in evaluating the success of solar energy interventions.

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