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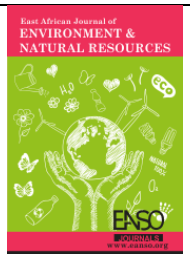

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Original Article

Contribution of Improved Cook Stoves to the reduction of wood fuel consumption in Rutsiro District, Rwanda

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Improved Cook Stove, Wood fuel, Stove quality, Stove cost, Household Characteristics.

ABSTRACT

This study aimed to examine the contribution of Improved Cook Stoves (ICS) in reducing wood fuel consumption in Rutsiro District, Rwanda. The research focused on three specific objectives: identifying the level of ICS utilization, assessing the reduction in wood fuel consumption and finding out whether there is any relationship between ICS usage and wood fuel consumption. A mixed-methods approach was adopted, incorporating both quantitative and qualitative research designs. The study targeted over 28,555 households in five sectors near Gishwati-Mukura forests in Rutsiro District, and 395 households were selected as sample size through Yamane's formula and stratified random sampling technique. Data were collected using questionnaires and documentary review and data were analyzed with SPSS software, employing descriptive and inferential statistics, including multiple linear regression. Analysis using descriptive statistics and multiple linear regression revealed that household characteristics (mean = 4.32), awareness levels (mean = 4.50), and stove quality (mean = 4.31) had a statistically significant and positive impact on reducing wood fuel consumption. However, stove cost, despite a high average score (mean = 4.45), did not show a significant effect. These factors were found to be more important than the stove cost, which was perceived as high but did not significantly affect fuel reduction. This highlights the crucial role of awareness, stove quality, and behavioural factors in the adoption and success of ICS. The study concluded that addressing the financial barrier to stove adoption, while important, is less significant than improving public awareness, stove quality, and behavioural change. The study recommended that the government and development partners prioritize awareness campaigns to promote the benefits of ICS. Additionally, financial incentives, subsidies, and better access to affordable payment options should be introduced to make ICS more accessible.

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INTRODUCTION

The use of improved cook stoves leads to a decrease in firewood consumption, which contributes to lower deforestation rates and enhances carbonization efficiency. This shift also plays a role in cutting down greenhouse gas emissions (Steve, 2020). Moreover, improved cookstoves help save time during cooking and reduce the hours spent collecting firewood, allowing individuals to focus on other productive activities (Ruiz *et al*., 2011).

China is one of the countries that has had successful improved cookstoves programs. By the early 1990s, the country had distributed around 120 million improved stoves to rural communities. According to Puzzolo *et al.* (2014), this success was largely due to a well-structured program design and effective implementation. Key strategies included focusing on regions with the greatest need, selecting pilot counties facing biomass shortages, and streamlining operations through direct agreements between the central government and local authorities. This approach reduced bureaucratic delays and fostered the growth of self-sustaining rural energy enterprises that produced, installed, and maintained stoves and related energy technologies.

In Kenya, approximately 90% of rural households rely on wood fuel, primarily in the form of firewood or charcoal (MoE, 2022). Wood fuel supplies more than 93% of energy needs in rural areas, while charcoal remains the primary source of cooking energy in urban settings (Kituyi 2003 cited in Mwawura, 2020). Beyond household use, wood fuel also plays a critical role in powering small-scale rural industries such as tobacco curing, tea drying, brick making, fish smoking, and local bakeries (Githiomi, 2021).

According to a World Bank report on the adoption of Liquefied Petroleum Gas (LPG), Rwanda aims to achieve 25% household usage of LPG by 2030. In contrast, countries like Angola have already reached 80% LPG usage and are targeting full adoption by 2025. (Kristin and Eva 2017) highlight that high firewood consumption in both rural and urban areas poses a significant environmental challenge. To address this, the Government of Rwanda and the Rwanda Energy Group have been actively promoting the use of LPG as the primary energy source for cooking, aiming to reduce reliance on firewood and charcoal (Čukić *et al.*, 2021).

Statement of the Problem

In Rutsiro District, the persistent reliance on traditional cookstoves continues to drive high woodfuel consumption, placing immense pressure on local forests, particularly Mukura and Gishwati. These forests have experienced severe degradation due to firewood collection, agricultural expansion, and illegal mining. In response, the Government of Rwanda gazetted Gishwati and Mukura as the country's fourth national park in 2016 to prevent further destruction and combat desertification.

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Despite these efforts and policies promoting affordable and sustainable energy solutions, many households still depend heavily on firewood and biomass fuels for essential domestic activities, including cooking, water boiling, heating, and lighting. This ongoing dependency perpetuates deforestation, exacerbates environmental degradation, and undermines long-term sustainability.

The loss of forest resources diminishes carbon sequestration capacity, contributing to climate change, reducing the resilience of local ecosystems and negatively impacting community livelihoods. Women and children, often tasked with collecting firewood, spend long hours travelling to and from forests, exposing them to safety risks, gender-based violence, and health complications. This time-consuming activity reduces educational opportunities for children and limits economic productivity. Moreover, households that lack direct access to forested areas must purchase firewood, incurring substantial costs that strain household income and perpetuate poverty. To mitigate these challenges, the Rwandan government and non-governmental organizations have introduced improved cook stoves (ICS) across the Rutsiro District, especially in sectors bordering Mukura and Gishwati forests. These stoves are designed to enhance energy efficiency, reduce firewood consumption, lower indoor air pollution, and alleviate economic burdens. Despite various initiatives to promote improved cook stoves, their actual contribution to the reduction of wood fuel usage, community resilience and sustainable environment remain insufficiently quantified and understood. Therefore, this study sought to examine the contribution of the improved cook stove to the reduction of wood fuel consumption in Rutsiro District.

Research Objectives

General Objective

To examine the contribution of Improved Cook Stoves to the reduction of wood fuel consumption in Rutsiro District.

Specific Objectives

The study was guided by the following specific objectives:

- To identify the level of Improved Cook Stove (ICS) utilization in Rutsiro District.
- To assess the level of reduction of wood fuel consumption in Rutsiro District.
- To determine the relationship between Improved Cook Stove and wood fuel consumption in Rutsiro District

LITERATURE REVIEW

Theoretical Review

This study is based on two theories namely: the environment and social theory, the fuel wood gap theory and Schumpeter's theory:

Environment and Social Theory

This study is grounded in environmental and social theory, which explores the intricate relationship between nature, the environment, and societal structures (Barry, 2007). It examines how social theory has historically engaged with environmental issues, including the way major world religions have interpreted the natural world. The theory also highlights the influence of non-human environmental elements in the works of prominent Western philosophers such as Rousseau, Malthus, Marx, Mill, Freud, and thinkers from the Frankfurt School. Additionally, the perspectives of modern theorists like Habermas, Giddens, and Dawkins are considered, along with debates sparked by environmental sceptics like Lomborg.

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This framework promotes a multidisciplinary green social theory that merges insights from both the natural and social sciences. It brings together knowledge from fields such as evolutionary biology, ecology, and physics with perspectives from sociology, politics, and ethics. Barry (2007) argues that today's environmental challenges differ significantly from those faced by previous generations, primarily because contemporary human activities have the potential to cause irreversible harm to the planet. This underscores the importance of acknowledging that the environment an ancient and essential system supporting all life can no longer be viewed as an inexhaustible resource.

Schumpeter's Theory

Schumpeter's theory emphasizes that innovation is central to entrepreneurship and the process of generating wealth. He viewed entrepreneurs as agents of change who seek temporary monopolies by introducing novel ideas or methods (Wickman, 2006). According to this perspective, entrepreneurs not only generate new knowledge but also apply it in ways that were previously absent from the economic landscape, often triggering significant transformations across the economy. Schumpeter argued that entrepreneurial ventures must introduce something new be it a product, service, or process to justify their market presence. Innovation, in his view, includes the introduction of entirely new offerings or improvements in the way existing products or services are delivered, particularly if such changes make them more accessible or cost-effective for consumers (Wickman, 2006). In this context, providers of improved energy-saving cookstoves identified a gap in rural markets and capitalized on it by establishing distribution channels that reached even the village level. This approach allowed them to offer affordable, innovative products that reshaped market dynamics. Schumpeter's theory thus helps explain how household characteristics can influence the adoption and use of improved cook stoves.

Empirical Review

Iyakaremye *et al*. (2019) conducted a study aimed at evaluating and comparing different types of burnt clay stoves to identify the most fuel-efficient model for recommendation to rural households. The developed stoves are designed to reduce firewood consumption, thereby decreasing deforestation rates and mitigating harmful indoor air pollution. The study involved five stove models developed by the College of Agriculture, Animal Sciences, and Veterinary Medicine (CAVM), alongside a local three-stone open-fire stove used as a control.

The study included cooking and boiling tests to evaluate the thermal efficiency of the stoves. Results showed that Model 5 outperformed the other models, requiring only 25% of the firewood needed by the local stove model. The thermal efficiency of Model 5 was found to be 27.61%, compared to just 8.46% for the local stove. Statistical analysis revealed significant differences in boiling and cooking times across the different stoves, with Model 5 showing the best performance in all aspects, including wood consumption. The study concluded that Model 5 should be adopted and promoted for use in rural households due to its environmental benefits and potential contributions to poverty reduction, by saving both fuel and time.

Rubabaza (2019) explored the impact of firewood consumption on environmental degradation in Musanze District, Rwanda, focusing on a period from March 2020 to March 2019. The study had four specific objectives: (1) to assess the effects of firewood consumption on environmental degradation over the last five years in Musanze District, (2) to examine the link between firewood use and environmental damage, (3) to identify necessary emergency responses to mitigate the effects of firewood use on the environment, and (4) to propose strategies to reduce firewood consumption and environmental degradation.

The literature review highlighted that firewood usage significantly contributes to environmental

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damage. The study found that most rural residents in Musanze District prefer using firewood for heating during colder seasons. According to the results, 94% of respondents agreed that the government should increase efforts to encourage alternative cooking energy sources. The study also demonstrated a strong positive relationship between species destruction and rapid industrialization ($p = .917$ with significance at 0.01 level). The study further identified socio-cultural factors, particularly conservative behaviour, as the key drivers influencing emergency responses to mitigate the negative impacts of firewood usage.

Additionally, the research found that Liquefied Petroleum Gas (LPG) was more affordable than other energy sources considered. Based on these findings, the study concluded that raising awareness, mobilizing the community, and enforcing environmental protection regulations and policies could help mitigate the effects of environmental degradation. The study recommended promoting LPG as a more affordable, safer, and cleaner energy option, enhancing safety awareness regarding its use, and strengthening regulatory measures on environmental protection. Furthermore, the study called for additional research on the impacts of mining activities, deforestation, fire incidents, and the use of biomass on environmental protection.

Nshimiyimana (2021) conducted a study on the socio-economic factors influencing the adoption of modern energy technologies in households, using panel data from the third, fourth, and fifth Integrated Household Living Standards Surveys (EICV 5) conducted by the National Institute of Statistics of Rwanda. The study employed binary logistic regression analysis and found that the household's type of habitat, the age of the household head, and the household's location were significant factors influencing the adoption of improved cook stoves. Additionally, factors related to the stove and fuel, such as the cost of the cook stove, the amount spent on cooking fuel, and the time spent on cooking, were key determinants of the adoption and usage of improved cook stoves. The study concluded that achieving a substantial increase in the adoption rate of these technologies requires consistent and focused collaboration between the government and non-governmental organizations, specifically through the development and dissemination of modern energy technology policies.

Kelly (2015) carried out a study to examine how improved technologies and market-driven strategies could support forest conservation and biodiversity protection in Rwanda. Their research focused on evaluating two main conservation strategies implemented in Nyungwe National Park: the promotion of improved cook stove technologies and the use of market-based policy tools. A household survey involving 250 participants, conducted in June 2020, revealed that the adoption of improved cook stoves significantly decreased firewood consumption among rural communities. Despite this positive outcome, several obstacles including issues related to stove design, technical functionality, and inconsistent policy frameworks were found to hinder the broader use of these efficient cooking solutions.

In the second phase of the study, the researchers applied the Analytic Hierarchy Process (AHP) within a Multi-Criteria Analysis (MCA) framework to assess different market-based instruments (MBIs) that could support Rwanda's conservation agenda, particularly in the ecologically diverse Nyungwe National Park. Stakeholder workshops were organized in June, October, and November 2020, involving both local actors (such as farmers and cooperative members) and national-level stakeholders (including environmental organizations and government officials). Through these sessions, participants identified key evaluation criteria for the MBIs and prioritized them. National experts then evaluated the potential of each proposed instrument to contribute to conservation targets. The study concluded by offering practical recommendations for the

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development and implementation of effective market-based tools to support biodiversity conservation in Rwanda.

Research Gap

Based on the reviewed literature, it is apparent that while research on wood fuel and Improved Cook Stoves (ICS) has been conducted in various parts of the world, previous studies have not clearly established the impact of ICS on reducing fuel wood consumption. Many of these studies did not utilize all variables to assess the actual contribution of ICS to fuel wood reduction. This study added to the existing literature by providing empirical evidence on the influence of household characteristics, level of awareness of stove quality and stove cost on the utilization of improved cook stoves for the reduction of wood fuel consumption. Additionally, both descriptive and inferential statistical methods were employed to evaluate the effects and relationships between ICS usage and fuel wood consumption reduction.

MATERIAL AND METHODS

Description of Study Area

Rutsiro District is one of seven Districts of Western Province in Rwanda. Despite the multiple economic, social, environmental, and health benefits of improved cook-stoves (ICS) in Rutsiro District, their adoption is still very low; there were some efforts by governmental and non-governmental organizations in disseminating different improved cook-stoves in Rutsiro District, especially in the sectors approaching Gishwati and Mukura forests in order to protect those forests from destroying them collecting wood fuel. Rutsiro District covers an area of 679 square kilometres in Rwanda's Western Province. It is bordered by the Democratic Republic of Congo to the west, Rubavu District to the north, Karongi District to the south, and Nyabihu District to the east. As one of the seven Districts in the Western Province, Rutsiro is also surrounded by Nyamasheke, Rusizi, Karongi, Ngororero, Nyabihu, and Rubavu Districts. The District plays a critical role in transportation, being located along the Kivu Belt Road, which connects the western Districts of Rusizi, Nyamasheke, and Karongi to Rubavu in the northwest, facilitating access to the Democratic Republic of Congo through the Rubavu and Rusizi border crossings. Administratively, Rutsiro is divided into 13 sectors, 62 cells, and 483 villages (NISR, 2019). According to the provisional results of the 2019 population census, the District has a total population of approximately 324,654 inhabitants, with 154,044 males (47.4%) and 170,610 females (52.6%) (NISR, 2019). The District's population density is 281 people per square kilometre, with an average annual growth rate of 2.0% (NISR, 2019). Additionally, Rutsiro District is characterized by a rich forest cover, including parts of the Gishwati-Mukura Forest, which has been designated as Rwanda's fourth national park, playing a vital role in biodiversity conservation and climate regulation.

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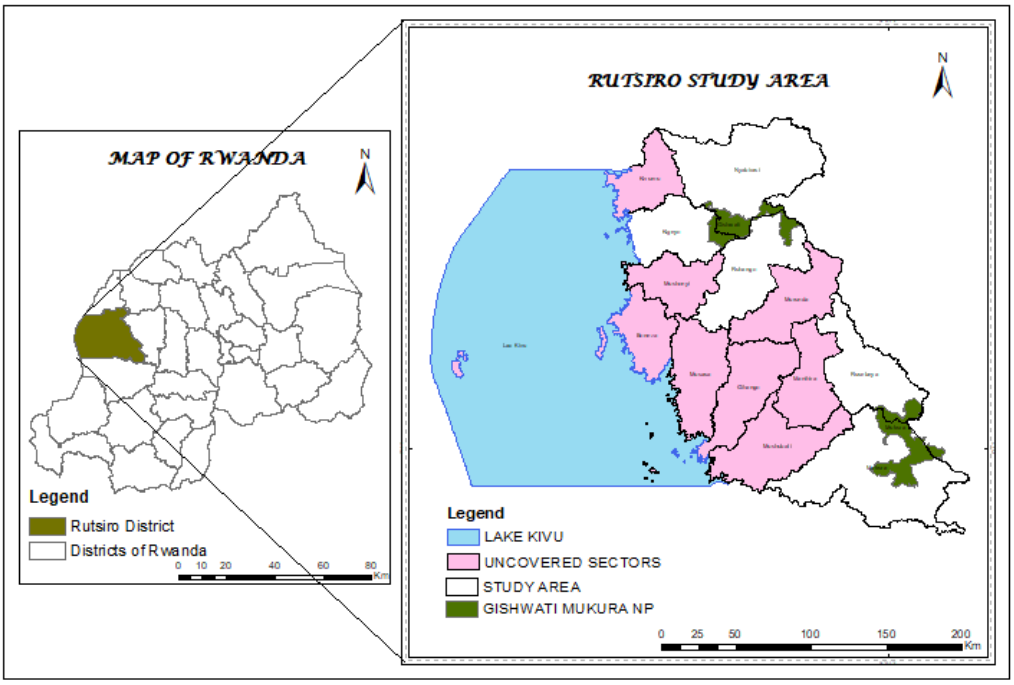
Map of Study Area



Source: *Researcher, 2025*

Target Population

The target population comprises 28,555 households from Kigeyo, Mukura, Nyabirasi, Ruhango and Rusebeya Sectors crossing Mukura and Gishwati forests and land managers of Rutsiro District.

Table 1: Population Size

Sector	Population	Target population (households)
Kigeyo	14,867	5,253
Mukura	21,039	6,511
Nyabirasi	17,077	5,079
Ruhango	17,624	5,780
Rusebeya	13,417	5,932
Total	**84,024**	**28,555**

Source: Rutsiro District report, 2018

Sample Size

A sample refers to a group of individuals chosen from a larger population, typically to represent that population in a research study (Newing, 2011). The primary aim of the research is to examine the sample and extend the findings to the broader population. The ability to generalize the results from a sample to the population depends on how representative the sample is. In this study, the sample consists solely of households in Rutsiro District. The sample size was calculated using Slovin's Formula (Yaman, 1967), which is outlined as follows:

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

Where n is the sample size, N is the population size = 28,555 and e is the level of precision = 5%.

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All those households in Rutsiro District

$$n = \frac{28{,}555}{1 + 28{,}555\ (0.05)^2} = 394.47 \approx 395$$

Table 2: Sample Size

Sector	Population size	Sample size $ni = \frac{Ni * n}{N}$
Kigeyo	5,253	70
Mukura	6,511	100
Nyabirasi	5,079	81
Ruhango	5,780	83
Rusebeya	5,932	64
Total	**28,555**	**395**
District Land manager	**1**	**1**
Total	**28,556**	**396**

Source: Researcher, 2025

This study collected data on 395 households and the Land manager of Rutsiro District

Sampling Techniques

Sampling techniques refer to the methods used by researchers to select individuals, units, or elements for a study. It involves choosing a subset from a larger population in a way that the selected group accurately reflects the characteristics of the overall population (Kombo & Tromp, 2006). Since the study does not involve the entire population, stratified random sampling was applied to ensure effective coverage of the study area and to include a representative number of respondents from each group within the population. Additionally, purposive sampling was employed to gather specific information from the land manager of Rutsiro District.

Data Collection Instruments

Questionnaires: A questionnaire was employed as the primary tool for gathering detailed information on the contribution of agricultural projects to the livelihoods of their beneficiaries. As Kothari (2018) highlights, this method facilitates a higher response rate and allows for more precise sampling. However, he also emphasizes the importance of properly briefing respondents to avoid unintentional bias that could affect the validity of the results. In alignment with the study's conceptual framework, the questionnaire was structured to capture data related to specific research variables. It incorporated both closed-ended and open-ended questions. Closed-ended items were used to collect quantifiable responses, particularly regarding household perceptions of Improved Cook Stoves and wood fuel usage. These questions included predetermined answer options and utilized a five-point Likert scale to measure the extent to which key variables were present in the population. Additionally, open-ended questions were included to provide respondents with the opportunity to elaborate on their experiences and opinions, offering richer insights into the use of Improved Cook Stoves and their impact on reducing wood fuel consumption in Rutsiro District.

Documentary review: In this approach, the researcher assessed the reliability, relevance, and adequacy of the collected data. This method was instrumental in obtaining supplementary information that supported and enriched the primary data gathered through questionnaires. Various sources such as books, academic journals, official reports from Rutsiro District, and other documented materials related to Improved Cook Stoves (ICS)

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and wood fuel usage were reviewed to provide a comprehensive understanding of the subject matter.

Data Analysis

Descriptive statistics were employed to summarize the basic characteristics of the data in the study, utilizing measures such as mean and standard deviation. This method was used to describe respondents' views on household characteristics related to using Improved Cook Stoves (ICS), their level of awareness about ICS, stove quality, stove cost, and the reduction of wood fuel consumption in Rutsiro District.

To explore the relationship between ICS and the reduction of wood fuel consumption, multiple regression analysis was applied. This analysis helped identify how household characteristics, awareness levels, stove quality, and stove cost influenced fuel consumption reduction. The study used a specific regression model to assess the impact of ICS on fuel consumption.

The multiple regression models are as laid below.

$Y = \beta 0+\beta_1 x_1+\beta_2 x_2+\beta_3 x_3+\beta_4 x_4+e$

Where: Y = Reduction of wood fuel consumption

{βi; i=1,2,3 and 4} = The coefficients representing the various independent variables. B0 = the Y-intercept

{Xi; i=1,2,3 and 4} = Values of the various independent (covariates) variables.

e = the error term which is assumed to be normally distributed with mean zero and constant variance

X1= Household characteristics in using ICS

X2 = Level of awareness in using ICS

X3= Stove quality

X4= Stove cost

RESEARCH RESULTS

Descriptive Results

Household Characteristics in Using ICS

The study sought to assess the Household characteristics in using ICS. Respondents were asked to indicate whether they agreed or disagreed with statements concerning how household characteristics influence the reduction of wood fuel consumption in Rutsiro District.

Table 3: Household Characteristics in Using ICS

Mean	St. dev	Mean
Older people tend to be conservative in accessible new cooking technology (ICS)	4.26	1.22
Household characteristics reduces risks of ICS failure	4.23	.97
Household characteristics enhances the quality and quantity operations of ICS	4.35	.88
It increased number of dealers of ICS in Rutsiro District	4.51	.72
It enhances decision-making and problem-solving on the adoption of cooking technology	4.36	.62
Single women are more likely to accept cooking technology	4.58	.89
Married women's decision to adopt new technology is affected by their spouses	3.95	1.25
Overall mean	4.32	0.93

Source: *Primary data, 2025*

Regarding household characteristics in using ICS, the results in Table 3 indicate that older people tend to be conservative in accessible new cooking technology (ICS) with (a mean of 4.26 and a

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standard deviation of 1.22). Household characteristics reduces risks of ICS failure with (Mean= 4.23 and Standard deviation= 0.97). The findings revealed that Household characteristics enhances the quality and quantity operations of ICS with (Mean= 4.35 and Standard deviation= 0.88). The results indicated that it increased the number of dealers of ICS in Rutsiro District with (Mean= 4.36 and Standard deviation= 0.62). The findings show that Single women are more likely to accept cooking technology (Mean=4.58 and Standard deviation=0.89) and the findings show that married women's decision to adopt new technology is affected by their spouses (Mean=3.95 and Standard deviation=1.25).

The overall views on household characteristics in using ICS were at a high extent with a very high mean score of 4.32 which implies that there is strong evidence of the existing fact that household characteristics in using ICS were at a very high extent. Lewis and Pattanayak (2019) concluded that household characteristics is a significant and positive determinant in the likelihood of adopting improved cook stoves, as shown in multiple studies they reviewed. The findings showed that larger households tend to adopt improved cook stoves more readily, likely due to their higher fuel wood consumption, which motivates them to seek more efficient energy solutions. Gebreegziabher *et al.* (2010) also reported a positive and significant relationship between household characteristics and the decision to adopt improved cookstoves. These findings suggest that households with more members are generally more inclined to adopt such technologies in an effort to reduce fuel usage and improve efficiency.

Regression Results

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.775[a]	.601	.597	.23462

a. Predictors: (Constant), X4= Stove cost, X2 = Level of awareness in using ICS, X1= Household characteristics in using ICS, X3= Stove quality

From the results in Table 4, the R-square for the association between Improved Cook Stove factors and reduction of wood fuel consumption in Rutsiro District is 0.601. This implies that ICS can only explain 60.1% of the variation in the reduction of wood fuel consumption. The remaining 39.9% of dissimilarity can be elucidated by other causes in relation to the reduction of wood fuel consumption in Rutsiro District. The R square value is an important indicator of the predictive accuracy of the equation. The implication of these findings is that ICS plays a significant role in enhancing the reduction of wood fuel consumption.

Table 5: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.383	4	8.096	147.066	.000[b]
	Residual	21.469	390	.055		
	Total	53.852	394			

a. Dependent Variable: Y = Reduction of wood fuel consumption
b. Predictors: (Constant), X4= Stove cost, X2 = Level of awareness in using ICS, X1= Household characteristics in using ICS, X3= Stove quality

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In this research, Analysis of Variance (ANOVA) was applied to assess the significance of the regression model. Statistical significance was considered substantial if the p-value was less than or equal to 0.05. The findings in Table 5 show that the regression model had a p-value of 0.000, which is less than 0.05, indicating that the model was statistically significant in predicting the impact of ICS on reducing wood fuel consumption.

The ANOVA results revealed that the F-critical value (4-390) was 2.39, while the F-calculated value was 147.066. Since the F-calculated value is greater than the F-critical value, it suggests a significant positive linear relationship between ICS and the reduction of wood fuel consumption. This indicates that changes in ICS are strongly associated with significant changes in wood fuel consumption reduction. Furthermore, the p-value of 0.000 is less than the significance level of 0.05, confirming that the model effectively predicts the positive and significant effect of ICS on reducing wood fuel consumption in Rutsiro District.

Table 6: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.943	.157		6.009	.000
X1= Household characteristics in using ICS	.088	.030	.103	2.973	.003
1 X2 = Level of awareness in using ICS	.370	.027	.478	13.601	.000
X3= Stove quality	.324	.027	.435	12.047	.000
X4= Stove cost	-.025	.022	-.041	-1.142	.254

a. Dependent Variable: Y = Reduction of wood fuel consumption

Reduction of wood fuel consumption = $0.943+0.088X_1+ 0.37X_2+0.324X_3-.025)X_4$

The regression equation above has established that taking all factors into account (household characteristics in using ICS, level of awareness in using ICS, stove quality and stove cost) constant at zero, reduction of wood fuel consumption will be 0.943.

The results in Table 6 show that the reduction of wood fuel consumption had a positive index of 0.88 when (X1) was held constant. This implies that as household characteristics in using ICS change by one unit, the reduction of wood fuel consumption changes by 0.88 units. The relationship is significant as the p-value (0.003) is less than the significance level (0.05). The finding shows that household characteristics in using ICS have a positive influence on the reduction of wood fuel consumption.

The findings revealed that ICS had a positive index of 0.37 when incident reporting (X2) was held constant. This implies that as the level of awareness in using ICS changes by one unit, the reduction of wood fuel consumption by 0.37 units. The relationship is significant as the p-value (0.000) is less than the significance level (0.05). The finding shows that the level of awareness of using ICS has a positive influence on the reduction of wood fuel consumption in Rutsiro District.

The results show that the reduction of wood fuel consumption in Rutsiro District had a positive index of 0.324 when stove quality (X3) was held constant. This implies that as stove quality changes by one unit, the reduction of wood fuel consumption by 0.324 units. The relationship is significant as the p-value (0.000) is less than the significance level (0.05). The finding shows that safe work practices

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have a positive effect on the reduction of wood fuel consumption in Rutsiro District.

The results show that the reduction of wood fuel consumption in Rutsiro District had a negative index of -0.025 when stove cost (X4) was held constant. This implies that as stove cost changes by one unit, reduction of wood fuel consumption in Rutsiro District by -0.025 units. The relationship is significant as the p-value (0.254) is greater than the significance level (0.05). The finding shows that stove cost has no effect on the reduction of wood fuel consumption in Rutsiro District.

DISCUSSION

With reference to Table 3, it is obvious that descriptive statistics revealed that household characteristics in using ICS had a very high mean equal to 4.32 which implies that there is strong evidence that household characteristics were at a very high extent. Regression and correlation analysis revealed that household characteristics is significantly and positively related to the reduction of wood fuel consumption in Rutsiro District. The study also established that the marital status and education of the household's head increase the adoption of the technology as single women are more likely to accept the technology and married women's decision to adopt new technology is affected by their spouses. The findings concur with Lewis and Pattanayak (2019), who reported that the educational level of the household head is a consistent and significant predictor of cookstove adoption. Educated individuals as household characteristics are more likely to understand the health and environmental advantages associated with improved cook stoves.

Descriptive statistics revealed that technology awareness in using ICS was very high mean equal to 4.5 which implies that there is strong evidence that technology awareness in using ICS which means that people agreed that involving technology awareness in using ICS has an effect in the reduction of wood fuel consumption in Rutsiro District. Inferential statistics revealed the involvement of technology awareness in using ICS is significantly and positively related to the reduction of wood fuel consumption in Rutsiro District as a result the null hypothesis was rejected. The study found that the awareness campaign contributed to an increase in the number of dealers of improved cook stoves in the study area, as the technical team received valuable information about advancements in the technology.

The accessibility of these cookstoves led to greater adoption among households, as it improved both the quality and quantity of stove operations. This access enabled the technical team to stay informed about ongoing improvements in the technology. In a study conducted in Burkina Faso, it was found that the use of improved cook stoves resulted in better health outcomes, a reduction in cooking time, and a 28% decrease in firewood consumption (Bensch *et al*, 2015) cited in Chepkurui and Makori (2016). Similarly, a study in Ethiopia identified stove design and the influence of neighbours as key factors for ICS adoption, suggesting that no single stove design is universally suitable. To increase adoption rates, the stove design should consider the socio-cultural feeding practices of the users.

The findings from descriptive statistics revealed that stove quality was very high mean equal to 4.31. The findings revealed that involving stove quality has an effect on the reduction of wood fuel consumption in Rutsiro District. The inferential statistics revealed shows that stove quality is significantly and positively related to reduction of wood fuel consumption in Rutsiro District which led to the rejection of the null hypothesis. This is in agreement with an interviewer who stated that stove design increased households' adoption of the technology as they stated that through a training on design for entrepreneurs on the technology on how to improve the quality of the product, modification by the users resulting from unsuitable design features.

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This reveals that stove quality is an important factor that boosts the utilization of improved energy-saving cookstoves for the reduction of wood fuel consumption in Rutsiro District. The findings are in line with Chepkurui and Makori (2016) who noted that poor quality of improved stoves is a major factor in the failure to utilise improved charcoal stoves in rural Zanzibar. Stove quality is determined by its design and its performance in terms of efficiency, safety and durability. This also reveals that the more stove quality becomes the more the utilization of improved energy-saving cook stoves more reduction of wood fuel consumption in Rutsiro District. Therefore, from these quantitative results, it can be deduced that the study which sought to establish the influence of stove quality on the utilization of improved energy-saving cook stoves for the reduction of wood fuel consumption in Rutsiro District was achieved.

The findings from descriptive statistics revealed that stove cost was very high mean equal to 4.45 which implies that there is strong evidence that stove cost has an effect on the reduction of wood fuel consumption in Rutsiro District. Inferential statistics revealed that stove cost was not significantly and positively related to reduction of wood fuel consumption in Rutsiro District which led to the acceptance of the null hypothesis stating that stove cost has no effect on reduction of wood fuel consumption in Rutsiro District. The findings indicated that the price of alternative cookstoves influences household adoption of the technology in Rutsiro District. The study revealed that people's purchasing decisions were largely based on the actual prices of alternative stoves, their knowledge of operational costs, and the subsidies available, although these were often insufficient to make the stoves affordable. Additionally, the decision-making process was influenced by pricing, which in turn affected technology adoption.

Respondents mentioned that information on available payment options, such as planning and negotiating purchases, as well as the possibility of paying in instalments or making a one-time payment, was crucial. The findings concur with Ervila (2008) cited in Chepkurui and Makori (2016) who reported that people base their decisions to buy a device on actual prices and do not have a good knowledge about the operational cost. Dupont (1998) cited in Chepkurui and Makori (2016) in a study found that both the USA and Thai ranked the price of technology as an important determinant for the adoption of energy-efficient appliances. The process of stove manufacture requires sufficient funding throughout, to finance the set up of factories, purchase of raw materials, labour, transport, research and development and marketing of the final products. This suggests that the payment structure played an important role in increasing the number of cookstoves dealers in Rutsiro District.

CONCLUSION

The study concludes that there was a statistical significance between the household characteristics of using ICS and the reduction of wood fuel consumption in Rutsiro District. This shows that an increase in household characteristics of using ICS leads to an increase in the reduction of wood fuel consumption in Rutsiro District. The research concludes that household characteristics in using ICS did influence the reduction of wood fuel consumption. The age of the household head, marital status and education level determined the adoption of the technology. This reveals a household head characteristic is an important factor that can affect the utilization of improved energy-saving cook stoves for the reduction of wood fuel consumption.

In terms of the level of awareness in using ICS, the research concludes that the level of awareness influenced the awareness campaign increased adoption of the technology in Rutsiro District and also increased the number of dealers of improved cook stoves utilisation as the technical team gets information about improvement on the technology by using ICS towards the reduction of wood fuel consumption in Rutsiro District.

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Regarding stove quality, the researcher concluded that the stove quality especially on stove design increased household's adoption of the technology in Rutsiro District. Training on design for entrepreneurs on the technology on how to improve the quality of the product, modification by the users resulting from unsuitable design features and the risks associated with compromising the efficiency of the stove and the durability impact on satisfaction for sustained use is important.

About stove cost, the study concludes that stove cost has no effect on the reduction of wood fuel consumption in Rutsiro District. The study concludes that the price of cookstoves did increase in households' adoption of the technology in Rutsiro District**.** The findings from descriptive statistics revealed that Stove cost was very high mean equal to 4.45 which implies that there is a strong relationship between Stove cost and reduction of wood fuel consumption in Rutsiro District however, it does not statistically affect the reduction of wood fuel consumption in Rutsiro District.

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