Journal of Social Development Studies
Volume 6, Issue 1, March 2025, pp. 51-67
ISSN 2721-3870 (Print), 2721-3889 (Online)
Doi: https://doi.org/10.22146/jsds.20299

The Effect of *Mirt* Stove Adoption on Women Empowerment and Fuelwood Saving through Results-based Financing Mechanism

Azmera Belachew[1]

Submitted: March 11, 2025; Revised: June 22, 2025; Accepted: July 24, 2025

Abstract

This study investigates the impact of the *Mirt* improved cookstove (ICS) on women's empowerment and fuelwood savings in the Gedeb Asassa district, with a particular focus on the role of results-based financing (RBF) in promoting sustainable cooking technologies. Data were collected through household surveys, focus group discussions, and key informant interviews, and analyzed using STATA software (version 18). The findings demonstrate significant improvements in women's empowerment regarding human, financial, social, physical, and natural assets due to ICS adoption. The *Mirt* stove reduced women's workload, improved health by creating a safer cooking environment, and enhanced economic stability by lowering both cooking time and fuel costs. It also contributed to environmental sustainability by reducing fuelwood consumption, thereby helping to mitigate deforestation. Furthermore, the *Mirt* stove enabled women to dedicate more time to income-generating activities, increasing household income and improving resource allocation. Key factors influencing the rate of ICS adoption included family size, farm land size, proximity to forests, and fuel expenditure. The study underscores the importance of coordinated efforts among government bodies, stakeholders, and local communities to optimize the dissemination of ICS technologies and further empower women. The *Mirt* stove presents a valuable model for future sustainable development initiatives that seek to enhance both women's well-being and environmental conservation.

Keywords: *fuelwood, improved cookstove, mirt stove, results-based financing, women empowerment.*

Introduction

Clean cooking fuels remain inaccessible to one-third of the global population, affecting approximately 2.4 billion people (WHO, 2022), with women being disproportionately impacted due to their primary role in cooking. This situation presents a major barrier to achieving Sustainable Development Goals, particularly SDG 7 (access to clean and affordable energy) and SDG 5 (women's empowerment) (Lee et al., 2024). While environmental sustainability initiatives in developing countries often focus on macro-level strategies (Rosenthal et al., 2018), meaningful progress can also result from individual and household-level behavioral changes (Verplanken, 2018). In Ethiopia, biomass-based energy sources such as fuelwood, agricultural residues, and dung remain the dominant forms of household energy, especially in rural areas (Derebe et al., 2025). Over 90% of households continue to rely on wood, charcoal, and other biomass fuels for cooking (Benti et al., 2021; Adhikari et al., 2025), contributing to widespread deforestation, environmental degradation, and significant health risks. Women and children, who are most frequently exposed to indoor air pollution, face increased vulnerability to respiratory diseases and other serious health conditions due to traditional cooking methods (Benti et al., 2021).

Women bear the burden of fuel collection and usage in addition to other household duties (Krishnapriya et al., 2021; Chandrasekaran, 2024). Reducing this burden through access to clean cooking solutions can offer women more leisure time and expand opportunities for income generation and productivity (Winther et al., 2018; Jagoe et al., 2020). Studies further show that reduced energy poverty is linked to increased female labor force participation, enhanced household decision-making power, and improved financial autonomy for women (Choudhuri & Desai, 2020; Choragudi, 2024; Nguyen-Phung & Nthenya, 2024). Health costs associated with traditional solid fuel usage are substantial and disproportionately affect women due to gendered cooking responsibilities and prolonged exposure to air pollutants (Chandrasekaran, 2024). Energy access inequalities undermine poverty reduction, food security, climate goals, public health, and broader social inclusion (Alvi et al., 2023; Habib

[1] Ethiopian Forestry Development, Central Ethiopia Forestry Development Center, Addis Ababa, Ethiopia (email correspondence: azmerabelachew@gmail.com)

et al., 2024; Chandrasekaran, 2024). Women in rural areas of low- and middle-income countries (LMICs), including Ethiopia, face particularly severe challenges in accessing reliable and sustainable energy technologies.

The *Mirt* stove has been widely promoted for its effectiveness in baking *injera*, Ethiopia's staple bread, while mitigating the negative impacts of traditional cooking methods (Getnet et al., 2023). Designed to improve fuel efficiency and reduce indoor air pollution, the *Mirt* stove also alleviates women's labor burdens by reducing time spent on fuel collection and cooking. Beyond its technical benefits, the stove's adoption has been linked to broader socioeconomic improvements, particularly in advancing women's empowerment through time savings, increased income-generating opportunities, and improved well-being. Improved cookstoves (ICS) in general are critical interventions for reducing fuel use and exposure to household air pollution (Barnes & Samad, 2018; Bhattacharya, 2025). While clean-fuel technologies can eliminate the need for biomass entirely, their feasibility in rural LMICs is often limited by fuel availability, high costs, lack of grid connectivity, and cultural preferences for traditional cooking methods (Pattanayak et al., 2019; Leary et al., 2021).

Financing mechanisms play a crucial role in enabling ICS adoption and scale-up (Goldrey et al., 2024). Among these, Results-Based Financing (RBF) has emerged as a promising strategy that links financial disbursements to the verified delivery and sustained use of ICS (Belachew, 2024). RBF schemes provide subsidies to stove producers and distributors contingent on measurable outcomes, ensuring accountability and optimizing the impact of investment (Stritzke et al., 2021; Belachew & Melka, 2023). In Ethiopia, RBF programs have sought to increase access to *Mirt* stoves by lowering upfront costs and incentivizing sustained usage, which in turn enhances environmental, health, and economic benefits (Berg et al., 2024; Goldrey et al., 2024).

The adoption of ICS is therefore pivotal for reducing household air pollution, enhancing energy efficiency, and mitigating deforestation. Traditional biomass-based cooking methods are a major contributor to indoor air pollution, particularly affecting women and children through increased rates of respiratory disease (Clasen & Smith, 2019; Chandrasekaran, 2024). Yet, the high initial costs of ICS remain a significant barrier to widespread adoption. RBF mechanisms have been introduced as demand-driven approaches to scale up ICS usage. However, further research is needed to understand the dynamics between women's empowerment and the adoption of clean cooking technologies.

Studies such as Nguyen and Su (2021) have explored how access to clean fuels and electricity correlates with indicators of women's empowerment, such as employment and education gaps, across 51 countries. Women's involvement in clean energy initiatives is widely regarded as essential for enhancing adoption rates. Yet, empirical research quantifying women's specific roles in promoting ICS adoption within RBF frameworks remains limited.

This study seeks to address that gap by examining the impact of the *Mirt* stove on women's empowerment and fuelwood savings in Ethiopia under an RBF scheme. By evaluating the stove's role in reducing fuelwood consumption and enhancing women's socioeconomic conditions, this research offers policy-relevant insights for advancing inclusive, sustainable energy solutions.

Conceptual framework of results-based financing for ICS adoption and women empowerment

Approximately 2.8 billion people, predominantly in the Global South, continue to face significant barriers to accessing clean cooking solutions, hindering progress toward the Sustainable Development Goals (Yumkella et al., 2021; Goldrey et al., 2024). Despite a global commitment to ensuring universal access to reliable, affordable, and modern energy by 2030, over 30% of the world's population still relies on polluting fuels and solid biomass for cooking. Current projections indicate that universal clean cooking access by 2030 is unlikely. Since 2012, the use of polluting cooking methods has increased by roughly 12%, meaning around 2 billion people will continue to depend on harmful fuels and technologies (Stritzke et al., 2023; Adhikari et al., 2025). Although transitioning to cleaner cooking technologies is essential for sustainable development, funding remains insufficient and often misaligned with local affordability or implementation needs (Goldrey et al., 2024).

In recent years, Development Finance Institutions (DFIs) have increasingly adopted Results-Based Financing (RBF) to address these challenges in the clean cooking sector, favoring it over direct grants or investments in stove manufacturers (Stritzke et al., 2021; Goldrey et al., 2024). RBF, exemplified by programs such as the Energising Development Programme (EnDev) and the World Bank's Clean Cooking Fund (CCF), has emerged as a key tool for accelerating the adoption of clean cooking technologies. Under this mechanism, funds are disbursed based on the achievement of pre-defined outcomes, ensuring accountability and incentivizing performance among suppliers and end-users alike (Stritzke et al., 2021; Musafili et al., 2024). In Ethiopia, where over 90% of households depend on biomass for energy (Gebreegziabher et al., 2018), promoting improved cookstoves (ICS) through RBF can enhance energy efficiency, reduce deforestation, and improve public health. This approach also supports Ethiopia's Climate Resilient Green Economy (CRGE) Strategy and aligns with international carbon financing mechanisms (World Bank, 2021).

This study employs an empowerment framework to examine the role of Results-Based Financing (RBF) in driving the adoption of improved cookstoves (ICS) and its impact on women's empowerment. It focuses on key dimensions of empowerment, including economic independence, health, social opportunities, and decision-making power. Empowerment is a complex, multifaceted concept that varies across socio-cultural contexts, making its measurement both challenging and contested (Laszlo et al., 2020). By analyzing specific aspects of empowerment, this research seeks to better understand how transitioning to clean fuels can positively influence women's lives. Access to clean cooking fuels can save time and improve health, thereby enabling women to engage in a wider range of economic and non-economic activities, such as accessing media, seeking employment, and opening bank accounts (Su & Azam, 2023). Restrictions on women's mobility often impede their agency, limiting opportunities for employment, social networking, and personal development. Figure 1 illustrates how the transition to clean cooking fuels can contribute to enhancing women's empowerment (Karber, 2018).

Methods

Description of the study area

The study was conducted in Gedeb Asassa district, located in the West Arsi Zone of the Oromia National Regional State, Ethiopia. It lies 285 kilometers southeast of Addis Ababa, along the Addis Ababa–Asella–Robe road, and is 110 kilometers from Asella. The district spans 1,139.38 square kilometers and sits at an altitude ranging from 1,000 to 3,280 meters

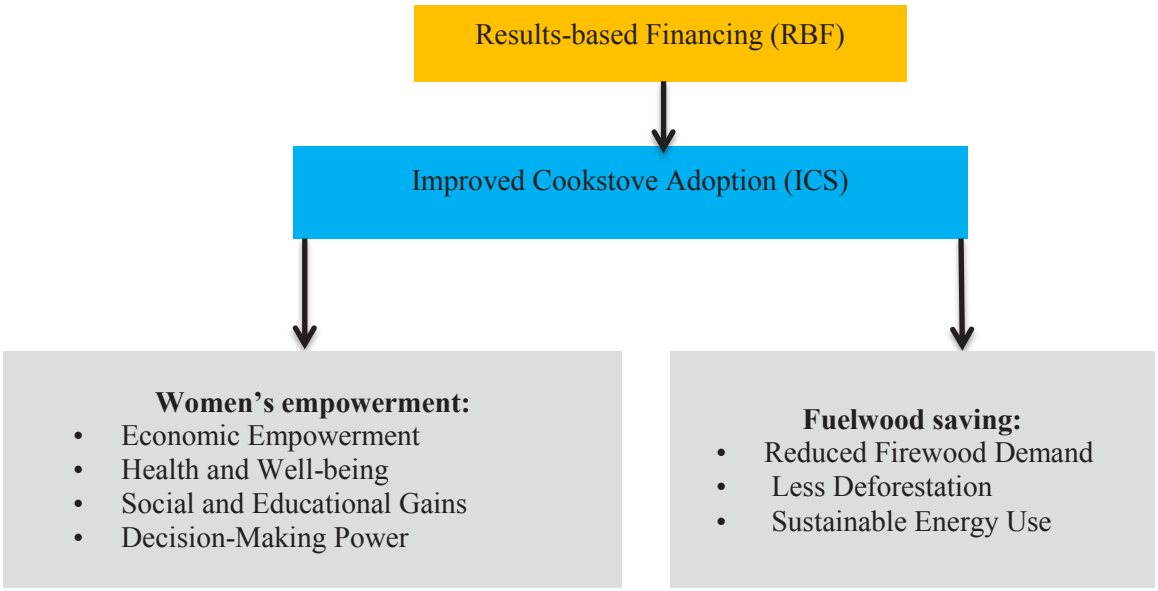

Figure 1. Women empowerment framework diagram
Source: Author (2025)

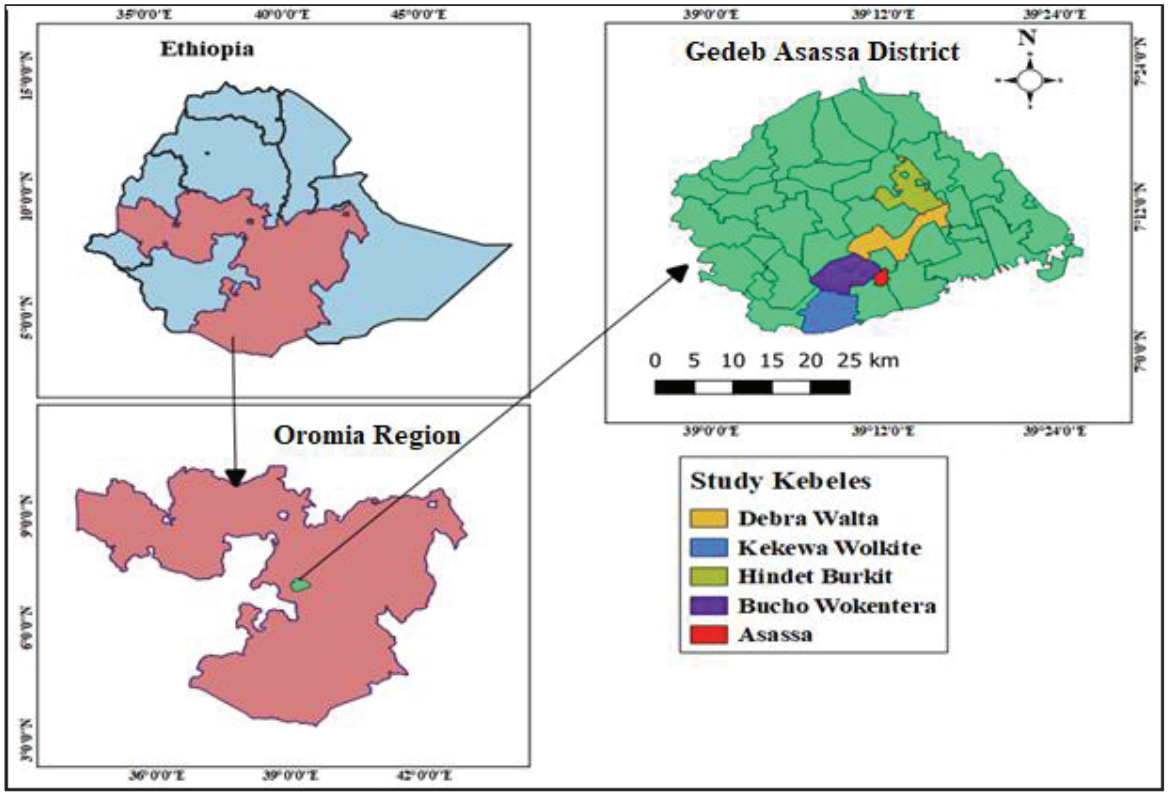

Figure 2. Map of the study area
Source: Author (2025)

above sea level. Gedeb Asassa experiences average annual temperatures between 12°C and 18°C, with rainfall concentrated primarily between June and September. As of 2022, the district's population was approximately 275,293 (City Population, 2022).

Agriculture is the primary source of livelihood in Gedeb Asassa, with most households engaged in subsistence farming. Commonly cultivated crops include teff, maize, barley, wheat, and legumes. Livestock production—especially cattle, sheep, goats, and poultry—plays a vital role in providing food, income, and transportation. Although forest cover is limited, fuelwood remains a critical resource for cooking and heating, and some communities also engage in small-scale charcoal production (WorldAfropedia, 2025). The district's agricultural practices and reliance on natural resources significantly shape both the local economy and daily life (World Bank, 2025).

In Gedeb Asassa district, biomass, primarily fuelwood, is the dominant energy source for cooking and heating, a situation that poses significant environmental and health challenges. To address these issues, the *Mirt* improved cookstove has been introduced as part of a Results-Based Financing (RBF) program supported by GIZ. The *Mirt* stove is designed to use less fuelwood than traditional stoves by improving the combustion process, which helps reduce indoor air pollution and the health risks associated with smoke inhalation. This program aims to promote sustainable energy solutions and reduce reliance on traditional biomass fuels in the area.

The *Mirt* stove, developed by the former Ethiopian Energy Studies and Research Centre of the Ministry of Mines and Energy, is a compact, enclosed *injera*-baking stove. Constructed from cement and pumice, it features a U-shaped section for pot resting and a chimney for smoke ventilation. Its design improves heat retention, reduces smoke emissions, and increases fuel efficiency. By linking *Mirt* stove adoption to measurable environmental and health outcomes, such as reduced deforestation and improved air quality, the RBF mechanism can support the widespread adoption of this technology. This contributes to both environmental sustainability and local development goals (Tesfaye et al., 2016)

Figure 3. Picture of *mirt* stove
Source: Adapted from GIZ-EnDev (2020)

Sampling technique

This study utilized a cross-sectional design, collecting data at a single point in time to capture a snapshot of *Mirt* stove adoption. This design facilitated the integration of both qualitative and quantitative methods to explore the phenomenon, gathering both numerical data and in-depth insights into household adoption behaviors. Households were categorized as either adopters or non-adopters, forming the basis for a comparative analysis of the two groups.

A comprehensive, three-stage sampling procedure was employed to ensure a representative sample. First, Gedeb Asassa district was selected from districts involved in the RBF intervention based on its potential for *Mirt* stove dissemination. Its active participation in the RBF program and significant *Mirt* stove usage made it an ideal location. Second, study *kebeles* within Gedeb Asassa district were purposively chosen based on the density and distribution of *Mirt* stove adopters, using information from RBF implementers and participants. Finally, households within these *kebeles* were stratified into adopter and non-adopter groups.

Stratified random sampling was then used to ensure balanced representation from each group, controlling for variation between them. Within each stratum, respondents were selected using simple random sampling, with the sample size determined using a 10 percent population proportion size (PPS) technique, following Taw and Abdul (2021). A total of 148 households were selected, equally divided between adopters and non-adopters. Non-adopter households were chosen to closely resemble adopter households, with the primary difference being the lack of *Mirt* stove ownership and use. This approach ensured a valid and meaningful comparison, enabling the identification of factors influencing adoption. The rigorous, multi-stage sampling strategy provided a robust and representative sample, enhancing the generalizability of the study's findings related to *Mirt* stove adoption in the region.

Data sources and methods of data collection

In the data collection process, a semi-structured questionnaire was used to collect field data. Before beginning the final data collection procedure, a pilot survey involving 20 households was conducted. Based on the pre-testing results, the final questionnaire was revised to incorporate information obtained from the pilot survey. Data for this study were obtained from both primary and secondary sources. These include quantitative and qualitative data, with the main sampling units being ICS user and non-user households.

To collect primary data, household surveys, focus group discussions (FGDs), and key informant interviews (KIIs) were conducted. A semi-structured questionnaire was used to gather data from households through face-to-face interviews, while a checklist guided the key informant interviews and focus group discussions. In each *kebele*, one FGD was conducted, with participants representing women, youth, and elders, comprising 8 to 10 members per group. In total, five FGDs were conducted across the five selected *kebeles*. Additionally, the study incorporated 15 KIIs, with three interviews conducted per *kebele*. The KII participants were selected based on their extensive experience and knowledge of the area.

Data analysis and model specification

The collected data were analyzed using both descriptive and inferential statistical methods. Quantitative analysis was conducted using STATA software (version 18) to examine the effects of the ICS intervention on respondents' socio-economic conditions, health, and environmental outcomes. In addition to statistical analysis, qualitative data obtained from FGDs and KIIs were analyzed using thematic techniques to provide deeper insight into the intervention's impact. Before analysis, data management procedures were applied to ensure accuracy and consistency. Diagnostic tests were also conducted to verify the correctness of the specified model and to check for potential

violations of key statistical assumptions, including multicollinearity. Various statistical techniques were applied to confirm the validity and reliability of the findings.

Descriptive statistics

Descriptive statistics—including mean, standard deviation, frequency, percentage, and graphical analysis—were used to examine respondents' characteristics and perceptions of ICS adoption. Statistical significance and associations between variables were tested using chi-square and t-tests. Independent and paired sample t-tests were used to examine differences in continuous variables, such as firewood consumption and time savings, between ICS users and non-users, as well as before and after RBF implementation. Chi-square tests were applied to compare categorical variables across these groups. Additionally, qualitative data from KIIs and FGDs were analyzed using thematic analysis to identify key themes and insights.

Specification of binary probit model

To estimate the effects of ICS adoption under the RBF intervention, a binary probit model can be formulated as follows:

The decision of a woman household to adopt ICS is represented as a binary outcome:

$$Y_i = \begin{cases} 1, & \text{if household adopts ICS} \\ 0, & \text{if household does not adopt ICS} \end{cases}$$

Since this observed decision (Y_i) is influenced by an unobserved latent variable (Y_i^*), the model is structured as:

$$Y_i^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_n X_{ni} + \varepsilon_i$$

where:

Y^*_i is the latent propensity to adopt ICS,

X_{1i}, X_{2i}..., Xni are explanatory variables (e.g., household income, education, fuelwood cost, stove availability, awareness level, and RBF incentives),

- β_0 is the intercept,
- β1, β2,...,,βn are coefficients to be estimated,
- εi~N(0,1) is a normally distributed error term.

The observed binary outcomeY_i is determined as:

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

The probability that a household adopts ICS is given by the cumulative distribution function (CDF) of the standard normal distribution:

$$P(Y_i = 1|X_i) = \Phi(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_n X_{ni})$$

where Φ(·)denotes the standard normal CDF.

The model parameters (β) are estimated using maximum likelihood estimation (MLE). The likelihood function is expressed as:

$$L(\beta) = \prod_{i=1}^{N} \Phi(X_i\beta)^{Y_i}[1 - \Phi(X_i\beta)]^{(1-Y_i)}$$

A positive coefficient (β_j) indicates that an increase in the corresponding variable (X_j) raises the probability of ICS adoption, while a negative coefficient suggests a decrease in adoption likelihood. This model helps analyze the effectiveness of the RBF intervention and identifies key factors influencing women decision to adopt ICS.

Results and Discussion

Demographic characteristics of respondents

The findings indicate that the education level of adopters was generally higher, particularly among those with secondary and above-secondary schooling (Table 1). Higher education levels were associated with increased ICS adoption rates, with 92.3 percent of individuals with secondary education and 77.8 percent of those with education beyond secondary school adopting the technology. This contrasts with a lower adoption rate of 58.5 percent among illiterate households.

In contrast, marital status did not show a significant difference between adopters and non-adopters, as adoption rates remained relatively similar among single (62.5 percent) and married (61.2 percent) respondents. No divorced or widowed individuals were recorded in the sample. These results suggest that education plays a key role in the adoption of

improved cooking technologies, whereas marital status has minimal influence (Table 1).

Variable	Category	Non-user (%)	User (%)
Education level	Illiterate	41.5	58.5
	Primary education (1-8 grade)	43.9	56.1
	Secondary education (9-12 grade)	7.7	92.3
	Above secondary	22.2	77.8
Marital Status	Single	37.5	62.5
	Married	38.8	61.2

Table 1. Education and marital status of ICS user and non-user households
Source: Author (2025)

Table 2 presents the association between household characteristics (age and family size) and *Mirt* stove adoption. The results indicate that the average age of household heads is slightly higher among non-users (38.92 years) compared to users (37.33 years). However, a notable difference is observed in family size, with *Mirt* stove users having a larger average household size (6.44) compared to non-users (5.40). This finding suggests that larger households are more likely to adopt the *Mirt* stove, potentially due to higher fuel consumption needs or greater labor availability for stove operation (Table 2).

Variable	Respondent	Mean	SD
Age of household head in years	Non-user	38.92	12.38
	User	37.33	8.70
Total family size	Non-user	5.40	2.76
	User	6.44	2.89

Note: SD= Standard Deviation

Table 2. Age and family size association with respective *mirt* stove user and non-user
Source: Author (2025)

Attitude and practice of RBF on ICS intervention and its effectiveness

Among the sample respondents, the majority of households (72 percent) primarily relied on fuelwood as their main source of energy (Figure 4). Dung cakes were the second most commonly used fuel, reported by 22 percent of households, followed by crop residues, used by 6 percent of households for energy consumption. These findings align with previous studies on rural energy consumption patterns. For example, Gebreegziabher et al. (2020) reported that in Ethiopia, fuelwood remains the dominant energy source, with over 70 percent of households depending on it, followed by dung cakes and crop residues. Similarly, Tadesse et al. (2022) found that households in rural areas of East Africa predominantly rely on biomass fuels, with fuelwood being the most common. This pattern reflects limited access to alternative energy sources. These studies underscore the continued reliance on traditional biomass fuels in many developing regions and highlight the challenges associated with transitioning to cleaner and more efficient energy alternatives.

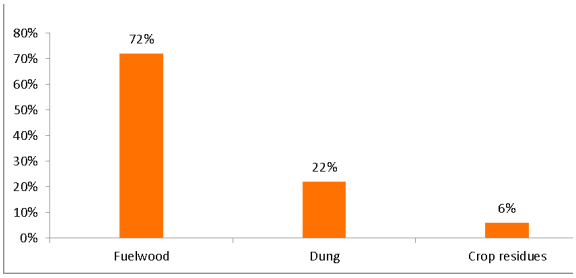

Figure 4. Types of fuel used by user households
Source: Author

The results showed that approximately 55 percent of households sourced their fuelwood from nearby markets, while 32 percent and 13 percent obtained their fuelwood from their own plantation forests and natural forests, respectively (Figure 5). These findings are consistent with previous studies on fuelwood sourcing in rural areas. For instance, a study by Gebremedhin et al. (2021) in Ethiopia found that a significant proportion of rural households obtain their fuelwood from local markets and surrounding forests, with a smaller share relying on plantation forests. Similarly, Kassa et al. (2023) reported that natural forests continue to serve as an important fuelwood source for many households in East Africa, despite ongoing pressure on these resources. The continued reliance on natural forests for fuelwood highlights the challenges of sustainable biomass resource management in the region.

The results revealed that a significant proportion of respondents (55 percent) learned about *Mirt* stove technology from their neighbors, followed by 27.9 percent who cited family and friends as their source (Table 3). This suggests that neighbors played a central role in disseminating information about *Mirt* stoves in the study area. Furthermore, insights from FGD participants

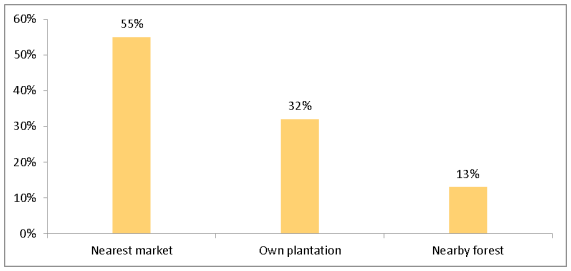

Figure 5. Sources of fuelwood for baking and cooking
Source: Author (2025)

and key informants indicated that other sources of information included friends, neighbors, local markets, and media outlets. However, both FGD participants and key informants noted that promotional efforts for improved cookstoves (ICS) were inadequate, and that the absence of a structured market for stove distribution could limit the technology's availability and broader adoption. This finding aligns with Tesfaye et al. (2022), who reported that informal sources such as neighbors and family members were instrumental in spreading information about ICS in rural Ethiopia. Similarly, Wubie et al. (2023) found that local networks significantly influence the adoption of clean cooking technologies, although they also emphasized that limited promotional activities and the lack of organized markets remain key barriers to widespread adoption.

Information Sources	*mirt* Stove Percent (%)
Extension service	2.6
Neighbors	55.0
Family and Friends	27.9
Media(TV, Radio)	0.9
NGOs	5.3
Market	8.3

Table 3. Sources of information about *mirt* stove technology
Source: Author (2025)

Effect of mirt adoption on women's empowerment from RBF intervention

The results from Table 4 reveal various aspects of social empowerment among women. Adoption of the *Mirt* stove has strengthened women's roles within their households and communities. Focus group discussions indicated that participatory training and peer demonstrations enhanced women's confidence. This was confirmed by key informant interviews, which emphasized messaging around health benefits, time savings, and dignity as key drivers of increased self-worth and spousal recognition. Both FGD and KII participants observed positive shifts in attitudes, with women increasingly taking initiative in household decision-making.

A significant proportion of women reported enhanced social capital through expanded networks, with 14.3 percent noting increased connections and 53.5 percent of responses overall reflecting this form of empowerment. The highest proportion of women, 23 percent, reported increased participation in community meetings, indicating a notable shift toward greater community engagement. Furthermore, 14.6 percent of women stated they could visit family or relatives without needing their husband's permission, and an equal percentage reported being able to make independent decisions regarding pregnancy. Social autonomy was also reflected in the responses of 11.7 percent of women, who said they could leave the house without informing their husbands.

These findings suggest significant progress in women's social empowerment, particularly regarding autonomy in both public and private spheres. This aligns with studies by Adama et al. (2023) and Tesfaye et al. (2022), which found that women's access to resources, decision-making power, and participation in community life improved through gender-focused interventions such as ICS adoption. These outcomes reflect a broader trend of increasing women's autonomy and influence within the household and community, a theme also explored by Yirga et al. (2021), who noted the positive social impacts of improved household technologies on women's empowerment.

Social empowerments	Frequency	Percent (%)
enhanced social capital through expanded networks	77	14.3
Increase participation in community meetings	124	23.0
Able to visit family or relatives without getting permission from husband	79	14.6
Able to go out without telling her husband	63	11.7
Able to decide to get pregnant or not	79	14.6

Table 4. Social empowerment of women
Source: Author (2025)

The results from Table 5 demonstrate significant improvements in economic empowerment among women. A notable proportion of women (18.1 percent) reported an increase in their income, with 66.0 percent of these cases reflecting meaningful economic gains. Furthermore, 15.0 percent of women reported increased ownership of resources, and 15.4 percent mentioned having the ability to make decisions regarding large household purchases. A higher proportion, 16.8 percent, indicated that they could decide on small household purchases, while 16.2 percent stated they were able to earn their own income and achieve financial independence from their husbands. Additionally, 18.5 percent of women reported diversifying their household income sources, reflecting broader economic gains.

These findings align with similar studies in the literature that highlight the positive impact of improved household technologies on women's economic empowerment. For example, studies by Adama et al. (2023) and Tesfaye et al. (2022) observed increased income generation, greater resource ownership, and enhanced decision-making power among women involved in interventions such as the adoption of ICS. These shifts contribute to changing economic dynamics within households, enabling women to gain greater control over finances and resource allocation, thereby improving their overall economic standing. Similarly, Yirga et al. (2021) found that women's participation in income-generating activities was a key indicator of empowerment, which is consistent with the results of this study.

Economic empowerment	Frequency	Percent (%)
There is an increase in income earned	95	18.1
There is an increase in the ownership of resources	79	15.0
Able to decide on large household purchases	81	15.4
Able to decide on small household purchases	88	16.8
Able to earn own income and become financially independent of my husband	85	16.2
Able to diversify household income	97	18.5

Table 5. Economic empowerment of women
Source: Author (2025)

The results in Table 6 indicate significant empowerment in women's decision-making abilities, particularly in relation to household management and family welfare. A notable 27.5 percent of women reported an increase in accessing life skills and knowledge, reflecting broader awareness and capacity in managing personal and family matters. Regarding healthcare, 35.8 percent of women indicated that they could independently make decisions about their health. Similarly, 36.7 percent reported having the autonomy to decide on sending their children to school. The decision regarding the purchase of improved cookstoves (ICS) showed a strong shift in decision-making power, with 57.2 percent of women stating that they were the primary decision-makers, compared to only 8.4 percent of men. An additional 34.2 percent of women and men reported sharing this responsibility.

These findings are consistent with studies that have shown how access to clean cooking technologies and related interventions can significantly enhance women's empowerment, particularly in decision-making roles within the household. For example, studies by Adugna et al. (2021) and Ayele et al. (2022) found that when women had more control over household purchases, such as clean cookstoves, their decision-making power increased in other areas including healthcare and education, thereby strengthening their overall social and economic roles within the household. These shifts reflect broader progress in empowering women to take on greater responsibilities in both personal and household decision-making.

FGD participants and key informants emphasized the substantial health benefits of *Mirt* stoves. Before their introduction, many households relied on traditional three-stone stoves, which were associated with high levels of indoor air pollution due to poor ventilation and incomplete combustion of biomass fuels. These conditions led to various health issues. However, with the adoption of *Mirt* stoves, households reported improvements such as reduced exposure to fire and smoke, fewer respiratory problems, a cleaner cooking environment, and reduced drudgery and risk of fire hazards or accidental burns.

Overall, KII revealed that community empowerment associated with the adoption of *Mirt* stoves was significantly influenced by

Skill empowerment	Percent (%)
There is an increase in accessing life skills and knowledge	27.5
Able to decide on my healthcare decisions	35.8
Able to decide on sending children to school	36.7
Decision on improved cookstove purchase	
Women	57.2
Men	8.4
Both	34.2

Table 6. Empowerment on women decision making of ICS purchase
Source: Author (2025)

the role of facilitators, particularly those from GIZ. These facilitators played a vital role in raising awareness and motivating individuals to adopt new cooking practices. They engaged with community leaders, conducted home visits, and organized public demonstrations to showcase the health, environmental, and economic benefits of the stove. Informants emphasized that these efforts were essential in shifting community perceptions, despite initial resistance rooted in long-standing cooking traditions. Over time, community members became more receptive, especially after observing the positive outcomes experienced by early adopters. Informants also highlighted that while behavior change is a gradual process requiring sustained engagement, the strategies implemented have laid a strong foundation for long-term community empowerment.

Effect of mirt stove adoption on fuelwood saving from RBF intervention

The results in Table 7 show a significant reduction in firewood consumption when using the *Mirt* stove compared to the traditional cookstove. On average, daily firewood consumption per capita decreased from 1.18 kilograms with the traditional stove to 0.78 kilograms with the *Mirt* stove, resulting in a daily saving of 0.40 kilograms of firewood. This translates to an annual saving of 144 kilograms, with the traditional stove consuming approximately 424.8 kilograms annually, compared to 280.8 kilograms with the *Mirt* stove.

These findings are consistent with previous research on improved cookstoves (ICS), which also report reductions in fuelwood consumption. For instance, studies by Tesfaye et al. (2022) and Wubie et al. (2023) found that the adoption of ICS led to significant fuel savings, thereby reducing pressure on local woodlands and improving household energy efficiency. The reduction in firewood use not only offers environmental benefits but also contributes to lower household fuel costs and time savings, particularly for women and children responsible for firewood collection.

Stove type	Daily average per capita consumption of firewood	Annual average per capita firewood consumption
Using traditional cookstove	1.18 kg	424.8kg
Using *mirt* stove	0.78 kg	280.8kg
Saving of per capita firewood using *mirt* stove	0.40 kg	144.0 kg

Table 7. Daily and annual firewood consumption using traditional and improved *mirt* stove
Source: Author (2025)

Effect of mirt stove adoption on women's empowerment dimensions from RBF intervention

The uptake of improved cookstoves (ICS) through the Results-Based Financing (RBF) intervention appears to be driven by several perceived benefits among users (Table 8). Approximately 48.9 percent of *Mirt* stove users reported increased crop production, and 93.6 percent observed a reduction in fuelwood consumption compared to traditional stove use. Additionally, 29.8 percent and 85.1 percent of households noted enhanced employment opportunities and reduced household expenditures, respectively. Significant improvements were also reported in fuelwood collection time (83 percent) and cooking time (91.5 percent).

Health-related benefits were evident, with 80.9 percent, 66 percent, and 85.1 percent of users reporting reductions in illness, fire-related accidents, and smoke exposure, respectively. Moreover, 17 percent of *Mirt* stove users mentioned improvements in social networks as a result of the intervention.

These findings are consistent with previous studies on the benefits of ICS adoption in rural households. For example, Tesfaye et al. (2022)

reported similar health and economic advantages, including reduced fuelwood use, shorter cooking time, and improved health outcomes following the adoption of cleaner cookstoves. Similarly, Wubie et al. (2023) found that ICS adoption contributed to both environmental and socio-economic improvements, such as time savings and reduced household expenses. Together, these studies underscore the multifaceted benefits of ICS adoption, particularly when supported by targeted interventions such as RBF.

Types of changes and improvements	After *mirt* stove intervention
	Percent (%)
Crop production increments	48.9
Fuelwood consumption reduction	93.6
Enhance employment creation opportunities	29.8
Household expenditure reduction	85.1
Time spent for fuel wood collection in hrs.	83.0
Reduction of cooking time	91.5
Reduce sick household member and cost of sickness	80.9
Reduction of fire accidents	66.0
Smoke reduction	85.1
Created Social networks	17.0

Table 8. Improvement of different women empowerment after *mirt* stove intervention
Source: Author (2025)

The results show significant differences between *Mirt* stove users and non-users across several key variables (Table 9). Users of *Mirt* stoves live closer to towns, averaging 38.92 kilometers, compared to 59.61 kilometers for non-users—a statistically significant difference (t = 4.942). *Mirt* stove users also spend less on fuel, with average weekly expenses of 55.46 Ethiopian Birr (ETB) compared to 117.38 ETB for non-users (t = 4.769). Additionally, users tend to have smaller farm sizes, averaging 1.68 hectares, compared to 2.65 hectares among non-users (t = 2.001).

However, there were no significant differences between the two groups in terms of distance to nearby forests, frequency of cooking, or woodlot size. Monthly income for *Mirt* stove users was higher, averaging 12,145.36 ETB, compared to 8,925 ETB for non-users, though this difference was not statistically significant.

These findings are consistent with prior studies highlighting the role of socio-economic factors in influencing improved cookstove (ICS) adoption. For example, Tadesse et al. (2023) and Wubie et al. (2022) found that households with higher incomes are more likely to invest in energy-efficient technologies such as ICS. Similarly, the lower fuel expenses reported by *Mirt* stove users in this study align with previous research, which indicates that adopting clean cookstoves can substantially reduce fuel costs and reliance on traditional biomass sources.

Variables	Respondent	*Mirt* stove		
		Mean	SD	T
Distance nearby forest in (min)	Non-user	39.55	16.79	-1.144
	User	47.10	33.73	
Distance nearby town in km	Non-user	59.61	24.03	4.942***
	User	38.92	20.19	
Frequency of cook per week	Non-user	2.31	0.65	.403
	User	2.26	0.65	
Weekly expense for fuel in ETB	Non-user	117.38	91.57	4.769***
	User	55.46	41.04	
size of Farm land in hectare	Non-user	2.65	3.83	2.001**
	User	1.68	1.66	
Woodlot size in hectare (ha)	Non-user	0.01	0.05	-.892
	User	0.02	0.06	
The monthly income in ETB	Non-user	8925	26423.89	-.637
	User	12145.36	20506.88	

Note: *, ** and *** presents 10%, 5% and 1% level of significance; SD = Standard Deviation

Table 9. Effect of RBF based *mirt* stove adoption on physical assets of women
Source: Author (2025)

Variables	Units	Intervention	Mean	SD	T
Number of educating girls	number	Before	1.59	1.28	2.705***
		After	2.06	1.24	
Number of educating boys	number	Before	1.78	1.27	.657
		After	1.89	1.11	
Fuel consumption/baking	kg	Before	3.06	6.91	4.778***
		After	1.62	4.27767	
Fuel collection /trip	minute	Before	134.92	466.47	1.434
		After	119.84	381.31	
Monthly income	ETB	Before	2441.67	4030.79	-1.208
		After	8049.67	27346.53	
Fuel expenditure/month	ETB	Before	131.06	160.81	2.655***
		After	89.91	112.90	
Number of meals/days	day	Before	2.42	0.78	8.822***
		After	2.93	0.44	
Baking time /week	hours	Before	5.11	15.79	2.713***
		After	3.27	14.08	
Time/ baking	hours	Before	1.87	0.66	13.173***
		After	1.02	0.64	
Saving amount	ETB	Before	1466.82	1639.00	-2.834**
		After	2927.27	3179.87	

Note: ** and *** represents 5% and 1% level of significance; SD= Standard Deviation

Table 10. Effect of mirt stove adoption on women's assets before and after RBF intervention
Source: Author (2025)

The results show significant improvements in several variables following the intervention. The average number of girls receiving education increased from 1.59 to 2.06 (t = 2.705), indicating a positive impact on educational outcomes (Table 10). Fuel consumption for baking declined significantly from 3.06 kilograms to 1.62 kilograms (t = 4.778), while monthly fuel expenditure dropped from 131.06 ETB to 89.91 ETB (t = 2.655). The number of meals per day increased from 2.42 to 2.93 (t = 8.822), and the weekly time spent on baking decreased from 5.11 hours to 3.27 hours (t = 2.713). Additionally, baking time per session was significantly reduced from 1.87 hours to 1.02 hours (t = 13.173).

Monthly income rose from 2,441.67 ETB to 8,049.67 ETB, though this change was not statistically significant (t = -1.208). However, the average amount of savings nearly doubled, increasing from 1,466.82 ETB to 2,927.27 ETB (t = -2.834).

These findings are consistent with previous studies highlighting the benefits of improved cookstoves (ICS) and other energy-efficient interventions. For example, Tadesse et al. (2022) reported similar reductions in fuel consumption and household expenditures following ICS adoption. Furthermore, the increase in daily meals and reduction in cooking time observed here align with the findings of Wubie et al. (2023), which demonstrated that ICS improve household nutrition and contribute to time savings. Overall, the observed improvements in education, energy use, and financial outcomes reflect the broader socio-economic impacts of adopting clean cooking technologies.

Probit estimates of mirt stove adoption of from the RBF intervention

The Probit model estimation results presented the effects of different factors on *Mirt* stove adoption from the RBF intervention (Table 11). The log-likelihood of -31.744, the Pseudo R^2 of 0.4162, and the likelihood ratio chi-square statistic of 29.83 (significant at the 1 percent level) indicate that the overall model is a good fit. The explanatory variables used in the model were collectively able to explain the household's decision regarding the adoption of the *Mirt* stove in the study area. This decision was influenced by a range of socio-economic variables. Some of the variable coefficients were found to be statistically significant.

The study found that family size positively influenced the adoption of *Mirt* stoves, with

larger households more likely to adopt ICS. Larger families typically have greater cooking demands, which increases their need for fuel. This higher demand for cooking energy makes them more inclined to adopt energy-efficient alternatives to reduce fuel costs and save time. This finding is consistent with related studies (Gizachew and Tolera, 2018; Fikru et al., 2023; Wubie et al., 2021; Ashagrie et al., 2024), which also found that larger households in rural areas are more likely to adopt energy-efficient technologies due to increased cooking fuel needs.

In contrast, the study observed that farm size negatively influenced *Mirt* stove adoption. Households with larger farms often have better access to traditional biomass fuels, such as firewood from their own land, which reduces the need to adopt ICS. Larger farms offer a steady supply of fuelwood, making households less motivated to switch to cleaner alternatives. Alemayehu et al. (2022) similarly found that households with access to biomass from their land are less likely to adopt energy-efficient stoves, as they do not face the same fuel scarcity pressures.

The study also found that households with separate kitchens were more likely to adopt the *Mirt* stove. Separate kitchens provide sufficient space and safer conditions for using ICS. These dedicated areas allow households to store and use the new technologies without interfering with daily routines. This finding is supported by Tesfaye et al. (2020) and Gizachew and Tolera (2018), who noted that households with separate kitchens are more likely to adopt improved cooking technologies due to increased space and better conditions for their use.

Proximity to nearby forests was another factor that positively influenced *Mirt* stove adoption. Households located closer to forests are often more aware of the burdens associated with fuelwood collection and are therefore more likely to adopt alternatives that reduce dependency on traditional biomass. This finding is consistent with Wubie et al. (2023), who observed that households near forests are more aware of the limitations of fuelwood availability, leading to greater interest in fuel-efficient solutions. Conversely, households farther from nearby towns were less likely to adopt the *Mirt* stove. This is likely due to reduced access to markets, information, and institutional support needed to facilitate the adoption of new technologies. Fikru et al. (2023) similarly found that rural households with limited access to urban centers face lower adoption rates due to information and resource gaps.

The study also found that households with higher fuel expenditures were more likely to adopt *Mirt* stoves. As fuel costs rise, households are more motivated to seek

Variables	Coef.	Robust Std. Err.	Z	P>|z|
Sex	-0.627	0.565	-1.11	0.267
Age	0.002	0.022	0.10	0.918
Educ	0.037	0.060	0.62	0.536
FAMS	0.189**	0.092	2.04	0.041
FARMSZ	-0.262**	0.122	-2.15	0.031
House type	-0.363	0.403	-0.90	0.368
Separate kitchen	0.803**	0.406	1.98	0.048
Dist. nearby forest	0.014**	0.007	-1.98	0.048
Dist. nearby town	-0.012*	0.007	-1.86	0.063
Log income	0.194	0.141	1.38	0.167
Fuel expenditure	0.010*	0.005	-1.90	0.058
Awareness ICS	2.553***	0.403	6.33	0.000
_cons	-1.533	1.733	-0.88	0.376
Number of obs.	148			
LR $chi^2(12)$	29.83			
Prob > chi^2	0.0030			
Log likelihood	-31.743759			
Pseudo R^2	0.4162			

Table 11. Probit model estimation of *mirt* stove adoption from RBF intervention
Source: Author (2025)

affordable alternatives to traditional cooking. The greater the expenditure, the stronger the incentive to invest in technologies that reduce fuel consumption. This result aligns with Wubie et al. (2021), who noted that households experiencing high fuel costs are more likely to adopt energy-saving technologies for long-term benefits.

Finally, the study found that awareness of ICS had the most significant impact on adoption. Households that were more informed about the benefits of *Mirt* stoves were significantly more likely to adopt them. This highlights the importance of awareness and information campaigns in promoting the uptake of improved cooking technologies. This finding is in agreement with Tesfaye et al. (2020) and Ashagrie et al. (2024), who emphasized that households that are well-informed about the advantages of clean cooking technologies are much more likely to adopt them.

Conclusions

The results of the study highlight several key impacts of the *Mirt* stove intervention through the RBF mechanism. Implemented as part of this results-based approach, the intervention has had a positive impact on women's lives by improving time management, health, and economic well-being. By reducing the time spent collecting firewood and cooking, women were able to dedicate more time to productive activities, which improved their overall quality of life. The stoves also helped reduce fuelwood consumption, contributing to household financial savings and reducing environmental degradation associated with traditional cooking methods.

Furthermore, the intervention contributed to improved indoor air quality, benefiting women and children by lowering exposure to smoke-related health risks. Women's empowerment emerged as a critical outcome, reflected in greater participation in household decision-making, stronger social networks, increased income generation, and more autonomy in household spending and reproductive health choices. The environmental benefits were also evident through decreased firewood use, which helped reduce pressure on natural forests and promoted more sustainable fuelwood practices. Economically, the savings from reduced fuelwood expenses were often redirected toward essential needs such as education, healthcare, and small businesses, thereby supporting greater financial stability. In addition, the local production and maintenance of *Mirt* stoves created employment opportunities, especially for women, and contributed to promoting gender equality in the community.

To build on these outcomes, it is recommended that *Mirt* stove adoption be expanded, with particular focus on accessible financing options for women in rural areas. Community-based awareness campaigns should be implemented to inform women about the health, environmental, and economic benefits of these stoves. Additional support for women's involvement in local decision-making and resource governance will further strengthen the long-term sustainability of such interventions. Integrating *Mirt* stove dissemination into broader development programs, including income-generating initiatives and education efforts, may enhance the empowerment impact and ensure that the benefits reach more women and families in rural communities.

Acknowledgements:

The author gratefully acknowledges the financial support from the GIZ EnDev Ethiopia for data collection costs.

Conflict of interest:

The author declares no competing interest

References

Adama, G., Alemu, A., & Kassa, B. (2023). The role of gender-focused interventions in promoting social empowerment: A study of rural Ethiopia. *Journal of Gender Studies, 32*(3), 250-264.

Adhikari, B., Kang, S. S. Y., Dahal, A., Mshamu, S., Deen, J., Pell, C., von Seidlein, L., Knudsen, J., & Bøjstrup, T. C. (2025). Acceptability of improved cook stoves—a scoping review of the literature. *PLOS Global Public Health*, *1*(1), e0004042. https://doi.org/10.1371/journal.pgph.0004042

Adugna, T., Bekele, T., & Yilma, Z. (2021). The empowerment effects of clean cookstoves on rural women's decision-making in Ethiopia. *Journal of Gender and Development, 30*(2), 302-316.

Alvi, M., Vemireddy, V., Ringler, C., & Tank, N. (2023). Developing a women's empowerment

in energy index: Conceptual framework and empirical evidence. https://hdl.handle.net/10568/137108

Ashagrie, T. A., Asabie, S. G., Alemu, W. M., Tadesse, A. S., Dires, T., & Maru, G. (2024). Perception and barriers to improved charcoal cookstoves adoption in Wereta, Ethiopia. *BMC Public Health, 24*(1), 3454. https://doi.org/10.1186/s12889-024-20938-3

Ayele, T., Dibaba, B., & Muluye, T. (2022). Women's empowerment through clean energy technologies: A case study of improved cookstoves in Ethiopia. *International Journal of Sustainable Development, 17*(1), 45-56.

Barnes, D. F., & Samad, H. (2018). *Measuring the benefits of energy access: A handbook for development practitioners*. Inter-American Development Bank.

Belachew, A. (2024). Impacts of results-based financing improved cookstove intervention on households' livelihood: Evidence from Ethiopia. *Forest Policy and Economics*, *158*, 103096. https://doi.org/10.1016/j.forpol.2023.103096

Belachew, A., & Melka, Y. (2023). Preferences and adoption of improved cookstove from results-based financing program in Southeastern Ethiopia. *Frontiers in Energy Research*, *11*, 1147545. https://doi.org/10.3390/en14154559

Benti, N. E., Gurmesa, G. S., Argaw, T., Aneseyee, A. B., Gunta, S., Kassahun, G. B., ... & Asfaw, A. A. (2021). The current status, challenges and prospects of using biomass energy in Ethiopia. *Biotechnology for Biofuels*, *14*, 1-24. https://doi.org/10.1186/s13068-021-02060-3

Berg, S., Ivarsson, R., & Sellén Stackegård, A. (2024). Clean Cooking in Makueni County: An Exploration of Multi-Stakeholder Interventions Needed for Increased Adoption in Rural Kenya.

Bhattacharya, S. (2025). Gender Dimension of Climate Vulnerability and Energy Transition: A Theoretical Perspective. In The Intersection of Global Energy Politics and Climate Change: A Comprehensive Analysis of Energy Markets and Economics (199-218). Singapore: Springer Nature Singapore. DOI: https://doi.org/10.1007/978-981-96-0535-4_9

Central Statistical Agency of Ethiopia (CSA). (2007). Population and Housing Census of Ethiopia. Available at: https://en.wikipedia.org/wiki/Gedeb_Asasa (Accessed: 4 March 2025).

Chandrasekaran, M. (2024). Energy Access, Time Use, and Women's Empowerment in Low-and Middle-Income Countries (Doctoral dissertation, Duke University). Retrieved from https://hdl.handle.net/10161/30841.

Choragudi, S. (2024). Do all the empowered women promote smokeless kitchens? Investigating rural India. *Journal of Cleaner Production, 447*, 140903. https://doi.org/10.1016/j.jclepro.2024.140903

Choudhuri, P., & Desai, S. (2020). Gender inequalities and household fuel choice in India. *Journal of cleaner production, 265*, 121487. https://doi.org/10.1016/j.jclepro.2020.121487

City Population. (2022). Gedeb Asasa (Woreda, Ethiopia). Available at: https://www.citypopulation.de/en/ethiopia/admin/oromia/ET041706__gedeb_asasa/ (Accessed: 4 March 2025).

Clasen, T., & Smith, K. R. (2019). Let the "A" in WASH stand for air: integrating research and interventions to improve household air pollution (HAP) and water, sanitation and hygiene (WaSH) in low-income settings. *Environmental health perspectives*, *127*(2), 025001.

Derebe, B., Alemu, A., & Asfaw, Z. (2025). Fuelwood dependence and alternative energy sources in Ethiopia: a systematic review. *Discover Sustainability*, *6*(1), 99. https://doi.org/10.1007/s43621-024-00721-5

Fikru, M., Tadesse, A., & Wubie, A. (2023). Drivers of improved cookstove adoption in rural Ethiopian households: Evidence from a field study. *Renewable Energy, 170*, 779-787. https://doi.org/10.1016/j.renene.2021.08.032

Gebreegziabher, Z., Amsalu, A., & Belay, A. (2020). Rural energy consumption patterns and the role of biomass in Ethiopia: Evidence from the rural household survey. *Energy Policy, 146*, 111866. https://doi.org/10.1016/j.enpol.2020.111866

Gebreegziabher, Z., Mekonnen, A., Kassie, M., & Kohlin, G. (2018). ***Household Tree Planting in Tigrai, Northern Ethiopia: Tree Species, Purposes, and Determinants***. Environment for Development Discussion Paper Series.

Gebremedhin, T., Amsalu, A., & Tsegaye, B. (2021). Fuelwood sourcing and its impact on rural energy consumption in Ethiopia: A case study in the Amhara region. *Energy for Sustainable Development, 60*, 56-64. https://doi.org/10.1016/j.esd.2020.09.005

Getnet, L. A., Meku, A. A., Getie, M. Z., & Mebratu, M. M. (2023). Technological Development and Adoption Rates of Injera Baking Stoves: A Review. *Advancement of Science and Technology: Materials and Energy*, 199-223. https://doi.org/10.1007/978-3-031-33610-2_11

Gizachew, B. and Tolera, M., 2018. Adoption and kitchen performance test of improved cook stove in the Bale Eco-Region of Ethiopia. *Energy for sustainable development*, *45*, pp.186-189.

GIZ-EnDev. (2020). *Improved cookstoves and result-based financing in Ethiopia*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Goldrey, B., et al. (2024). Financing clean energy transitions: Addressing barriers and promoting sustainable development. *Renewable Energy, 45*(2), 122-138.

Habib, M., Ejaz, L., & Alvi, G. F. (2024). Empowering Women's Educational Journeys: Navigating Challenges in Pursuit of Higher Education in Dera Ghazi Khan. *Journal of Development and Social Sciences, 5*(3), 19-33. DOI: https://doi.org/10.47205/jdss.2024(5-III)03

Jagoe, K., Rossanese, M., Charron, D., Rouse, J., Waweru, F., Waruguru, M., ... & Ipe, J. (2020). Sharing the burden: Shifts in family time use, agency and gender dynamics after introduction of new cookstoves in rural Kenya. *Energy Research & Social Science, 64*, 101413. https://doi.org/10.1016/j.erss.2019.101413

Karber, K. M. (2018). *Theory of Change for Off-Grid Solar Uptake in Emerging Economies: A Means to Identify Drivers and Barriers, and Develop Appropriate Interventions* (Doctoral dissertation, University of Colorado at Boulder).

Kassa, A., Tadesse, A., & Assefa, M. (2023). The role of natural forests in rural household energy consumption in East Africa: A review of trends and challenges. *Renewable Energy, 191*, 1184-1193. https://doi.org/10.1016/j.renene.2022.07.030

Krishnapriya, P. P., Chandrasekaran, M., Jeuland, M., & Pattanayak, S. K. (2021). Do improved cookstoves save time and improve gender outcomes? Evidence from six developing countries. *Energy Economics, 102*, 105456. https://doi.org/10.1016/j.eneco.2021.105456

Leary, J., Menyeh, B., Chapungu, V., & Troncoso, K. (2021). eCooking: challenges and opportunities from a consumer behaviour perspective. *Energies, 14*(14), 4345. https://doi.org/10.3390/en14144345

Lee, Y. J., Husain, Z., & Dutta, M. (2024). Does improved cooking fuel empower women? Evidence from India. *Sustainable Development, 32*(1), 574–587. https://doi.org/10.1002/sd.2695

Musafili, I., Ayuya, O. I., Birachi, E. A., & Ngabitsinze, J. C. (2024). Assessing the effect of women empowerment on labor time allocated to soil and water conservation strategies in northern rwanda. *GeoJournal, 89*(4), 161. DOIhttps://doi.org/10.1007/s10708-024-11018-5

Nguyen, C. P., & Su, T. D. (2021). The 'vicious cycle'of energy poverty and productivity: insights from 45 developing countries. *Environmental Science and Pollution Research, 28*(40), 56345-56362. https://doi.org/10.1007/s11356-021-14614-x

Nguyen-Phung, H. T., & Nthenya, N. N. (2024). The causal effect of education on women's empowerment: evidence from Kenya. *Education Economics, 32*(2), 210-228. https://doi.org/10.1080/09645292.2023.2202370

Pattanayak, S. K., Jeuland, M., Lewis, J. J., Usmani, F., Brooks, N., Bhojvaid, V., & Ramanathan, V. (2019). Experimental evidence on promotion of electric and improved biomass cookstoves. *Proceedings of the national Academy of Sciences, 116*(27), 13282-13287. https://doi.org/10.1073/pnas.1808827116

Rosenthal, J., Quinn, A., Grieshop, A. P., Pillarisetti, A., & Glass, R. I. (2018). Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals. *Energy for Sustainable Development, 42*, 152–159. https://doi.org/10.1016/j. esd.2017.11.003

Stritzke, S., Bricknell, M., Leach, M., Thapa, S., Khalifa, Y., & Brown, E. (2023). Impact financing for clean cooking energy transitions: reviews and prospects. *Energies, 16*(16), 5992. https://doi.org/10.3390/en16165992

Stritzke, S., Sakyi-Nyarko, C., Bisaga, I., Bricknell, M., Leary, J., & Brown, E. (2021). Results-based financing (RBF) for modern energy cooking solutions: An effective driver for innovation and scale? *Energies, 14*(15), 4559. https://doi.org/10.3390/en14154559

Tadesse, A., Wossen, T., & Dagne, T. (2022). Biomass energy use and household energy consumption in rural East Africa: A review of the literature. *Renewable and Sustainable Energy Reviews, 148*, 111321. https://doi.org/10.1016/j.rser.2021.111321

Tadesse, A., Wossen, T., & Kassa, A. (2022). Impact of improved cookstoves on household energy consumption and socio-economic outcomes in rural Ethiopia. *Renewable and Sustainable Energy Reviews, 154*, 111754. https://doi.org/10.1016/j.rser.2022.111754

Tadesse, A., Wossen, T., & Kassa, A. (2023). Factors influencing the adoption of improved cookstoves in rural households of Ethiopia. *Renewable and Sustainable Energy Reviews, 158*, 112233. https://doi.org/10.1016/j.rser.2022.112233

Tesfaye, F., Alemayehu, M., & Gebru, A. (2020). Evaluating the adoption of improved cookstoves in Ethiopia: Role of awareness and socio-economic factors. *Renewable and Sustainable Energy Reviews, 129*, 109924. https://doi.org/10.1016/j.rser.2020.109924

Tesfaye, F., Alemayehu, M., & Gebru, A. (2022). The role of social networks in the adoption of improved cookstoves in rural Ethiopia. *Energy for Sustainable Development, 66*, 105-113. https://doi.org/10.1016/j.esd.2022.06.005

Tesfaye, M., Teshome, K., & Degu, S. (2022). Gender equality and social empowerment through improved cookstove adoption: Insights from rural Ethiopia. *Development in Practice, 42*(5), 563-578.

Tesfaye, S., Tadesse, W., & Zewdu, S. (2016). Indoor air pollution and health benefits of improved cooking technologies in Ethiopia: A case study of the Mirt stove. *Journal of Environmental Health, 78*(4), 104-112.

Verplanken, B. (2018). Promoting sustainability: Towards a segmentation model of individual and household behaviour and behaviour change. *Sustainable Development, 26*(3), 193–205. https://doi.org/10.1002/sd.1694

Winther, E. (2018). Kompetenzerfassung und-entwicklung in der Bildungsforschung. *Handbuch Bildungsforschung*, 1055-1070. DOI: https://doi.org/10.1007/978-3-531-19981-8_46

World Bank (2021). *Results-Based Financing for Clean Cooking: Scaling Sustainable Energy Solutions in Africa*. World Bank Group Report.

World Health Organization. (2022). *The Global Health Observatory, Air Pollution Data*. https://www.who.int/data/gho/data/themes/air-pollution

WorldAfropedia. (2025). *Gedeb Asassa Woreda Overview*. Available at: https://worldafropedia.com/w/Gedeb (Accessed: 4 March 2025).

Wubie, A., Tadesse, A., & Fikru, M. (2021). The role of socio-economic factors in the adoption of improved cookstoves in rural Ethiopia. *Energy for Sustainable Development, 62*, 58-66. https://doi.org/10.1016/j.esd.2021.06.005

Wubie, A., Tadesse, A., & Fikru, M. (2023). Barriers to the adoption of clean cooking technologies: Insights from rural East Africa. *Renewable and Sustainable Energy Reviews, 158*, 112051. https://doi.org/10.1016/j.rser.2023.112051

Yirga, A., Desta, B., & Kebede, M. (2021). Improved cookstoves and women's empowerment in rural Ethiopia: A social capital approach. *Journal of Rural Development, 45*(4), 512-527.

Yumkella, K., Batchelor, S., Haselip, J. A., & Brown, E. (2021). Solving the clean cooking conundrum in Africa: Technology options in support of SDG7 and the Paris Agreement on Climate Change. *In Scaling up investment in climate technologies: Pathways to realising technology development and transfer in support of the Paris Agreement* (pp. 13-26).