

The role of Government and Non-Governmental Actors in the Adoption of Improved Cooking Stoves in Rural Households: A Case of Kisarawe District, Coastal Region, Tanzania

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Abstract

Traditional cooking stoves that burn biomass fuels have significant negative impacts on both the environment and human health. Globally, over 50% of the population, especially in developing countries, depends on biomass fuels for cooking, heating, and lighting. To address these challenges, governments and non-governmental organizations (NGOs) have intensified efforts to promote Improved Cooking Stoves (ICS) and clean cooking technologies, which offer benefits such as reduced indoor air pollution and environmental preservation. However, despite these initiatives, ICS adoption remains low, particularly in rural areas. This study examines the roles of government and non-governmental actors in facilitating the adoption of ICS in Kisarawe District. Using a cross-sectional design, data were collected from 166 household respondents and 13 key informants through interviews, two focus group discussions, and direct observations. Quantitative data were analysed using SPSS version 29, while qualitative data were examined through thematic analysis. Findings reveal that while governmental and non-governmental actors actively facilitate capacity building, stove production, and awareness, only 46% of households have adopted ICS, with the majority still relying on traditional stoves. Factors driving adoption include family size, education level, and income source; smaller households, those with higher education, and those engaged in business or formal employment are more likely to adopt ICS. The study recommends that governments and NGOs continue to foster a supportive environment by developing relevant policies, providing technical assistance, subsidizing raw material costs, and investing in research to enhance ICS adoption. Additionally, targeted training and awareness campaigns in rural communities should empha-

size the health, economic, and environmental benefits of ICS to shift perceptions and encourage broader acceptance. Strengthening these efforts can accelerate the transition to cleaner cooking technologies and improve community well-being.

Keywords

Improved Cooking Stoves, Adoption, Government and Non-Governmental Actors, Rural Households

1. Introduction

More than 50% of the global population relies on traditional biomass fuels and stove technologies for essential needs such as lighting, heating, and cooking (Lusambo, 2016). In Tanzania, this dependency is even more pronounced, with 95% of the population using biomass fuels like firewood and charcoal as their primary energy source (Mhache, 2021). However, burning solid biomass fuels in traditional stoves releases harmful pollutants that contribute to severe health issues and accelerate climate change (Tebagulwa & Coimbra, 2015). Exposure to indoor cooking smoke from biomass fuels is estimated to cause over two million deaths annually, disproportionately affecting low- and middle-income countries (Ahmad et al., 2022). Furthermore, the continued use of raw biomass fuels exacerbates the impacts of climate change, and with projected population growth, environmental challenges are expected to intensify. This situation underscores the urgent need for cleaner and more sustainable cooking solutions (Jeuland et al., 2015; Barnes et al., 1994).

In response to these environmental and public health challenges, governments, donors, NGOs, and the private sector have initiated various programs to promote the adoption of Improved Cook Stoves (ICS) in developing countries (Puzzolo et al., 2016). Since the 1980s, ICS dissemination programs have aimed to reduce deforestation, improve household income, and mitigate health risks associated with indoor air pollution (Abdalla & Makame, 2017). ICS have also been recognized for their potential to address both local and global climate issues by reducing emissions and deforestation while improving health outcomes (Roy et al., 2018). These programs often include stove financing and education initiatives across Africa, Asia, and Latin America to encourage broader ICS distribution and adoption (Tebagulwa & Coimbra, 2015).

Despite these global efforts, the adoption of ICS in developing countries, particularly in rural areas, remains relatively low. Challenges related to dissemination, diffusion, and implementation continue to hinder widespread adoption, despite strong scientific evidence supporting the benefits of ICS (Lewis & Pattanayak, 2012; Okuthe, 2014). By the 1980s, only a few countries had achieved notable success in promoting ICS. For example, in Sri Lanka, over 3 million people

had adopted ICS by 1991, driven by government and NGO efforts and exposure to international experiences. Similarly, about 30–40% of Kenyan households had adopted ICS, positioning Kenya as a leader in Africa (Puzzolo et al., 2013). In contrast, only 25% of rural households in Tanzania use improved stoves (Kulindwa et al., 2018).

Several studies have examined the use of biomass energy and the adoption of improved cookstoves. However, most research has focused on individual decision-making models (Beltramo et al., 2015) or on factors such as age, community interaction, income, and cultural beliefs that limit ICS adoption (Odongo, 2017). Other studies have explored adoption strategies, challenges, and benefits (Maes & Verbist, 2012; Massawe et al., 2015). While the factors influencing ICS adoption at the household level are well-documented, less attention has been paid to the roles of external actors, both governmental and non-governmental, in driving adoption.

Although research by Jeuland et al. (2015) in India and by Karanja and Gasparatos (2020) in Kenya explored strategies and impacts of ICS adoption, they did not fully examine the critical role of government and non-governmental actors in this process. Therefore, this study aims to assess the roles of these actors in facilitating ICS adoption in rural areas, focusing on the Kisarawe district in Tanzania. The findings will provide valuable insights for policymakers and program leaders, helping to identify best practices and effective strategies for promoting ICS adoption in rural settings. By considering the specific needs and cultural contexts of rural communities, this research will contribute to more effective policy design and interventions for sustainable natural resource use and environmental management.

2. Materials and Methods

2.1. Research Approach

To understand the roles of government and non-government actors in promoting Improved Cooking Stoves (ICS), several key theories provide valuable insights: Energy Stacking (Masera et al., 2000; Ruiz-Mercado et al., 2011), Diffusion of Innovation (Rogers, 2003; Karakara & Osabuohien, 2021), and Targeted Subsidization (Gill-Wiehl et al., 2021; Puzzolo et al., 2016). The Energy Stacking theory explains that households often use multiple types of stoves and fuels simultaneously rather than switching entirely to a single option (Jewitt et al., 2020; Shankar et al., 2020). In this study, ICS adoption is defined as household ownership and operational utilization of an improved cooking stove within a 30-day recall period (Quinn et al., 2018; Rosenthal et al., 2018). Households using an ICS alongside a three-stone fire were classified as practising stove stacking; occasional ICS use was recorded separately and not categorized as full adoption (Stanistreet et al., 2019). This approach reflects practical considerations such as fuel availability and cooking needs (Odongo, 2017). Critics argue that simple models like the Energy Ladder overlook this complexity, as many households continue to use traditional stoves alongside

modern ones (Ruiz-Mercado & Masera, 2015). Diffusion of Innovation theory (Rogers, 2003) explains how ICS adoption spreads through communities, emphasizing the innovation's characteristics, social networks, communication channels, and time. This suggests that improving stove design and maintaining ongoing awareness campaigns are crucial for wider acceptance. Subsidization plays a complementary role by reducing upfront costs and overcoming market barriers, making ICS more affordable and accessible to low-income households (Sahin, 2006; Kulindwa et al., 2018). Together, these theories informed the key informant interviews and focus group discussions, which explored household exposure to government and NGO activities such as attendance at demonstration events, participation in training sessions, and receipt of stove subsidies, balancing economic, social, and technological factors (see Figure 1).

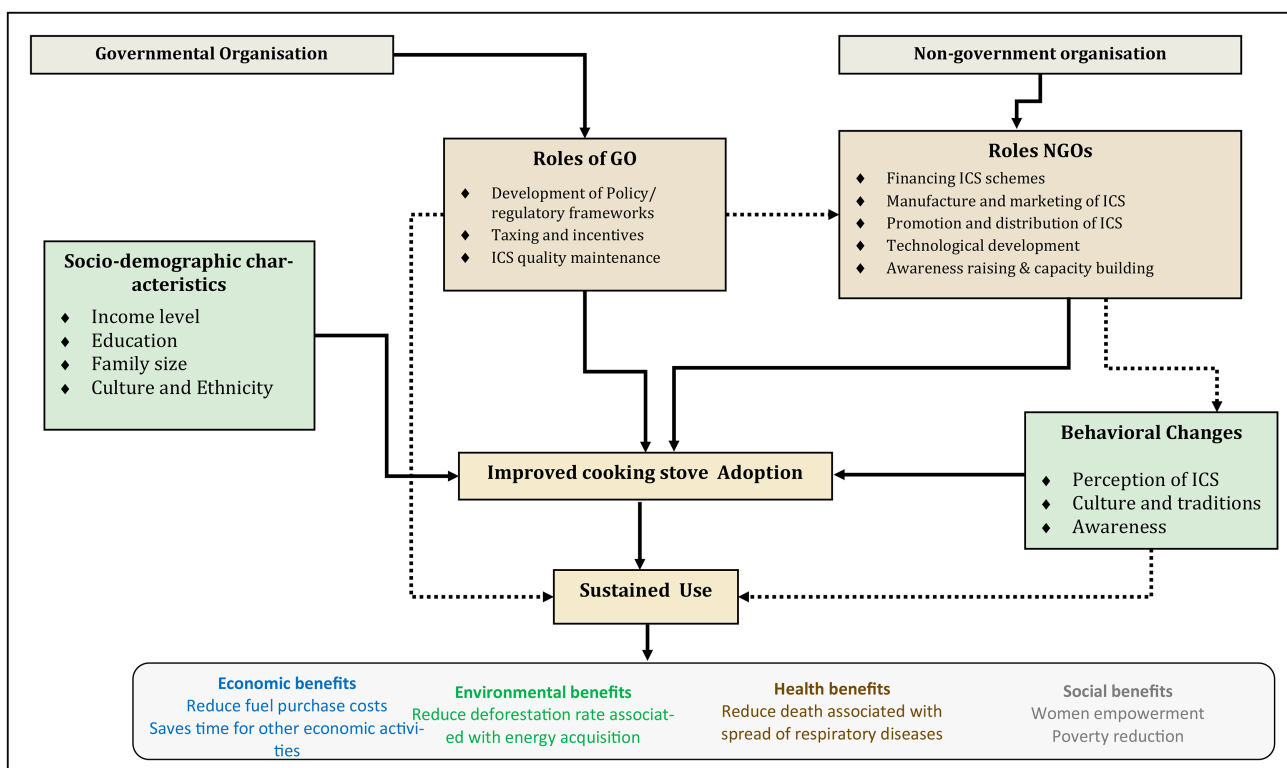


Figure 1. Conceptual framework (Modified from Karanja & Gasparatos, 2020).

2.2. Study Area

The study was conducted in the Kisarawe district, located in the Coastal Region of Eastern Tanzania. This district lies between latitudes 6°50'S and 3°50'S, and longitudes 38°15'E and 39°30'E, encompassing an area of 4464 square kilometers, of which approximately 23.5 square kilometers are covered by forest. The remainder of the district comprises arable land, rivers, settlements, and other features. Kisarawe experiences two rainy seasons: the short rains, commonly referred to as autumn, occur from October to December, while the long rains (Masika) take place from March to early June. Average rainfall ranges from 1400 mm to 1600

mm in the eastern part of the district, particularly in the Sungwi division, whereas the western areas, including the Chole and Mzenga divisions, receive an average of 1000 mm. The region is characterized by high temperatures, ranging from 28°C to 30°C, with a mean temperature of 29°C. According to the 2022 National Census, Kisarawe District has a population of 159,226, across approximately 44,229 households (mean household size = 3.6). Within the six targeted study villages, the total frame comprising 3319 eligible households. The primary economic activity in the area is agriculture, which employs approximately 95% of the population. Kisarawe has around 380,000 hectares of arable land, of which 30,000 hectares have been cultivated (United Republic of Tanzania, 2018). (As shown in **Figure 2**)

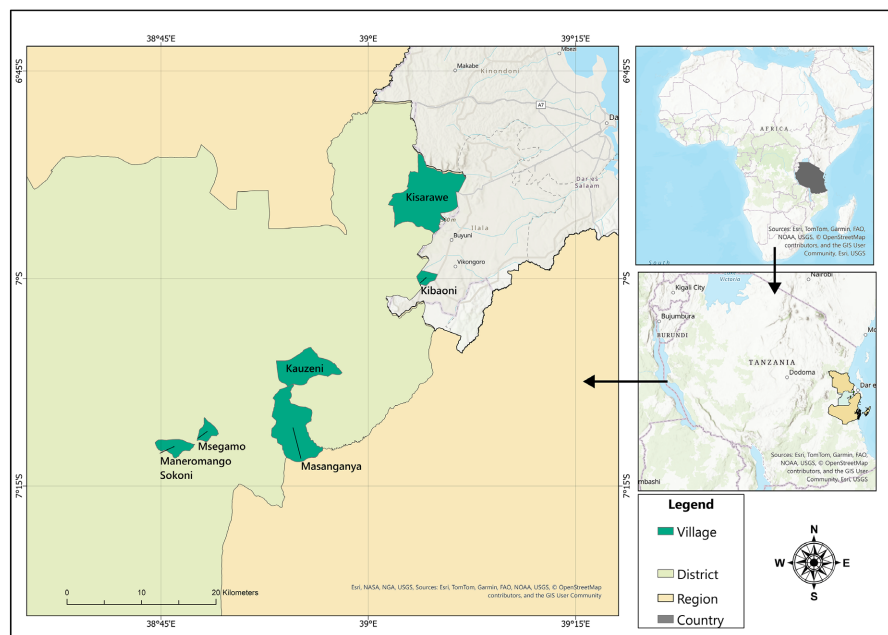


Figure 2. Map showing the study area in Kisarawe district.

2.3. Sampling Design

Because wards were purposively selected based on active NGO intervention programs, findings apply primarily to the areas with ongoing institutional engagement rather than Kisarawe District as a whole. Moreover, sampling frames were established from updated August 2023 household registers: Kisarawe (N = 900), Kibaoni (N = 600), Masanganya (N = 680), Kauzeni (N = 540), Maneromango Sokoni (N = 380), and Msegamo (N = 219). Using a pragmatic 5% sampling fraction per village, 166 households were selected via simple random sampling. The response rate was 100%; standard random replacement from the register was prepared for non-responsive households.

2.4. Data Collection

Data collection involved interviewing a total of 166 household heads across six villages. Kisarawe (N = 45), Kibaoni (N = 30), Masanganya (N = 34), Kauzeni (N

= 27), Maneromango Sokoni (N = 19), and Msegamo (N = 11). The sample size was determined by selecting 5% of the total households in each village, using equation 1, as recommended by [Boyd et al. \(1981\)](#).

$$C = \frac{n}{N} \times 100$$

where:

C = The percentage of the total population that meets the specified criterion;

N = The total number of individuals in the entire population;

n = The number of individuals in the sample.

In addition to household interviews, 13 key informants were deliberately selected for their expertise and roles. This group included district officers, representatives of non-governmental organisations, village leaders, and artisans who work with improved cooking stoves (ICS). We conducted two focus group discussions (FGDs), each lasting approximately 40 minutes and involving six participants, in the villages of Kisarawe and Masanganya. The FGDs included both household members and village leaders, which allowed us to gather deeper insights into the adoption of improved cooking stoves.

2.5 Data Analysis

The data analysis employed both quantitative and qualitative methods. Quantitative data collected from household questionnaires were analysed using the Statistical Package for Social Sciences (SPSS V.29), yielding tables, frequencies, and percentages. Descriptive statistics, along with significance tests such as Chi-Squared Tests and Fisher's Exact Test, were utilised to compare key variables. The qualitative data gathered from focus group discussions (FGDs) and key informant interviews were analysed using thematic analysis. This approach allowed for the identification and organisation of key themes and patterns. By combining both quantitative and qualitative analyses, the study provided valuable insights into the factors influencing the adoption of Improved Cooking Stoves (ICS) in the study area.

3. Results and Discussion

3.1. Adoption of ICS

The findings indicated no significant difference ($p > 0.05$) between the number of users of traditional stoves and those using Improved Cooking Stoves (ICS) in the sampled villages. The data revealed that 46% of respondents have adopted ICS, while 54% continue to use traditional stoves. The villages of Kisarawe and Kibaoni exhibited the highest adoption rates of ICS, at 70% and 69%, respectively. In contrast, Maneromango Sokoni had a moderate adoption rate of 47%, while Msegamo, Masanganya, and Kauzeni showed significantly lower rates, with most respondents in these areas still relying on traditional stoves (see [Table 1](#)). The overall adoption rates in this study were 54% for traditional stoves and 46% for

ICS, which aligns with the findings of [Adrianzén \(2010\)](#), who reported similarly low adoption rates of 45% for ICS in Bangladesh and Peru. Additionally, the results reflect a broader trend noted by [Odongo \(2017\)](#) in rural Kenyan households, where reliance on traditional three-stone stoves remains common. Previous studies ([Lewis and Pattanayak, 2012](#); [Rehfuess et al., 2014](#)) have shown that ICS adoption rates are lower in rural than in urban areas. This disparity is primarily due to the availability of fuels and improved cook stoves ([Puzzolo et al., 2016](#)). In rural regions, wood is the most common fuel and is generally easy for most users to acquire, making it more challenging to persuade people to invest in improved cook stoves ([GACC, 2012](#)).

Table 1. The number of respondents (adopters and non-adopters) of the ICS.

Village	Respondents	Adopters	Percentage	Non-Adopters	Percentage
Kisarawe	30	21	70	9	30
Kibaoni	45	31	69	14	31
Maneromango Sokoni	19	9	47	10	53
Msegamo	11	3	27	8	73
Masanganya	34	9	26	25	74
Kauzeni	27	4	15	23	85
Total	166	77	46	89	54

3.2 Drivers for ICS Adoption

3.2.1. Socio-Demographic Characteristics

The findings revealed that family size, education level, and source of income significantly influence the adoption of Improved Cooking Stoves (ICS), with a p-value of less than 0.01 for family size and 0.05 for education level and source of income. Households with fewer members (1-3) are more likely to adopt ICS, whereas larger households (8 or more members) exhibit the lowest adoption rates ([Table 2](#)). Education emerges as a critical factor, with higher adoption rates among individuals with secondary education or higher. Additionally, the source of income plays a significant role, as farming households exhibit lower adoption rates than those engaged in business or formal employment. Conversely, factors such as gender, marital status, and age do not significantly affect ICS adoption, as rates appear similar across these groups ([Table 2](#)). This indicates that socio-economic factors, particularly education and income, are key drivers of ICS adoption in the study area. [Jan \(2012\)](#) similarly identified income and education as the two most influential factors affecting a household's willingness to adopt improved biomass stoves. Therefore, ongoing efforts to raise awareness of the benefits of ICS and alleviate financial barriers could increase adoption rates in rural regions.

Table 2. The Socio-demographic and economic characteristics and their effect on the adoption of improved cookstoves (ICS) in Kisarawe District.

Demographic Characteristic	Category	Total Respondents (N)	Adopted ICS (n, %)	Not Adopted (n, %)	p-value	Statistical Test Applied
Family Size	1 - 3 Members	61	35 (57.4%)	26 (42.6%)	0.004**	Pearson Chi-Square ($\chi^2 = 11.08$)
	4 - 7 Members	88	40 (45.5%)	48 (54.5%)		
	≥8 Members	17	2 (11.8%)	15 (88.2%)		
Education Level (Collapsed)	Informal/None	29	9 (31.0%)	20 (69.0%)	0.019*	Fisher's Exact Test χ^2 (Collapsed Tertiary & Univ: N = 6, 83.3% adopted)
	Primary Education	103	44 (42.7%)	59 (57.3%)		
	Secondary Education	28	19 (67.9%)	9 (32.1%)		
	Tertiary & Higher	6	5 (83.3%)	1 (16.7%)		
Income Source (Collapsed)	Farming	77	29 (37.7%)	48 (62.3%)	0.015*	Fisher's Exact Test Collapsed Formal/Govt/Other: N = 16, 81.3% adopted)
	Business/Self-Employed	51	23 (45.1%)	28 (54.9%)		
	Casual Laborer	22	12 (54.5%)	10 (45.5%)		
	Formal Employment & Other	16	13 (81.3%)	3 (18.8%)		
Sex	Male	60	27 (45.0%)	33 (55.0%)	0.788	Pearson Chi-Square ($\chi^2 = 0.07$)
	Female	106	50 (47.2%)	56 (52.8%)		
Age	18 - 35 years	34	19 (55.9%)	15 (44.1%)	0.539	Pearson Chi-Square ($\chi^2 = 2.16$)
	36 - 45 years	50	24 (48.0%)	26 (52.0%)		
	46 - 60 years	54	23 (42.6%)	31 (57.4%)		
	>60 years	28	11 (39.3%)	17 (60.7%)		

*Significant at $p < 0.05$; **Significant at $p < 0.01$.

3.2.2. Energy Source and Stoves Used

The findings indicate that firewood and charcoal are the most commonly used energy sources in the study area. A combination of firewood and charcoal is utilised by 32.5% of households, while 31.9% use firewood alone. Charcoal and liquefied natural gas (LNG) are used by 17.5% of respondents, and 9.6% rely solely on charcoal. A smaller percentage of households use a combination of firewood, charcoal, and LNG (4.2%) or firewood and LNG (3.6%). Only 0.6% use a mix of charcoal, electricity, and LNG, as shown in **Table 3** and **Figure 3**. Traditional fuels, particularly firewood, dominate energy use due to their affordability and accessibility. Many households rely on firewood with simple traditional three-stone cookstoves, largely due to poverty and the scarcity of affordable alternative

energy sources. This aligns with research indicating that rural African households primarily depend on fuelwood because of low incomes and its availability (Lusambo & Mbeyale, 2021).

Table 3. Energy source and stoves used.

Energy source	Frequency	Percent response	Ranking
Firewood + Charcoal	54	32.5	1
Firewood only	53	31.9	2
Charcoal + LNG	29	17.5	3
Charcoal only	16	9.6	4
Firewood +Charcoal + LNG	7	4.2	5
Firewood + LNG	6	3.6	6
Charcoal +Electricity + LNG	1	0.6	7
Total	166	100	



Figure 3. The fuel-wood (Charcoal and firewood) stoves used at the study site (Kisarawe district).

Charcoal is the second most common energy source, especially in towns and village centers, but its high cost limits its use in more remote areas. Factors influencing energy use include household purchasing power, fuel costs, availability, family size, and cooking habits. Interestingly, some households that have adopted Improved Cooking Stoves (ICS) still use traditional three-stone stoves, often due to fuel cost and convenience. The practice of “stacking” multiple stoves and fuels is prevalent in developing countries, even among wealthier households (Akpalu et al., 2011).

Both traditional and improved stoves are in use in the study area. The predominant traditional stove is the three-stone fire, valued for its low initial cost and the

use of freely available local biomass. Among ICS, the Matawi improved charcoal stove, made locally from clay, is the most widely used due to its affordability, availability, and ability to keep food warm for up to an hour after cooking. While metal stoves with clay liners are also available, their higher cost makes them less popular. Fixed mud stoves are present but rarely used due to issues such as smoke retention and slow cooking, and offer few health benefits beyond reducing firewood consumption. These findings align with other research, such as Grimsby et al. (2016), which found that 81% of households use multiple stoves depending on the type of food being prepared.

According to Dickinson et al. (2019), the primary factors driving fuel stacking include the high cost of energy sources, cultural preferences, familiarity with current fuels, and the desire to avoid reliance on a single fuel type that may be vulnerable to price fluctuations and availability issues. Similarly, studies by Burwen and Levine (2012) and Rehfuess et al. (2014) indicate that stove stacking occurs when households purchase new stoves while continuing to use their existing ones for certain cooking tasks. For example, users may prefer cooking specific types of food on their traditional stoves, believing that the taste is superior to that of dishes prepared on newer stoves (Dickinson et al., 2019). Therefore, programs aimed at promoting stove adoption should focus on ensuring that new stoves are acceptable and practical for a variety of cooking tasks while also guaranteeing the availability and affordability of fuels.

3.2.3. Roles of Actors in ICS Adoption

Key informant interviews and focus group discussions indicated that both government and non-governmental actors were perceived by respondents as playing active roles in promoting the adoption of Improved Cooking Stoves (ICS) in the study area; however, this study did not statistically test the association between actor exposure and adoption. Non-governmental actors include development agencies, foundations, donors, research organisations, and enterprises, all of which work to improve the accessibility and affordability of ICS (Sinton & Sathaye, 2002). Key initiatives include awareness-raising campaigns, technological development, capacity building, and financial support for production and distribution. Collaboration between government and non-governmental actors is crucial for overcoming institutional, political, social, economic, and cultural barriers to ICS adoption (Jan, 2012).

The government's involvement includes public awareness programs that emphasize the environmental and health benefits of ICS, as well as support for local ICS artisans through training, financial assistance, and marketing strategies. These initiatives aim to ensure that ICSs are available at affordable prices. Additionally, the government affects the market through taxation, subsidies, and credit schemes, which influence the availability and cost of both cooking fuels and stoves. This aligns with findings from Odongo (2017), which indicate that institutional factors such as laws, financing schemes, and policies have a significant impact on ICS adoption.

Non-governmental actors complement government efforts by implementing ICS-related programs, including awareness campaigns, research, funding schemes, and capacity-building activities, to boost adoption rates. A summary of the actors and their roles in promoting ICS is provided in **Table 4**, highlighting the importance of multi-stakeholder collaboration in driving adoption.

Table 4. The role played by different NGOs in facilitating the adoption and use of ICS in the study area.

Organizations	Role played
Tanzania Traditional Energy Development Organization (TaTEDO)	<ul style="list-style-type: none"> ❖ Research and development to improve integrated cooking technologies ❖ Training local ICS artisans and entrepreneurs ❖ Innovative stove design using locally available materials
Tanzania Gender and Sustainable Energy Network (TANGSEN)	<ul style="list-style-type: none"> ❖ Awareness-raising programs about sustainable energy use and environmental conservation
UpEnergy Group	<ul style="list-style-type: none"> ❖ Distribution and promotion of Smart Home Stoves (burning charcoal or briquettes)
Jane Goodall Institute	<ul style="list-style-type: none"> ❖ Awareness-raising programs about sustainable energy use ❖ Environmental conservation education
World Wildlife Fund (WWF)	<ul style="list-style-type: none"> ❖ Awareness-raising programs ❖ Funding the ICS innovative research
Caritas Tanzania	<ul style="list-style-type: none"> ❖ Awareness-raising programs on ICS adoption ❖ Training on stove making using locally available materials

Several organizations, including TaTEDO, UpEnergy Group, and Caritas Tanzania, have played key roles in promoting ICS adoption in the study area. TaTEDO focused on raising awareness and training local artisans to design and produce stoves using locally available materials to meet the needs and preferences of rural communities. With funding from Vodacom Tanzania and WWF, TaTEDO launched a two-year project (2020-2022) in Kisarawe District, providing raw materials and training to help artisans manufacture improved stoves. UpEnergy Group concentrated on advertising and distributing Smart Home Stoves; however, the high cost of these stoves limited their popularity compared to locally made Matawi stoves, which are more affordable and better suited to local needs. Caritas Tanzania contributed to ICS adoption through training programs in rural communities, such as teaching villagers in Masanganya how to construct fixed mud stoves.

Local artisans played a pivotal role in increasing ICS adoption by producing affordable stoves using locally sourced materials. The Matawi stoves are priced between 3000 and 8000 Tanzanian Shillings (TZS), making them significantly cheaper than metal-clay liner stoves, which cost between 10,000 and 15,000 TZS. However, limited access to financial resources and knowledge about lending institutions hindered artisans from scaling up production. Providing financial incentives such as grants, subsidies, and microcredit loans could enhance produc-

tion and affordability, positively influencing stove adoption rates (Rehfuess et al., 2014).

These initiatives have the potential to raise awareness and increase ICS adoption by making stoves more accessible and affordable. As communities become more informed about the environmental and health benefits of ICS, the demand for these stoves may rise, underscoring the importance of sustained awareness campaigns to improve adoption in rural areas (Massawe et al., 2015).

4. Conclusion

The study examined the roles of both government and non-governmental organizations in promoting the adoption of improved cooking stoves (ICS). Qualitative evidence from key informants and focus group participants suggested that these entities are seen as important in raising awareness, providing financial support, and facilitating training for local artisans, although this study did not statistically measure their effect on adoption. Their collaborative efforts are vital in creating an environment that encourages ICS adoption, highlighting the importance of cooperation among various stakeholders to effectively implement sustainable cooking solutions. Despite significant efforts from different organizations and local artisans, only 46% of households in the area have adopted ICS, with most still relying on traditional stoves. Key factors influencing the adoption of ICS include family size, education level, and income source; smaller households, those with higher education, and families engaged in business or formal employment are more likely to adopt ICS. The limited adoption of ICS in rural areas is primarily due to the accessibility and affordability of traditional fuels, especially firewood, and the high cost of improved stoves. Local artisans face financial constraints, and the expense of some stoves poses challenges in scaling up production and increasing ICS adoption. Additionally, “stove stacking,” where households continue to use traditional stoves alongside improved ones, is common and further obstructs full ICS adoption.

5. Recommendations

To effectively promote the adoption of Improved Cooking Stoves (ICS) in Kisarawe District, a comprehensive approach that addresses identified barriers and leverages stakeholder roles is essential. Policymakers should implement financial support mechanisms, such as subsidies or microfinance options, to make ICS more accessible to low-income households. This financial assistance will help alleviate the initial cost burden and encourage more families to transition from traditional cooking methods to improved technologies. Furthermore, ongoing education and awareness campaigns are critical to changing community perceptions of ICS. These campaigns should focus on the tangible health and environmental benefits of using improved stoves and deliver messages that resonate with local cultural practices. Engaging community leaders and local influencers can enhance the effectiveness of these initiatives, fostering a sense of ownership and encouraging adoption.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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