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Assessing the Socio-Economic Factors Influencing the Adoption of Improved Cookstoves in Rural Rwanda: Evidence from Rwanda EICV-5

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Abstract

This study aimed to assess the socio-economic factors influencing the adoption of improved cookstoves in rural Rwanda. The increased use of improved cooking fuels is recognized as a potential solution to alleviate pressure on forest resources, mitigate greenhouse gas emissions, reduce premature deaths, and offer several economic advantages, including fuel savings through increased efficiency, time savings due to reduced cooking time and potential reductions in healthcare costs associated with indoor air pollution, among others. The study employed cross-sectional data, to analyse household factors, stove and fuel factors, and institutional factors that affect the decision of households to adopt the improved cookstoves. The sample size consisted of 12,048 households selected from cross-sectional data collected during the Fifth Integrated Household Living Conditions Survey (EICV-5). Among this sample, 31.45% were adopters while 68.55% were non-adopters of improved cookstoves. The Probit model was used to evaluate the factors influencing households' decisions to adopt improved cookstoves, while the Tobit model was used to assess factors affecting the frequency of improved cookstove usage. The results of the study provided empirical evidence of a significant positive effect of age of the household head, education level of the household head, income, cooperative membership, access to information and social influence in enhancing the adoption of improved cookstoves. Also, the results showed that access to information, cooperative membership and type of habitat had a significant positive impact on the frequency use of the improved cookstoves. The study recommends strategic policymaking on areas that require emphasis for increasing the adoption of improved cookstoves that will help contribute to economic well-being, alleviate pressure on forest degradation, and reduce environmental and health risks associated with Household Air Pollution (HAP) in the country in general and in rural area in particular.

Key words: *Adoption, improved cookstoves, household air pollution*

1.0 Introduction

The global reliance on traditional fuels and stoves has persisted for centuries, with over 40% of the world's population still dependent on outdated technologies. In low-income countries,

approximately 2.8 billion people have continued to use solid fuels, such as wood, charcoal, dung, crop residues, and coal, for cooking since 1990. Sub-Saharan Africa, including Rwanda, faces a significant challenge, with about 700 million households relying on traditional biomass. Despite efforts globally, the prevalence of solid fuel usage is on the rise in Africa, projecting an increase to 900 million people by 2020.

In Rwanda, firewood remains a predominant fuel source, with about 76.1% of the rural population relying on it for cooking. The use of solid fuels, particularly biomass, poses health risks comparable to second-hand smoke and active smoking. Additionally, it demands considerable time and effort for fuel collection, impacting income-generating activities, childcare, and education. The inefficient use of solid fuels has far-reaching consequences on health, the environment, and climate change.

Rwanda faces challenges of inadequate wood supply despite a commendable forest cover of 29.8%. This imbalance leads to excessive exploitation, deforestation, and depletion of limited tree reserves. The use of solid fuels contributes significantly to household air pollution (HAP), responsible for numerous premature deaths globally.

To mitigate these challenges, the Rwandan government has initiated programs to decrease reliance on wood fuel, enhance forestry programs, regulate tree harvesting, and introduce alternative fuels like biogas and LPG. Improved cookstoves, hailed for their effectiveness and safety, play a crucial role in this transition.

1.1 Statement of the Problem

The adoption of improved cookstoves, promoted as a solution to economic, environmental, and health challenges, faces obstacles in Rwanda. Despite extensive efforts, the adoption rate remains low, with approximately 85% of households relying on solid biomass fuels. This research aims to address the knowledge gap by investigating socio-economic, fuel-related, and stove-related factors influencing the adoption of improved cookstoves in rural Rwanda.

2.1 Theoretical Review

This section presents a review of the theories and concepts related to the study.

2.1.1 Consumer theory

Consumer behavior, as defined by Solomon *et al*. (2006) and Tanja L. (2015), encompasses the processes of selection, acquisition, use, and rejection of items, ideas, services, or experiences. Consumer theory, focused on financial decision-making to maximize utility, delves into the evaluation of hypotheses related to consumer objectives, behavioral norms, and decision-making constraints (P. Anton, 2005). Utility, representing satisfaction or happiness, becomes the central measure, with individuals striving to choose bundles that maximize their well-being.

Factors influencing consumer behavior span cultural, social, personal, and psychological realms (Kotler & Armstrong, 2010). Social factors, including groups, family, roles, and status, shape self-image and brand perceptions. Personal aspects such as age, occupation, and financial condition, along with psychological considerations like motivation, perception, learning, beliefs, and attitudes, collectively impact consumer decisions (Kotler & Armstrong, 2010).

2.1.2 Demand Theory

Demand theory, firmly grounded in economic principles, delves into the intricate relationship between consumer demand, product pricing, and an array of external factors. The determinants of market demand encompass a wide range of factors, including product price, consumer income, prices of other goods, individual preferences, income distribution, population size, wealth levels, credit availability, government policies, and historical demand patterns (Koutsoyiannis., 2011). This theory provides a comprehensive framework for understanding how these variables interact and influence the demand for products and services in economic contexts..

2.1.4 Diffusion of Innovation Theory

The diffusion of innovation theory informs the study approach, particularly drawing from Rogers' innovation-decision process model. This model, consisting of five stages - knowledge, persuasion, decision, implementation, and confirmation - provides valuable insights into the intricate dynamics of technology adoption (Rogers, 2003). Within this framework, the study emphasizes the role of perceived innovation attributes, including relative advantage, compatibility, complexity, trialability, and observability, in influencing adoption decisions. It underscores that the perception of these attributes, rather than their objective characteristics, significantly impacts the acceptance of innovations in the context of this research..

2.2 Empirical Review

Economic considerations play a pivotal role, with income emerging as a key determinant. Notably, the studies by Vania Vigolo *et al*. (2018) and Lee (2013) underscore the impact of income on sustainable cooking practices, indicating that households with higher incomes tend to use such methods more frequently.

Within the economic domain, the cost-related aspects of improved cookstoves, including the price of the stoves and access to credit, contribute significantly to adoption patterns. The study by Kulindwa *et al*. (2018) sheds light on the influence of cookstove prices, revealing a 17% decrease in adoption rates as prices rise. Moreover, Maré and Annegarn (2017) and Vania Vigolo *et al*. (2018) emphasize the role of credit accessibility in shaping consumers' choices, indicating that financial opportunities impact the widespread adoption of improved cookstoves.

Socio-demographic factors further deepen the understanding of adoption dynamics. Age, gender, household size, and education collectively shape the decision-making process. Age, as explored by Baiyegunhi and Hassan (2014) and Guta (2012), exhibits varying associations with fuel preferences, indicating the complexity of generational influences on cooking choices. Gender, a subject of debate in studies by Rahut *et al*. (2014) and Link *et al*. (2012), underscores the diverse roles that women play in household cooking and the nuanced impact on fuel choices. The influence of household size, as studied by Pandey and Chaubal (2011) and Onyeneke *et al*. (2017), suggests that larger families may prefer more efficient cooking technologies due to increased time and fuelwood consumption.

Educational levels consistently emerge as a significant socio-demographic factor influencing adoption patterns. Studies by Démurger and Fournier (2011) and Hassan (2014) demonstrate the negative correlation between education levels and firewood consumption, indicating that higher education encourages a shift away from traditional cooking methods.

Beyond socio-demographics, fuel and stove availability play a crucial role in shaping household fuel choices. Gupta and Köhlin (2006) highlight the impact of distance from fuel sources on the transition to alternative fuels, emphasizing the higher opportunity costs associated with collecting fuelwood. Additionally, Jagger and Jumbe's (2016) study points to increased interest in improved cookstove adoption when households have their own resources or rely on crop residues as fuel.

Attitudes toward technology and awareness of the risks of traditional cooking and benefits of improved cookstoves introduce psychological dimensions to adoption dynamics. Reluctance to experiment with alternative technologies, as noted by Rehman *et al*. (2012), suggests a barrier to adoption beyond the availability of improved cookstoves. Meanwhile, the heightened awareness campaigns discussed by Poddar and Chakrabarti (2016) and Maré and Annegarn (2017) indicate the pivotal role of understanding the risks associated with traditional stoves in fostering a demand for more sustainable and safer cooking solutions.

Socio-cultural influences, as explored by Martin *et al*. (2013) in peri-urban Uganda, reveal the impact of community actions on individual choices. The positive influence of neighbors who have already adopted improved cookstoves showcases the importance of social networks in shaping adoption patterns. The comprehensive empirical literature collectively underscores the intricate and interconnected nature of factors that influence households' decisions in adopting improved cooking solutions.

3.0 Research Methodology

The study conducted in Rwanda utilized a cross-sectional analysis based on data from the Fifth Integrated Household Living Conditions Survey (EICV-5) of 2016/17. It focused on 12,048 households in rural areas across all Rwandan districts, gathering comprehensive data on demographics, income, housing, and more. Descriptive statistics, chi-square tests, and t-tests were used to analyze the data and differentiate between adopters and non-adopters of improved cookstoves (ICS). Econometric models like Logit, Probit, and Tobit were employed to examine the factors influencing ICS adoption and usage intensity. These models accounted for variables like education, income, age, technology adaptability, and household size. Diagnostic tests ensured the regression models' validity, with Probit models analyzing adoption decisions and Tobit models focusing on usage intensity. This thorough approach aimed to understand the socio-economic factors influencing ICS usage in rural Rwanda.

4.0 Study Results

This section presents the study findings based on the research objectives.

4.1 Cook stoves adoption in rural Rwanda

The results indicate a notable progress in Rwanda's adoption of improved cookstoves. Figure 1 shows the cook stove distribution in rural Rwanda.

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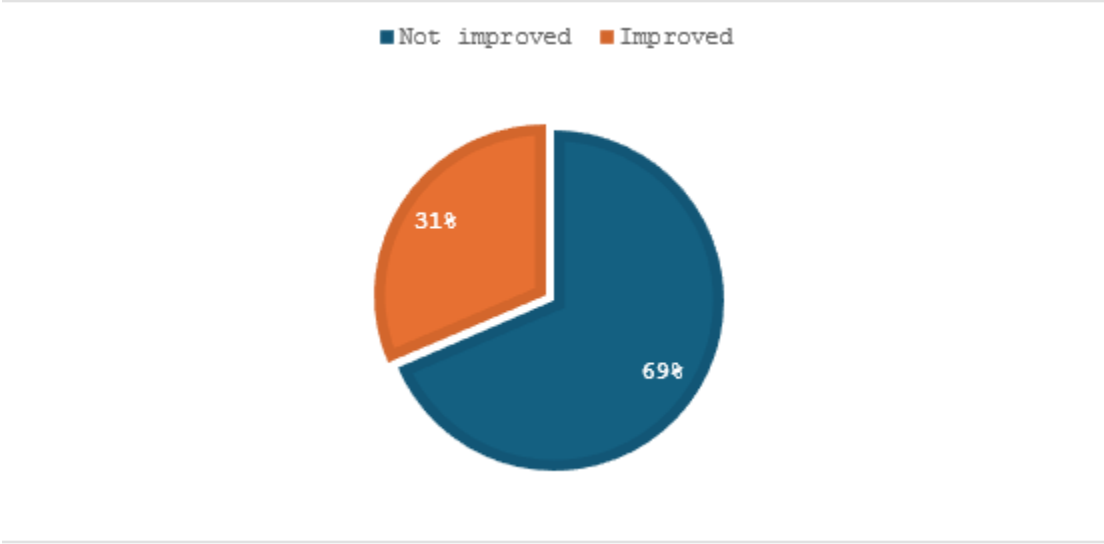

Figure 1: Cookstoves distribution in rural Rwanda

Source: Author (2023).

Results in Figure 1 show that among the surveyed households, 31.45% have embraced improved cookstoves, reflecting a positive shift towards more sustainable and efficient cooking technologies. This suggests a significant uptake of cleaner and advanced cooking solutions, potentially driven by awareness campaigns, policy initiatives, or other factors promoting the transition to improved cookstoves. However, it's crucial to note that 68.55% of households still use traditional, non-improved cookstoves. While the progress is evident, there remains a substantial proportion of households relying on traditional cooking methods.

4.2 Factors affecting the adoption of improved cook stoves.

Probit regression results in Table 1 reveal significant influences on the household's decision to adopt improved cook stoves.

Table 1: Probit Model Results - Improved Cook Stove Adoption

Variables	Coefficient	Std. err.	z	P>z
Age of HHH	0.1044	0.0205	5.1	0.000
Education of HHH	0.0121	0.0023	5.26	0.000
Cooperative membership	0.2324	0.035	6.64	0.000
Household income	0.8937	0.0213	41.97	0.000
Household size	0.0621	0.0073	8.54	0.000
Access to information	0.2122	0.0424	5	0.000
Type of habitat	0.215	0.0336	6.4	0.000

Based on Table 1, the results indicate that age, education, cooperative membership, income, household size, access to information, and type of habitat significantly influence improved cookstove adoption. Notably, income and education show a strong positive association, while household size and age exhibit a positive correlation.

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4.3 Factors affecting the frequency of improved cookstoves use.

Tobit regression analysis findings in Table 2 unveil factors influencing the weekly frequency of improved cook stove usage.

Table 2: Tobit Model Results - Frequency of Improved Cook stove Use

Variables	Coefficient	Std. err.	z	P>z
Gender of HHH	-0.5213	0.0397	-13.13	0.000
Time to gather fuel	-0.0864	0.0076	-11.43	0.000
Fuel cost	-0.0766	0.0291	-2.63	0.009
Cooperative membership	0.0911	0.0327	2.79	0.005
Household size	-0.0165	0.0075	-2.19	0.028
Any stove harm	0.2049	0.0659	3.11	0.002
Information access	0.1532	0.0355	4.31	0.000
Type of habitat	0.1135	0.0302	3.76	0.000

Results in Table 2 indicate that gender, time to gather fuel, fuel cost, cooperative membership, household size, any stove harm, information access, and type of habitat significantly impact the frequency of improved cookstove use. Gender, time to gather fuel, fuel cost, and household size exhibit a negative relationship, while cooperative membership, stove harm, information access, and type of habitat demonstrate a positive correlation.

5.0 Summary of Findings

The study sought to investigate the socio-economic factors impacting the adoption and usage frequency of improved cookstoves in rural Rwanda. The study established that the age of the household head, household income, cooperative membership, access to information, and residing in planned settings (agglomeration) are significant influencers of improved cookstove adoption. Additionally, the findings indicate that basic formal education alone is insufficient, emphasizing the need for supplementary information and training programs to enhance adoption rates. Furthermore, the study revealed that factors like awareness of potential stove-related harm, access to information, and the type of habitat significantly affect the frequency of improved cookstove use. Households with access to information and those located in planned settings are better positioned to acquire knowledge and make more effective use of improved cookstoves.

6.0 Conclusion

The study concludes that the age and education level of the household head significantly affect improved cookstove adoption. Younger and more educated household heads are more likely to adopt these stoves. Additionally, cooperative membership, higher household income, and larger household sizes positively impact improved cookstove adoption. Moreover, in terms of the frequency of improved cookstove use, female-headed households tend to use these stoves more frequently. Factors such as the time spent on fuel gathering, fuel costs, and household size also influence the frequency of improved cookstove use. These findings provide valuable insights into the complex factors influencing improved cookstove adoption and usage in rural Rwanda.

7.0 Recommendations

The study recommends strategies to boost improved cookstove adoption in rural Rwanda, including the promotion of planned habitats and agglomeration to create a conducive environment, the introduction of financial incentives and installment payment plans to ease upfront costs, and the encouragement of cooperative formation among households for mutual support and access to resources. These recommendations aim to enhance the adoption of improved cookstoves and improve cooking practices in rural areas, ultimately contributing to better socio-economic outcomes in these communities.

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