

DETERMINANTS OF SUSTAINABILITY OF IMPROVED COOK STOVES USE AMONG HOUSEHOLDS IN MARSABIT CENTRAL SUB COUNTY, MARSABIT COUNTY, KENYA

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ABSTRACT

This study investigated the determinants that affect the sustainability of improved cookstove (ICS) use among households in Marsabit Central Sub-county, Marsabit County, Kenya. The study specifically examined the influence of stove characteristics, socio-economic factors, and the availability of support services on the sustained use of improved cookstoves among beneficiary households. Despite the promotion and distribution of improved cookstoves as a strategy to reduce indoor air pollution, improve energy efficiency, and enhance household welfare, sustained use of the technology remains a challenge in many rural and marginalized communities. Many households continue to rely on traditional cooking methods due to issues related to stove durability, affordability, cultural compatibility, and inadequate technical support. This raises concerns regarding the long-term sustainability and effectiveness of improved cookstove interventions. The study adopted a cross-sectional research design. A sample of 205 respondents was selected from a target population of 2,250 households using appropriate sampling procedures. Primary data was collected using structured household questionnaires. Data analysis using descriptive statistics, t-tests, and multiple regression analysis were used to examine the relationship between the independent variables and sustainability of improved cookstove use. The findings revealed that improved cookstoves achieved widespread adoption among sampled households, although daily usage remained limited due to stove breakage, durability concerns, and reliance on alternative cooking devices. Users identified positive stove attributes such as fuel efficiency, portability, and reduced smokiness, but also reported challenges including incompatibility with common cooking pots, insufficient heat output, and limited durability. The regression results showed that stove characteristics had the strongest and most statistically significant influence on sustainability of improved cookstove use ($B = 0.651$, $p < 0.001$), while socio-economic factors such as affordability also had a significant positive influence ($B = 0.186$, $p = 0.018$). However, availability of support services was found to have no statistically significant influence on sustainability ($B = 0.023$, $p = 0.705$). The study concluded that stove characteristics and affordability are the most critical determinants of the sustainability of improved cookstove use among households in Marsabit Central Sub-county. The study recommends that stakeholders and programme implementers prioritize user-centered stove designs that improve durability, fuel efficiency, portability, and compatibility with local cooking practices.

Keywords: *Determinants, Sustainability, Cook Stoves, Households, In Marsabit Central Sub County*

INTRODUCTION

Energy is a very crucial aspect of human civilization. It is an important pillar of development whose role is critical to all other aspects of human, social and economic progress. Energy is an integral ingredient in nearly all goods and services. Taking various forms, energy has made life possible. Heat, light and power are essential in extracting raw materials and transforming them into consumer goods. Additionally, even the establishment of the factories and plants that create the goods require energy. Transportation, which facilitates distribution of goods, is made possible by energy. At the household level, energy is required for lighting, heating and cooking, which are important aspects for the well-being of people.

According to the international energy agency, about 40% of the global population rely on solid biomass fuels for cooking (International Energy Agency, 2012). An estimated 70% of the world's poorest 1.3 billion people are women who rely on biomass energy including firewood, crop residues and charcoal, burned in traditional and inefficient cookstoves (Person et al. (2012). Inefficient combustion of solid fuels in traditional cook stoves emits high concentrations of respirable particulate matter and other harmful emissions which emissions, according to many studies, are responsible for adverse health impacts. Presently around the world, there exists many kinds of cooking stoves which also utilize various types of energy sources. These include the traditional cooking place (3-stones), simple non-traditional stoves (such as clay pots or simple ceramic liners), chimney stoves, rocket stoves, charcoal and gasifier stoves. These use solid fuels and are common in rural areas of developing countries. On the other hand, we have more modern cooking stoves, such as liquefied petroleum gas (LPG), natural gas and electric cookers that are common in urban areas of both developing and developed countries.

Environmental degradation in the county is mainly because of deforestation and forest encroachment due to dependency on firewood and overgrazing. Desertification has been witnessed over the years with the drying up of water sources due to long dry spells and the activity of man. Firewood and charcoal are scarce as is reflected in the prices of these commodities, especially in and around Marsabit town. A 50kg bag of charcoal sells between 700 and 1,000 Kenya shillings while a load of about 15 kg of firewood goes for 500 Kenya shillings. Women bear the brunt of provision of fuel wood to the market, which is a strenuous activity besides the other danger women get exposed to like accidents and attack by wild animals while collecting firewood in the bush. These factors, among others have been at the

background of efforts at promotion of energy saving cooking technologies in the County in recent times. Marsabit central sub county is the most densely populated of all the four sub counties of Marsabit County with a population 79,181 and a density of density of 37 people per square kilometer (Kenya National Bureau of Statistics, 2019). It hosts the county headquarters, Marsabit town, as well as Marsabit forest and National Park, a major source of fuel wood, charcoal and other forest resources. In this sub county, the importance of improved cook stoves cannot be overstated. However, a critical study of the sustainability of such technologies is necessary to inform action by various actors and stakeholders in that sub sector.

The adverse health, livelihood, local environment, and climate impacts generated by household biomass burning have gained increased attention in the past few years. Improved cook stoves have been designed to alleviate these negative impacts through increased combustion efficiency that requires less fuel and reduces cooking time. A growing global consensus that improved cook stoves can produce this significant combination of beneficial impacts culminated in the creation of the Global Alliance for Clean Cook stoves (GACC) in 2011. However, the benefits of improved cooking stoves are far from certain according to Jeuland and Pattanayak (2012). Additionally, households that use improved cooking stoves or cleaner fuels often maintain concurrent use of their traditional and improved cooking systems.

STATEMENT OF THE PROBLEM

One of the real phenomena that different societies are grappling with is desertification. This is true for Marsabit county. Several higher potential areas within the county, including Marsabit Central Sub County, used to be a food basket several years back. Even today, evidence of climate change can be seen in a few coffee trees around Marsabit central, which is no longer a feasible economic activity. Additionally, land is increasingly being lost to competing alternative use such as settlements with population growth, real estate and other uses. Environmental degradation in the county has been the result of deforestation, forest encroachment and overgrazing.

These factors have led to a decline in the available forest resources, including wood fuel. This has made efforts in the promotion of fuel-saving household cooking stoves extremely necessary over the last few years. Many actors have been involved with the distribution and promotion of fuel-saving household cooking stoves in Marsabit central sub county. The stoves majorly promoted include the clay circular cooking stoves (commonly known as Maendeleo liners and

the clay-lined metallic cooking jikos. These actors include non-governmental organizations (NGOs), parastatals, particularly the Kenya Wildlife service which recently distributed ICS to households within the sub county as part of their social corporate responsibility and private businesses in the major trading centers which also stock various forms of improved cooking stoves. The prices of these stoves ranging between 450 to 700 Kenya shillings depending on the stove size and type.

However, all the cooking stoves available are not manufactured within Marsabit; they are all imported from Nairobi and other places. Additionally, many have been distributed to households free of charge and there has not been any efforts at studying the availability of local materials for the manufacture of the stoves. By the fact of many of the ICS being distributed to households free of charge, it is not clear if the households, and how many, would acquire and use the stoves of their own volition. Additionally, there has not been concerted efforts at coordination since various actors have undertaken projects in distribution and promotion of improved cooking stoves but there exists no central repository of data on the numbers and types of ICS distributed and promoted. Therefore, it cannot be assumed that these technologies are the best action to be undertaken. In terms of capacity, there exists no programmes to capacitate the population, especially local artisans, women and youth groups on the production, use and maintenance of these stoves through vocational training. Further, there are no government subsidies that are directed at the promotion of improved cooking stoves. The potential to locally manufacture or fabricate ICS in Marsabit has not been fully investigated. Additionally, it is not known whether the local population has the capacity to maintain and replace the already distributed ICS or if the populations have been equipped with all the necessary product information at the time of distribution, which information would be useful for optimal operation and maintenance of the cookstoves. The need for support services, and the availability of the same towards maintenance and sustainability of fuel-saving cooking stoves has also not been considered. In totality, no study into the sustainability of the various cook stoves' use in the sub county has ever been conducted and as such, it is not known whether these technologies are a good programmatic and development endeavor from the standpoint of sustainability.

RESEARCH OBJECTIVES

- i. To assess the socio-economic determinants of sustainability of household improved cook stoves use in Marsabit Central Sub-county

- ii. To assess the stove characteristics that influence the sustainability of household improved cook stoves use in Marsabit Central Sub county
- iii. To assess the effect of availability of support services on sustainability of household improved cook stoves use in Marsabit Central Sub-county

RESEARCH HYPOTHESES

H₀₁: Stove characteristics have no statistically significant effect on the sustainability of household improved cook stove use in Marsabit Central Sub-County.

H₀₂: Socio-economic determinants have no statistically significant effect on the sustainability of household improved cook stove use in Marsabit Central Sub-County.

H₀₃: The availability of support services has no statistically significant effect on the sustainability of household improved cook stove use in Marsabit Central Sub-County.

THEORETICAL FRAMEWORK

This chapter describes the theories that underpin the study as identified by the researcher. Two theories have been described – Rogers’ diffusions of innovations theory and the theory of change. For each of the theories, the researcher describes the key postulations of the theory as well as their relevance to the study being proposed. The Rogers theory is one of the widely used theoretical frameworks in the subject of technology diffusion and adoption. Rogers (2003) usually used technology and innovation interchangeably. According to this theory, a ‘technology’ is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome” and is composed of two parts: hardware and software. The hardware component is the tool that embodies the technology in the form of a material or physical object while the software is the information base for the tool. According to Rogers, adoption is a decision of “full use of an innovation as the best course of action available” and rejection is a decision “not to adopt an innovation” Rogers defines diffusion as “the process in which an innovation is communicated thorough certain channels over time among the members of a social system” Accordingly, the diffusion of innovations(technologies) has several parameters including the innovation/technology itself, communication channels, time, and social system.

The Theory of Change (ToC) approach is widely believed to have first emerged in the United States in the 1990s. This was in the context of improving evaluation theory and practice in the field of community initiatives. Although opinion is divided on how to define the theory of change, it is commonly understood as an articulation of how and why a given intervention will

lead to specific change. Weiss described a ToC as “a theory of how and why an initiative works.” The theory presupposes a set of critical assumptions that underpin both the milestones that lead to a pre-determined long-term goal (or impact) as well as the connections between these milestones and the outcomes of an intervention or programme. In the context of evaluation, Weiss postulated that programs need to be underpinned by some theory to make evaluation meaningfully useful. Further, evaluations have a relationship with governance in that effective evaluation should of necessity lead to improvement of programs and delivery of projects in the future. Timely and targeted decision-making based on the results of evaluation in this case would be an indicator of good governance.

EMPIRICAL REVIEW

Several improved stove characteristics have been associated with the adoption and sustained use, or otherwise, of the technologies. A review study on enablers and barriers to large-scale uptake of improved solid fuel stoves finds that many ICS programs had specific design problems that led to stove modifications by users limiting stove effectiveness and promoting to use traditional stoves (Rehfuess, Puzzolo, Stanistreet, Pope, & Bruce, 2014). The study also reports that cookstove portability is also important where households switch between outdoor and indoor cooking in different seasons and that the design should meet other household energy needs. However, even if this requirement is satisfied, the use of the stove will decline if durability is poor. Design and durability also affect the requirements for and costs of cleaning and maintenance, which can be a disincentive if high, according to the review study.

Assessing the relative strength of factors in terms of marginal willingness to pay, Takama, Tsephele, & Johnson (2012) found that product-specific factors such as usage cost, stove price, safety and smokiness, significantly affected stove and fuel choices in Addis Ababa, Ethiopia. The study finds that low-wealth households were more sensitive to stove prices and usage cost as compared to the medium and high-wealth households. Additionally, the medium and high-wealth group had more willingness to pay for reductions in indoor smoke and safety improvement as compared to the low-wealth households.

The durability and design of the cook stove can also have an economic impact in terms of the costs of cleaning, maintenance and replacement as the need arises. The study finds that despite households' willingness to purchase ICS, the cost of ICS remains the most important factor in decision making in rural Haryana State, India. Further, it found that households used a

combination of dung and fuelwood and that most of the households studied owned at least one buffalo that was enough to meet their annual dung needs. This points to the importance of ownership of other economic assets such as the buffalo in augmenting the use of the ICS. The use of dung for cooking and the use of the agithi cook stove which has a slow-burning effect, allowed household members to perform other tasks since the fire did not require close management as with fuelwood. Social requirements such as the need for social gatherings and meetings also affect the choice and use of ICS as found out by Bielecki and Wingenbach (2014).

Jan (2012) in rural northwest Pakistan found that education and household income are the most significant factors that determine a household's willingness to adopt improved biomass stoves. A case study on social perceptions about a technological innovation for fuelwood cooking in rural Mexico found that the socioeconomic level of households was positively correlated with the adoption of the improved cookstoves and that the age and the educational levels were not (Troncoso, Castillo, Masera, & Merino, 2007). The study also found that the cost of the stove was not a factor in adoption. Further, on a gender perspective, the study finds that men were the main fuelwood harvesters and that they should be considered as an important group in ICS diffusion programs. In a research into clean fuel-saving technology adoption in urban Ethiopia, Beyene and Koch (2013) examined the reasons underpinning the lack of widespread adoption of Mirte and Lakech, two types of new cooking technologies in urban Ethiopia. The research found that the lack of widespread adoption correlated with socioeconomic factors including product price, household income and household wealth. The study also found evidence that the availability of substitute technologies, including electric and metal stoves, tended to hinder adoption and that large regional differences in adoption rates existed which necessitated a further analysis of factors influencing the various regional adoption decision making processes. The review by Puzzolo et al. (2013) also finds that user training on the correct and safe use technology is a factor influencing initial acquisition decisions and that experience sharing by existing users through social networks can have strong influences on prospective adopters. The study underscores the importance of supply chains and infrastructure in enabling accessibility of cooking technologies to users, replacements and follow ups by technicians. Barnes et al. (2012) found that the poor maintenance of stoves disseminated through a government incentive system failed in maintenance by the combination of both the lack of initiative by the owners

by not appreciating the benefits of the stoves and the failure of the administration to conduct awareness raising activities on the use and maintenance of the stoves.

CONCEPTUAL FRAMEWORK

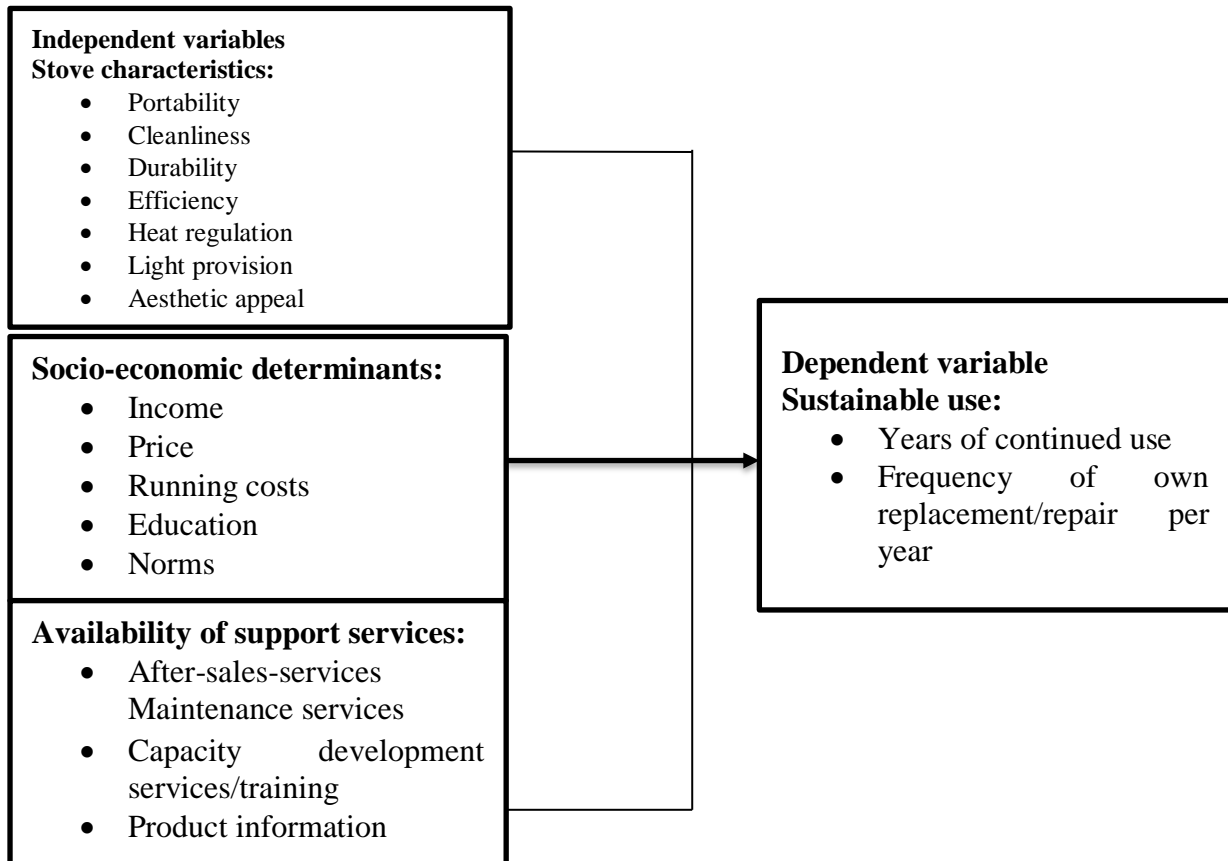


Figure 1: Conceptual Framework

RESEARCH METHODOLOGY

The study adopted a cross-sectional research design and quantitative approach to examine determinants influencing the sustainability of improved cookstove use among households in Marsabit Central Sub-county, Kenya. The target population was 15,849 households, while the sampling frame comprised 2,250 households that benefited from the German Agro Action stove distribution programme. Stratified random sampling was used across nine programme regions, and Fisher’s formula determined a sample size of 205 households. Data were collected using structured questionnaires with both open-ended and closed-ended questions. A pilot study was conducted to test validity and reliability, with Cronbach’s Alpha values exceeding 0.70. Data were cleaned, coded, and analyzed using SPSS. Descriptive statistics summarized the findings, while t-tests and multiple regression analysis examined the influence of stove

characteristics, socio-economic factors, and support services on the sustainability of improved cookstove use.

RESULTS AND DISCUSSIONS

This section presents the findings on the sustainability of improved cookstove use among households in Marsabit Central Sub-county. The results cover response rate and demographic characteristics, stove characteristics, socio-economic determinants, availability of support services, sustainability of improved cookstove use, and regression analysis.

Response Rate and Demographic Characteristics

The study administered 205 questionnaires, out of which 176 were properly completed and returned, giving a response rate of 85.9%. This response rate was adequate for analysis. The respondents were mainly female, reflecting women’s central role in household cooking and energy management. Most respondents were aged between 35 and 50 years, and many households had more than seven members. Most respondents had primary education or no formal education, which has implications for awareness creation, stove use, and maintenance.

Stove Characteristics

This subsection presents findings on ownership, continued use, daily use, and preferred characteristics of improved cookstoves. These findings help explain whether households had adopted and sustained use of the stoves.

Table 1: Stove Ownership and Use

Item	Frequency	Percent
Received stove from German Agro Action	176	100.0
Still use the stove	159	90.3
Use the stove every day	47	26.7

The findings show that all respondents received improved cookstoves, and most still used them. However, daily use was low, indicating that ownership did not automatically translate into consistent use.

Table 2: Reasons for Non-Daily Use of Stove

Reason	Frequency	Percent
Alternative cooking device	58	45.0
Stove partially broke	71	55.0
Total	129	100.0

Most respondents who did not use the stove daily cited partial breakage, while others relied on alternative cooking devices. This shows that durability and functionality affected sustained use.

Table 3: Preferred Stove Characteristics

Preferred characteristic	Percent
Burns fuel steadily	88.6
Portable	82.4
Less smoky	76.1
Saves fuel	72.7
Easy to maintain/clean	60.2
Safe for children	38.1
Durable	31.8
Clean	13.1

The most valued stove attributes were steady burning, portability, reduced smoke, and fuel saving. However, low ratings on durability, child safety, and cleanliness suggest areas that require improvement in stove design.

Socio-Economic Determinants

This subsection presents findings on how households acquired the stove, whether they replaced it, sources of money for replacement, and the cost of replacement. These factors help explain the role of affordability in sustained use.

Table 4: Affordability of Improved Cookstove

Item	Response	Frequency	Percent
Mode of acquisition	Own purchase	0	0.0
	Free donation	176	100.0
Stove replacement/repurchase	Yes	102	58.0
	No	74	42.0
Source of replacement funds	Own savings	10	9.8
	Spouse	40	39.2
	Family and friends	34	33.3
	Other sources	18	17.6
Purchase price	Below KES 1,000	81	79.4
	KES 1,000–2,000	21	20.6

All respondents initially acquired the stove through donation. However, 58% had replaced or repurchased a similar stove, mostly using support from spouses, family, or friends. This shows that affordability and household financial support influence continued use.

Table 5: Motivation and Willingness to Acquire Stove

Item	Frequency	Percent
Previous knowledge of benefits	86	48.9
Information from social gatherings	76	43.2
Encouraged by neighbours	58	33.0
Promotion by leaders/NGOs	12	6.8
Willing to buy stove if not donated	113	64.2
Need to consult household member before purchase/maintenance	176	100.0

The findings show that awareness was mainly influenced by prior knowledge, social gatherings, and neighbours. The majority were willing to buy the stove, but household consultation was necessary before purchase or maintenance decisions.

Availability of Support Services

This subsection presents findings on installation, training, repair, maintenance, after-sales services, and subsidies. Support services are important in ensuring proper use and long-term sustainability of improved cookstoves.

Table 6: Availability of Support Services

Support service	Frequency	Percent
Received usage/installation information	20	11.4
Paid for installation service	19	10.8
Trained on installation, repair, and maintenance	142	80.7
Received after-sales services	14	8.0
Availability of trained local artisans	115	65.3
Benefited from subsidy programme	14	8.0

The findings indicate that training and local artisan support were available to many respondents. However, usage information, after-sales services, and subsidies were limited, showing weak post-distribution support.

Table 7: Installation of Improved Cookstoves

Installer	Frequency	Percent
Self	117	66.5
Local artisan	51	29.0
Not installed yet	8	4.5
Total	176	100.0

Most respondents installed the stoves by themselves, while a smaller proportion used local artisans. This suggests the need for better technical support to ensure proper installation and safe use.

Sustainability of Improved Cookstove Use

This subsection presents findings on continued use, perceived cost-effectiveness, and the importance of the stove to households.

Table 8: Sustainability of Improved Cookstove Use

Sustainability indicator	Frequency	Percent
Plan to continue using the stove	156	88.6
Stove is cost-effective in the long run	93	52.8
Stove is essential to the household	154	87.5

The findings show strong commitment to continued use, with most respondents considering the stove essential. However, only slightly more than half viewed it as cost-effective, suggesting that affordability and maintenance costs remain important concerns.

Table 9: Challenges Affecting Future Use

Challenge	Percent
Availability of support services	100.0
Cost of stove	76.5
Cost of repair and maintenance	70.6
Superior cooking solutions in the market	29.4

Among respondents who did not intend to continue using the stove, the main challenges were limited support services, stove cost, and repair and maintenance costs. This shows that sustainability requires both affordable technology and reliable support systems.

Regression Analysis

Multiple regression analysis was conducted to examine the influence of stove characteristics, socio-economic factors, and availability of support services on the sustainability of improved cookstove use.

Table 10: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.635	0.403	0.390	1.49175

The model explains 40.3% of the variation in sustainability of improved cookstove use. This indicates that stove characteristics, socio-economic factors, and support services jointly contribute to sustainability.

Table 12: Regression Coefficients

Predictor	B	Std. Error	Beta	t	Sig.
Constant	1.550	0.905	—	8.346	0.000
Stove characteristics	0.651	0.067	0.688	9.722	0.000
Socio-economic factors	0.186	0.077	0.178	2.395	0.018
Availability of support services	0.023	0.061	0.027	0.379	0.705

The regression results show that stove characteristics had the strongest and statistically significant influence on sustainability of improved cookstove use. Socio-economic factors also had a significant positive influence. However, availability of support services was not statistically significant. The regression model was:

$$\text{Sustainability of ICS Use} = 1.550 + 0.651(\text{Stove Characteristics}) + 0.186(\text{Socio-economic Factors}) + 0.023(\text{Support Services}) + e$$

Overall, the findings show that the sustainability of improved cookstove use in Marsabit Central Sub-county is mainly determined by stove design, durability, fuel efficiency, affordability, and compatibility with household cooking practices. Support services remain important but did not independently predict sustainability in the regression model.

CONCLUSIONS

The study concludes that stove characteristics represent the most critical determinant of the sustainability of improved cookstoves. Features such as durability, fuel efficiency, portability, safety, and compatibility with traditional cooking practices strongly influence users' decisions to continue using the technology. This finding confirms that user-centered stove design plays a crucial role in promoting long-term adoption and user satisfaction. Affordability was also found to contribute significantly to the sustainability of improved cookstoves, although its influence was less pronounced compared to stove characteristics. The findings indicate that the cost of purchasing, installing, and maintaining the stoves affects continued use, particularly among low-income households. Therefore, while functional design remains the primary driver of sustained adoption, affordability remains an important factor in ensuring wider accessibility and continued utilization.

The availability of support services such as training, repairs, and maintenance was found to have a limited influence on the sustainability of improved cookstoves use. This suggests that users may place less emphasis on post-sale services when deciding whether to continue using the technology. Possible explanations include sufficient baseline knowledge among users,

relatively low rates of stove malfunction, or limited variation in access to support services. As a result, support services may not independently drive sustained use but could be more effective when integrated with improvements in stove design and affordability.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed to enhance the sustainability of improved cookstoves: Stakeholders involved in the development and promotion of improved cookstove technologies should prioritize improving stove characteristics by incorporating features that align with users' practical and cultural needs. Greater emphasis should be placed on enhancing durability, portability, fuel efficiency, multifunctionality, and compatibility with traditional cooking practices to encourage long-term adoption.

To address the influence of affordability on improved cookstove sustainability, implementers of stove promotion interventions should consider implementing targeted subsidies, flexible payment arrangements, and micro-financing schemes. These initiatives would help reduce the financial burden on low-income households and improve access to technology. Awareness campaigns by implementers of stove promotion programmes should be undertaken to educate households about the long-term benefits associated with improved cookstove usage. These campaigns should leverage informal community networks, peer demonstrations and social gatherings.

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