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DETERMINANTS OF ADOPTION OF IMPROVED BIOMASS STOVE IN RURAL HOUSEHOLDS OF MUHAZI SECTOR IN RWAMAGANA DISTRICT.

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ABSTRACT

The adoption and continued use of improved biomass stoves in developing countries is of social, economic and environmental concern. Many of rural households use traditional stoves which have low energy efficiency leading to using more wood fuel, increase in indoor air pollution and also putting a lot of pressure on biomass resources. There have been efforts to promote use of efficient wood fuel technologies; this program has been spearheaded by the Ministry of Infrastructure and Nongovernmental Organizations. The purpose of the study was to evaluate the determinants of adoption of improved biomass stoves among rural household in Rwamagana District. To achieve this, the study was guided by the following objectives; to assess the social factors determining the adoption of the improved biomass stoves, assess the level at which the economic status of the household influences the adoption of the improved biomass stoves, examine how cultural beliefs and practices influence the adoption of improved biomass stoves and investigate the level at which sensitization of the rural households influence the adoption of improved biomass stoves in Rwamagana District. The study adopted a descriptive research design. The target population comprised 350 households from Rwamagana District. The sample size of 187 households from Rwamagana was determined using Slovin's formula. Purposive sampling technique was employed to select Rwamagana District as the study site since the improved biomass stoves programme was present in the area. To determine the sample size to consider in each Cell, stratified random sampling technique was used whereby a random sample from each stratum (Cell) was taken in a number proportional to the stratum size when compared to the target population. The study utilized questionnaires as an instrument for data collection. Data collected was analyzed through SPSS version 23. Data analysis involved statistical computations for averages, percentages, and correlation and regression analysis. Findings of the study were presented using frequency distribution tables. From the correlation analysis, it was found that social status, economic level, cultural beliefs and sensitization of households had a significant positive influence on the adoption of improved biomass stoves in Rwamagana District with (0.902, 0.989, 0.852, and 0.941) respectively. From the study, it is concluded that there is a positive relationship between social status, economic level, cultural beliefs, sensitization of households and adoption of improved biomass stove. The four determinants had a significant positive influence on the adoption of improved biomass stoves in Rwamagana District with all the determinants contributing 98% to adoption. Using linear regression analysis, the significance values for relationship of Social status, Economic status, Cultural beliefs and Sensitization of rural households on adoption were 0.056, 0.000, 0.717 and 0.015 respectively. Through the study findings, it is recommended that more strength should be put on Economic status and sensitization of rural households to have a successful adoption and use of improved biomass stove because these are the factors that highly contributed in Rwamagana.

Key words: Adoption of improved biomass stoves, Social status, Economic status, Cultural beliefs and practices and Level of sensitization of the rural households

1.1 Introduction

Renewable energy is a priority for sustainable development and is included in the global climate change initiative and several United Nations (UN) conventions. In developing countries 1.6 million people still lack access to electricity and 3 billion people rely on traditional biomass fuels for cooking, heating, and other basic household needs (IEA 2002). According to Njenga, B. K. 2001 the use of these traditional biomass energy sources results in forest degradation and negatively impact climate change, through reduced carbon sequestration and increased greenhouse gas (GHG) emissions. Additionally, they present a public health challenge from indoor air pollution. Such negative impacts highlight the need to invest in sustainable and cleaner energy technology, yet despite investment in research and field testing of energy technologies, uptake remains limited, (UNEP 2005).

Over 3 billion people throughout the world rely on locally available fuels, such as wood, charcoal, dung, and agricultural residues, for cooking and heating Nigel, (2004). The global total production of wood in 2000 reached approximately 3.9 billion cubic meters of which 2.3 billion cubic meters was used as wood fuels. This means that approximately 60 percent of the world's total wood removals from forests and trees outside forests are used for energy purposes (FAO, 2008**).**

Biomass cooking stoves are devices, in which biomass (wood, agricultural residues etc) is used to furnish need for cooking. Although the three-stone is very common it is often modified in many ways. This includes sinking the combustion zone below ground level or constructing a barrier around it to shield the fire. However, most types of these traditional cooking stoves are not only inefficient but also pollute the indoor air affecting the health of the householders. According to the WHO report 2002, up to 15 million people die each year as a result of air pollution. The first attempt to improve traditional solid biomass stoves were made in India in the 1950s. These stoves were designed with a chimney to remove smoke from the kitchen. In the 1970's the oil crisis brought energy issues back to the top of the agenda and improved cooking stove programs were considered as solution to the fuel wood crisis, deforestation and desertification around the world (FAO 1983). During this period research was focused on the technical aspects like thermodynamic and heat transfer. Various international donors promoted biomass stoves all over the world particularly in Asia, Africa and Latin America (FAO 1983). However, the effects of these programmers have often been short-lived.

The main beneficiaries of the improved biomass stove programs are the most vulnerable groups in society, i.e. women, children, and law income groups (Karekezi et al, 2005,). In many developing countries fuel wood collection and use is the primary responsibility of women who devote a considerable time to fuel collection. Kumar and Hotchkiss (1988) estimated that women in the hill areas of Nepal spent 2.5 hours per day on fuel collection. Similarly, Karekezi et al (2005) recorded that in Botswana, the average time spent on fuel wood collection was sometimes spent up to 6 hours per day collecting fuel wood. With improved biomass stove program, the combustion efficiency increases, reducing cooking time and minimizing the fuel wood demand of a household (Johnson et al, 2008). This not only reduces household cash outlays for fuel woods, but also reduces time spent by women collecting fuel wood.

In Brazil 1 million of people rely on wood fuels for most of their energy needs, despite the problems associated with traditional use of wood fuel including energy inefficiency, deforestation, increasing use of time for collection of fuel and deleterious health and environmental degradation (Smith *et. al* 2004). Modern efficient cook stoves can alleviate some of these problems by reducing some household's cash outlays for fuel, diminish the time spent to collect fuels, reducing air pollution, and relieving local pressure on wood resources. Yet despite the apparent benefits of improved stoves an elusive number of dissemination programs in many countries like Brazil has failed to adapt an own strategy (UNICEF 2003).

In Pakistan a majority of the Pakistan's population 62% reside in rural areas and semi urban slums (Ministry of Finance 2010). The country faces depletion of the already scant forest 4.22 million hectares. People living in close vicinity to forestlands sometimes use the forest in unsustainable ways to satisfy their domestic, energy needs and other commercial needs. (Lubna, 2007) Pakistan is already an energy deficient country.

In sub-Saharan Africa countries, Ethiopia for example is highly dependent on biomass energy sources such as fuel wood, charcoal and crop residues. These biomass energy sources account for more than 90% of the total domestic energy demand, according to the United States Environmental Protection Agency (EPA, 2004). The EPA further reports that about 95% of the total population in Ethiopia uses biomass fuels as their main source of energy for cooking, heating and lighting. Even though urban households have better access to commercial energy than the rural population, the difference in biomass use is not large approximately 99% of rural households and 94% of urban households.

Given the high levels of dependence, biomass will continue to dominate energy demand in both rural and urban Ethiopia in foreseeable future. The heavy dependence and inefficient utilization of biomass resources for energy have resulted in high depletion of the forest resources in Ethiopia. In general, Ethiopians are poor and as noted by Geist and Lambin (2003) as well as Vance and Lovanna (2006), poverty, in particular, as well as other socioeconomic factors, result in exploitation of forest resources for domestic energy consumption and commercial gain by the developing world's population.

In order to reduce the social, economic, environmental, and health related risks associated with the use of traditional biomass stoves, some NGOS working in different areas of Pakistan have launched interventions to disseminate improved biomass stoves in their project areas. One such program was initiated in Swat district for a series of socio political, financial and institutional reasons that by local NGO called Kalam Integrated Development Project (KIDP). In 1998, however, KIDIP terminated its activities in Swat for a series of socio-political, financial, and institutional reasons.

In China, the Chinese National Improved Cook Stove Program (CNISP) started in 1980 with leadership of the department which operates under the ministry of infrastructure. The CNISP has disseminated 144 million improved biomass stove by 1994. This translates to 62% of all rural households by 1994, World Bank (2005). In Malawi it was discovered that households that buy firewood can use 12% to 23% of their weekly expenditure on buying firewood, and hence firewood saving can improve disposable income for these households (Andiema, 2013).

In the year 2002 enterprise work Ghana launched the Gyapa improved charcoal stove, a variant of Kenya ceramic jiko with funding from USAID and the shell Foundation. By July 2004, over 36,000 stoves had been sold. This equates to an annual saving of charcoal worth 250,000 USD, a total of 28,000 tonnes of carbon dioxide emissions averted with sale now climbing beyond 3000 per month (Agyei et al 2014).

In Rwanda, the government has put a lot of restriction on collecting firewood from forests as this has led to severe deforestation in many parts of the nation causing environmental degradation. According to the Rwanda Vision 2020, wood is the source of energy for 99 % of the population, which leads to massive deforestation and soil destruction. About 22% of primary energy is lost in diesel power generation, electricity transmission and distribution losses, and charcoal making. The level of penetration of improved efficient wood stoves for the rural households in Rwanda is still below 5%, yet there is enormous potential (Albert B 2013). UNEP adds that the adoption of these technologies has been slow and unevenly extended as there are still many households which are unaware of the technologies. This is despite the fact that the technologies were initiated over 30 years ago. Therefore, the objective of the Rwandan government to reduce demand on wood fuel, conserve the forests and thus mitigate against increase in greenhouse gases (GHG) and reduce indoor air pollution is yet to be achieved (WHO 2008).

There have been several improved stove programs facilitated and implemented for communities in different parts of the world with support from Government organizations, scientific institution and funding agencies, for more than five decades. The use of improved biomass stoves is expected to reduce the volume of fire woods used for cooking and to enhance local environmental and health conditions (Andiema C, 2013).
Evidence linking solid fuel use in developing countries to climate change is slowly but strongly building up and there are growing concerns that inefficient biomass burning may be contributing significantly to global warming, Johnson (2008). Adoption and continued use of improved biomass stoves in developing countries is therefore an important sustainability strategy which should be adopted by as many households as possible, World watch Institute (2009).
There is need to assess the levels of acquisition and use of the wood fuel saving technologies in order to be able to estimate how successful the government has been in reducing demand on fuel wood from forest and other sources as well as reducing the burden on women and children who are involved in gathering firewood and other domestic activities as well as improve on the indoor air conditions.

1.2 Statement of the Problem

The social and environmental impacts related to traditional energy practices are negatively affecting the efforts to alleviate poverty. Disease burden posed by indoor air pollution, for example, is costing many governments in the developing countries billions of dollars which could be used on other developmental projects hence hampering their efforts to bring about development (PCIA, 2009). In countries like Rwanda for instance, reliance on solid fuels is one of the most important threats to public health (Rehfuess, 2007). Evidence linking solid fuel use in developing countries to climate change is slowly but strongly building up and there are growing concerns that inefficient biomass burning may be contributing significantly to global warming (Johnson et al., 2008). Adoption and continued use of improved biomass stoves in developing countries is therefore a sustainable development case.

The adoption and continued use of improved stoves in the developing countries is of social, economic and environmental concern. In most developing countries, biomass-based energy accounts for more than 90% of all household energy consumption. It is estimated that every year in Rwanda 8,100 people die because of indoor air pollution in smoky kitchens and 2 million die globally according to the 2008 world Health report. One way to minimize pressure on forests, reduce household ‘s wood fuel demand, improve indoor air conditions as well as mitigate against global warming and climate change is by adopting wood fuel conservation technologies. These technologies do not only assist in energy conservation but they also emit less pollutants thus reducing women and children exposure to indoor air pollution. There has been a disparity in their adoption and limited data are available relating to adoption of these technologies. It is believed that the use of improved biomass stoves would save on use of wood fuel yet the take up is low. Promotion of energy technologies such as improved biomass stoves has been going on in many countries yet the uptakes of the technology remains relatively low.

According to UNDP report 2002, black carbon mainly from open and residential burning of biomass, is altering the reflective ability of the atmosphere and ice surfaces hence exacerbating global warming. The invention and diffusion of improved stoves in developing countries is therefore perceived as instrumental in the efforts to combat the negative effects related to the use of traditional hearths. This research therefore evaluated determinants of adoption of improved biomass stove technologies in rural households of Rwamagana District.

1.3 Objectives of the study

1.3.1 General objective

The general objective of the study was to evaluate the determinants of adoption of improved biomass stoves among rural household of Rwamagana District.

1.3.2 Specific objectives

The study was guided by the following specific objectives:

1. To examine the influence of social status of the household on adoption of improved biomass stoves in the rural area.
2. To assess the level at which the economic status of the household influences the adoption of the improved biomass stoves among rural households.
3. To examine the influence of cultural beliefs and practices on the adoption of improved biomass stove among rural households.
4. To investigate the level at which sensitization of the rural households influence the adoption of improved biomass stoves among the rural households.

1.4 Research questions

This study was guided by the following research questions:

1. How does social status of the households influence the adoption of improved biomass stoves?
2. To what level does economic status of the household influence adoption of improved biomass stoves?
3. How does cultural believes and practices influence the adoption of improved biomass stove in the rural areas?
4. How does sensitization level of the household influence the adoption of the improved biomass stove in the rural areas?

2.0 Literature Review

2.1 Empirical review

Menon and Thandapani (2011) conducted a study to understand the adoption dynamics of improved biomass stoves among people living in rural India by including variables of motivation, affordability and level of engagement in their analysis. Neighbors influence, awareness campaigns, the effect of perceived risks/benefits of improve cook stoves vis- a-vis traditional stoves, income, education and stove design were found to be enabling factors for adoption decision. The study revealed that respondents who were recommended by their neighbors had founded to be adopters of improved biomass stoves.

Adrianzen (2009) analyzed the concerns of village technology adoption pattern and village social capital and household characteristics to identify factors affecting improved biomass stoves adoption decision in Northern Peruvian Andes. The study investigated that the higher success village adoption pattern, with stronger social capital, has a significant positive effect on a household's improved biomass stoves adoption decision. From household characteristics, the household's head gender and level of education, the household's number of adults, presence of a female adult member in the household, the household's wealth and the household's participation in women and environmental clubs were found statistically significant factors to influence a household's decision of improved biomass stoves adoption.

A recent study by Levine et al (2013) identified factors that impede the adoption of improved biomass stoves in Uganda by considering variables of information, liquidity and present bias/term of payment. From

the study it was found that customers' liquidity constraint, imperfect information, lack of confidence on the new stove's fuel saving performance and skepticism about the durability of the stove are important barriers of improved cook stoves adoption. The study examined the effect of a contract made for a free trial, time payments, and the right to return the stove in Kampala and Mbarara. The result showed that improved wood burning cook stoves adoption increased from 4 % to 46 % in Kampala and in Mbarara the adoption increased from 5 % to 57 %. In addition, the study found household size to be one significant factor in determining a household's improved cook stoves adoption decision.

In Ethiopia Damte and Kohlin (2011) investigated the determinants of improved biomass stoves (Lakech, Mirt stove and Electric Mitad) in urban areas by analyzing the variables of household characteristics, stove type and ownership, substitutability of stoves and separate kitchen and it features. With regard to Mirt stove, the household heads level of education, income, separate kitchen and household head's gender (female) were found to be positive significant determinant factors of adoption decision. Other variables of substitutability of the stove and the size of children in a household were found to be insignificant in relation to Mirt stove adoption. A study by Gebreegziabher et al (2010) identified factors affecting urban energy transition and technology adoption in Tigray, Northern Ethiopia, with the focuses of household characteristics and price variables. Household head's age, education, family size, and income/expenditure were indicated to be positive and significant factors to determine the adoption of new cooking appliance, electric 'Mitad' and improved wood-burning stoves while prices of fuel-wood, charcoal and kerosene were found to be insignificant in determining the adoption decision.

2.2 Conceptual Framework

Conceptual framework is a schematic presentation which identifies the variables that when put together explain the issue of concern (Peters, Elmendorf, Kandola & Chellaraj, 2000). It is a set of broad ideas used to explain the relationship between the independent variables (factors) and the dependent variables (outcome) (Coulthard, 2004). The conceptual frame work of this study is based on four variables namely social, economic status of the household, cultural beliefs and practices of the members of the households and the sensitization level of the members of the household. Figure 2.1 below shows how the independent variables influence the adoption of the improved biomass stoves which is the dependent variable.

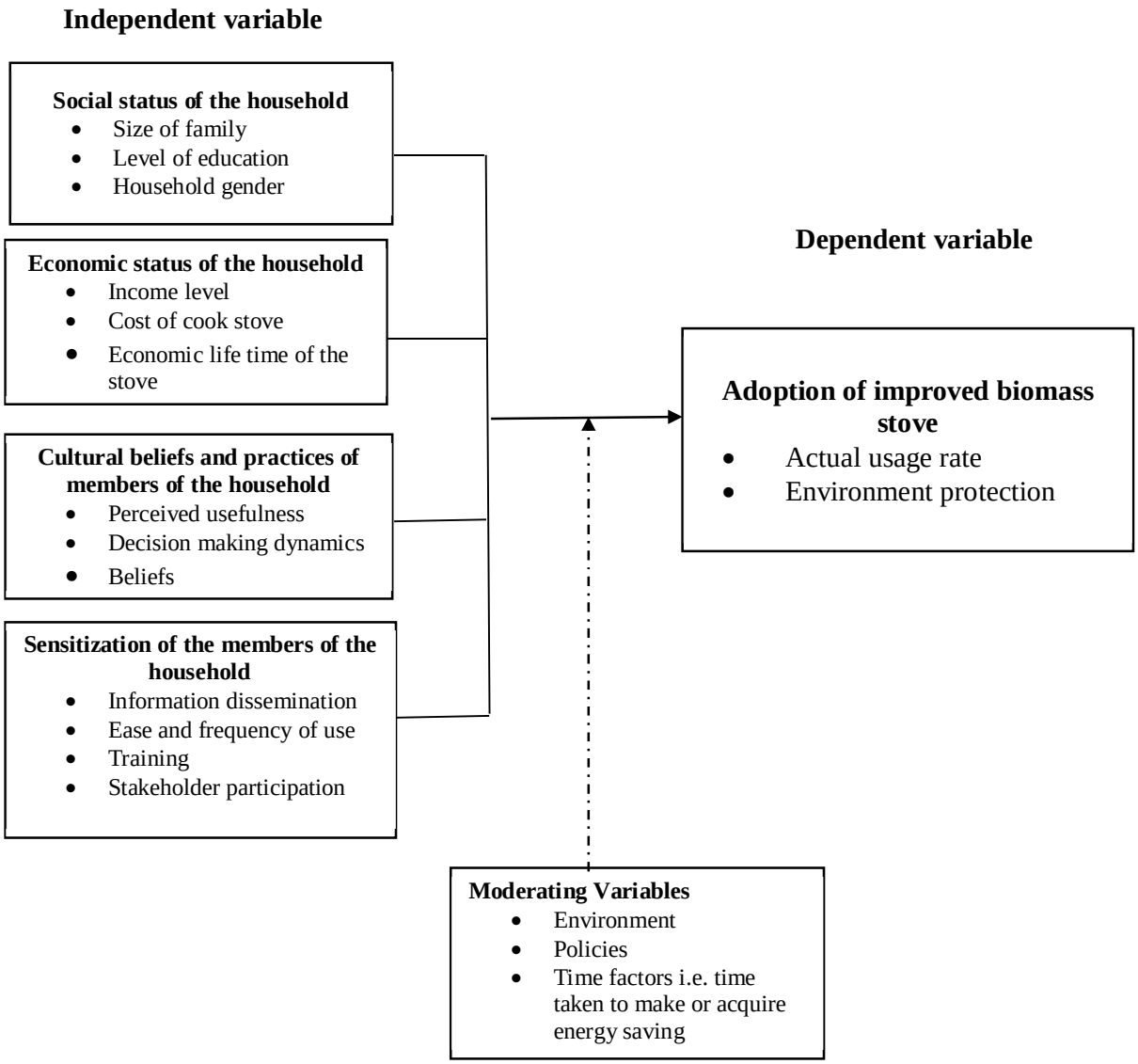

Figure 7: Conceptual framework

3.0 Methodology

3.2 Research design

The study adopted descriptive survey design. According to Kerlinger (2008), Research Design is the plan and structure of investigation conceived so as to obtain answers to research questions or test the research hypothesis. The plan represents the overall strategy used in collecting and analyzing data in order to answer the research questions. Cooper and Schindler (2003) summarize the essentials of research design as an activity and time based plan. Descriptive research design is used to gather information on the nature or condition of a present situation. Past events and how they relate to current conditions are also put into consideration (Cresswell, 2009; Best & Kahn, 2006). The study adopted descriptive survey because it allows the researcher study phenomenon that do not allow for manipulation of variables as noted by Kombo and Tromp (2006). He observed that descriptive survey design is used on preliminary and exploratory studies to allow the researcher to gather the information, summarize, present and interpret.

3.3 Target population

Target population is the specific population about which information is desired. According to Ngechu (2004), a population is a set of people, services, elements, and events, group of things or households that are being investigated. Mugenda and Mugenda, (2003), explain that the target population should have some observable characteristics, to which the researcher generalized the results of the study. The target population of this study considered households from Muhazi sector in Rwamagana District. The households were targeted because the study was focusing on the rural residents of Rwamagana District who could best be found in households as opposed to meeting people on street. A total of 350 households was chosen because the study required household survey.

3.4 Sample size and sampling procedure

A purposive sampling technique was employed to select Rwamagana District as the study site since the improved biomass stoves programme is present in the area. In Rwamagana District, Muhazi Sector was purposively selected as the study location. This was because Muhazi was the only Sector in Rwamagana District where the improved biomass stove programme was promoted by the District since 6 years ago. According to the District's department of Agriculture and Natural Resources, the improved biomass stove programme has been promoted in four Cells within Muhazi Sector which are: Ruhimbi, Gapi, Nyarubuye and Nyarusange. According to Rwamagana District census carried out in 2012, Ruhimbi is composed of 95 households; Gapi has 88 households, Nyarubuye has 84 households and Nyarusange has 83 households.

To determine the sample size to consider in each Cell, stratified random sampling technique was used whereby a random sample from each stratum (Cell) was taken in a number proportional to the stratum size when compared to the population (Table 3.1). These subsets of the strata were then pooled to form a random sample which was considered as the sample size in each stratum (Iyoke et al 2006).

In this study the researcher was interested in the household owner, woman or the man who did the cooking. In a case where a child was the one heading a household then he or she was to take part in the study if he or she fell within the sample of 187 households. Otherwise the researcher will skip such households with no person in charge of cooking.

3.4.1 Sample frame

Sampling frame is a list of all the population subjects that the researcher will target during the study. Based on the District census carried out in 2012, households in Ruhimbi, Gapi, Nyarubuye and Nyarusange are 95, 88, 84 and 83 respectively. This forms a total of 350 households which have been considered as the target population of the study. Through the use of the Slovin's formula, a sample size of 187 households has been determined. To determine the proportion, the total number of households in each Cell (strata) has been divided by the total number of households found in the four Cells (Target population); and to determine the sample size in each Village, the stratified sampling technique has been used whereby this understands multiplying each group size by the sample size and divide by the total population size (Target population).
The size of private households in Rwanda ranges between one to over 15 people per household. At the national level, about 9% and 12% of households are constituted by one and two individuals respectively, while the most common sizes vary between three and five individuals (about 51%). From this point the distribution drops substantially when the numbers reach eight individuals (about 4%) and 10 individuals or more (about 2%) according to the fourth population and housing census 2012. This study considered an average of 5 people per household to determine the population size in the four villages.

The sample frame for this study is shown in the table 3.1

Table 3.18: Sample frame

District	Sector	Cell	Households	No. of people	Proportion	Sample size per village (Households/ respondents)
Rwamagana	Muhazi	Ruhimbi	95	475	0.27	51
		Gapi	88	440	0.25	47
		Nyarubuye	84	420	0.24	45
		Nyarusange	83	415	0.24	44
Total			**350**	**1750**	**1**	**187**

4.0 RESEARCH FINDINGS AND DISCUSSION

4.1: Influence of Social Status of the Household on Adoption of Improved Biomass Stoves

The first objective of the study was to establish whether the social status of the household members influenced the adoption of improved biomass stoves. It was necessary to find out the influence of the social status of the household members. In determining the social status of the household members in influencing the adoption of improved biomass stoves the following factors were investigated through the use of statements tested by frequencies of respondents: Family size, level of education and household head gender.

4.1.1 Statements under Social status of the household variable.

The study further sought to test the strength of the following statements among the respondents. The following statements in the table were tested using:

1. Strongly disagree 2. Disagree 3. Undecided 4. Agree 5. Strongly agree

Table 4.19: Statements under Social status of the household variable

N°	Social status of the household (Statements)	5		4		3		2		1		Total		Mean	Standard deviation
		F	%	F	%	F	%	F	%	F	%	F	%		
1	The bigger the family size means more interest in using the efficient cooking devices	28	15.0	50	26.7	6	3.2	65	34.8	38	20.3	187	100	2.81	1.415
2	Rational choices of cooking device depends on education level	47	25.1	53	28.3	1	0.5	55	29.4	31	16.6	187	100	3.16	1.494
3	Decision making is based on household head gender when it comes to buying stoves	57	30.5	34	18.2	3	1.6	70	37.4	23	12.3	187	100	3.17	1.500
4	Households headed by female stand better chance of selecting the suitable cooking device.	82	43.9	32	17.1	1	0.5	61	32.6	11	5.9	187	100	3.60	1.460

Source: Primary data, 2016

From the Table 4.2, according to Aggresti (2009), a mean of 1.00-2.49 is very weak, a mean of 2.50-3.49 is weak, a mean of 3.50-4.49 is strong and a mean of 4.50-5.00 is very strong. Based on the range above, the first statement Mean is weak which means that interest in using efficient cooking devices does not necessarily depend on the size of the household. According to Inayat (2011), household size is expected to have a positive influence on the adoption of technology on energy saving cook stoves. The study findings disagree with (Inayats 2011) which stated that family size is assumed to have a positive influence on the adoption of the improved energy saving cook stove technology. It was assumed that larger household will cook more food for the family members requiring use of larger pans and more fuel wood hence, will be inclined to adopt the improved energy saving technology.

It can therefore be deduced that large families can end up becoming poor managers of environmental resources and thus the need for awareness creation to larger families on the benefits of energy conservation when energy saving technologies are adopted.

The second statement Mean is also weak, which means that rational choices of cooking device do not necessarily depend on education level. In some cases, illiterate people can make better choices than educated people. This shows that education had very small positive influence on the adoption level, such that as the level of education increased, there was a tendency of progressive adoption.

However from these results we can deduce that, the level of education might not have been a major reason for adoption of the energy saving cook stoves technology.

The findings of this study agree with that of Cotlear (1990) argument that formal, non-formal and informal education may provide specific general knowledge, which provides the benefit and uses of new technology hence the adoption of the energy saving cook stoves.

These findings disagree with Hirock and Ashok (2010) findings that people with higher education level have better access to information and knowledge that is beneficial in their domestic activities hence easy

adoption of the improved cook stove technology.

The third statement is also weak, which means that decision making is not necessarily based on household head gender when it comes to buying improved stoves. These findings disagree with most of the previous findings, such as those in Africa, when energy technology must be purchased, men tend to play a central role in the decision- making because these are important financial decisions even when they involve the kitchen which is generally viewed as women's domain (WEC/FAO 1996) (Clany 2003).

The fourth statement surprisingly had a strong Mean, which means that households headed by female stand better chance of selecting the suitable cooking device. According to respondents, this is mainly because females spend more hours in the kitchen than males and understand clearly challenges experienced when it comes to the usage and performance of various cooking devices. This implies that women were highly involved in the acquisition of improved biomass stoves than men. These results agree with Wickramasinghe (2011) findings that women were more likely to switch to cleaner, and energy saving fuels if they are more involved in kitchen activities than men.

4.2: Economic status of the household and the adoption of the improved biomass stoves.

The economic status of the household was important to find out its influence on adoption of improved biomass stoves. The respondents were asked to state, their average income per month, the cost of the devices and the economic life time of the stove. The influence of economic status on adoption was tested through the use of statements reflected in the table below.

The study further sought to test the strength of the following statements among the respondents. The following statements in the table were tested using:

1. Strongly disagree 2. Disagree 3. Undecided 4. Agree 5. Strongly agree

Table 4.20: Statements under Economic status of the household variable

N°	Economic status	5		4		3		2		1		Total		Mean	Standard deviation
		F	%	F	%	F	%	F	%	F	%	F	%		
1	High income level influences an upgrade to efficient cooking stove	126	67.4	15	8.0	1	0.5	31	16.6	14	7.5	187	100	4.11	1.419
2	Low cost of stoves increase the demand	135	72.2	15	8.0	1	0.5	10	5.3	26	13.9	187	100	4.19	1.472
3	The cost of biomass stove is worth it	97	51.9	26	13.9	12	6.4	48	25.7	4	2.1	187	100	3.88	1.340
4	High economic life time amplifies demand	9	4.8	26	13.9	0	0	27	14.4	125	66.8	187	100	1.75	1.267

Source: Primary data, 2016

From the Table 4.13, according to Aggresti (2009), a mean of 1.00-2.49 is very weak, a mean of 2.50-3.49 is weak, a mean of 3.50-4.49 is strong and a mean of 4.50-5.00 is very strong. Based on the range above, the first statement Mean is strong which means that high income level influences an upgrade to efficient cooking devices.

According to GIZ (2008), the low level of income of the households depending on biomass fuels is a major barrier to increasing the dissemination of improved stoves. For poor households, stoves represent a high initial investment cost which prevents them from purchasing the products. Income levels play a role in determining whether one acquires a new technology or not. The lower the level of income the lower the adoption of any new technology while the higher the level of income, the higher the level of acquiring the use of a new technology.

The second statement Mean is also strong, which means that low cost of stoves increases the demand. This conquers with Jafee (2003) findings that as the cost of the technology fall, more consumers receive positive net benefit and adopt the technology. These findings are also consistent with the findings of Abara and Sigh (1993), that those larger fixed costs become constraints to technology adoption especially if technology requires substantial amount of initial step-up cost.

The third statement is also strong, which means that the cost of biomass stove is worth it. It is clear from table 4.12 that improved biomass stoves costing 5,000 to 10,000 Rwanda francs, according to the responses on the price, is a moderate price and therefore does not hinder its adoption. This conquers with Jafee (2003) findings that as the cost of the technology fall, more consumers receive positive net benefit and adopt the technology.

The fourth statement had a very weak Mean, which means that high economic life time of the stove does not amplifies demand. This was due to the fact that respondents connected high economic life time of the stove with an increase in the price of the stove due to durable materials expected to be used while making the device. These findings are also consistent with the findings of Abara and Sigh (1993), that those larger fixed costs become constraints to technology adoption especially if technology requires substantial amount of initial step-up cost.

4.3: Cultural beliefs and practices of the members of the households and adoption of improved biomass stoves.

The study sought the view of the respondents in regard to influence of cultural beliefs and practices of the members of the household on adoption of improved biomass stoves. In addition, they were asked to state how perceived usefulness and decision making dynamics influenced adoption of improved biomass stoves. Respondents' opinion on the statementsis shown below in table 4.4.

Table 21.4: Statements under cultural beliefs and practices status of the household variable

The study further sought to test the strength of the following statements among the respondents. The following statements in the table were tested using:
1. Strongly disagree 2. Disagree 3. Undecided 4. Agree 5. Strongly agree

N°	Culture	5		4		3		2		1		Total		Mean	Standard deviation
		F	%	F	%	F	%	F	%	F	%	F	%		
1	User fail to understand the immediate benefit of biomass stove	78	41.7	0	0	0	0	102	54.5	7	3.7	187	100	3.21	1.527
2	The usage of biomass stove depends on husband decision as the head	122	65.2	0	0	0	0	11	5.9	54	28.9	187	100	3.67	1.843
3	There is lack of differentiation between traditional stove and improved biomass stove	12	6.4	59	31.6	0	0	18	9.6	98	52.4	187	100	2.30	1.512
4	Believes and culture prohibit the usage of improved stoves	26	13.9	17	9.1	0	0	22	11.8	122	65.2	187	100	1.95	1.509

Source: Primary data, 2016

From the Table 4.4, according to Aggresti (2009), a mean of 1.00-2.49 is very weak, a mean of 2.50-3.49 is weak, a mean of 3.50-4.49 is strong and a mean of 4.50-5.00 is very strong. Based on the range above, the first statement Mean is weak which means that user manage to understand the immediate benefit of biomass stove but need to increase awareness is still required to boost their knowledge on the benefits of the biomass stove. The findings agree with (Wozniak, 1993) who said that constant flow of information about the new innovation to users has a bearing on the diffusion of innovations and sustained adoptions.

The second statement Mean is strong, which means that the usage of biomass stove depends on husband decision as the head. This finding agree with most of the previous findings, such as those in Africa, when energy technology must be purchased, men tend to play a central role in the decision- making because these are important financial decisions even when they involve the kitchen which is generally viewed as women's domain (Clany 2003).

The third statement is weak, which means that users noticed the difference between traditional stove and improved biomass stove. During the interview, respondents mentioned that the improved biomass stove consumes less wood fuel than the traditional stove, hence less expenditure going on wood fuel. It can be deduced that residents from Rwamagana District perceive improved biomass stove to be very useful when it comes to fuel consumption.

The fourth statement had a very weak Mean, which means that beliefs and culture had a very negligible impact when it came to prohibiting the usage of improved stoves. These findings agree with Vitell et al (1993) findings that, culture differentially affects individuals formation of teleological and deontological norms; hence, individuals' prescriptive reasoning, however, Baran, Patterson, Harris and Beyond (2006) perceives that technology adoption incorporates two essential elements, the embracement of the technology by individuals and its embedment in society.

4.4: Sensitization of Household Members and Adoption of Improved Biomass Stoves

To establish the influence of sensitization of household members on adoption of improved biomass stoves, respondents were asked whether they have heard of the improved biomass stoves, with a binary response of yes or no. Using a questionnaire, they were also asked exactly where they acquired the information, and the extent to which they agreed with statements related to sensitization.
This was achieved through testing the strength of statements mentioned in table 4.5.

Table 4.22: Statements under sensitization status of the household variable

The study further sought to test the strength of the following statements among the respondents. The following statements in the table were tested using:

1. Strongly disagree 2. Disagree 3. Undecided 4. Agree 5. Strongly agree

N°	Sensitization	5		4		3		2		1		Total		Mean	Standard deviation
		F	%	F	%	F	%	F	%	F	%	F	%		
1	It is easy to use the improved biomass stove	109	58.3	37	19.8	0	0	32	17.1	9	4.8	187	100	4.10	1.304
2	Users have adequate knowledge on the benefit of biomass stove	72	38.5	18	9.6	3	1.6	80	42.8	14	7.5	187	100	3.29	1.514
3	Information about the biomass stove at households level is effective	123	65.8	11	5.9	0	0	16	8.6	37	19.8	187	100	3.89	1.669
4	Poor user involvement in the innovation leads to low acceptance	123	65.8	11	5.9	0	0	16	8.6	37	19.8	187	100	3.91	1.447

Source: Primary data, 2016

From the Table 4.5, according to Aggresti (2009), a mean of 1.00-2.49 is very weak, a mean of 2.50-3.49 is weak, a mean of 3.50-4.49 is strong and a mean of 4.50-5.00 is very strong. Based on the range above, the first statement Mean is strong which means that majority of the respondents found it easy to use the improved biomass stove.

The second statement Mean is weak, which means that users don't have adequate knowledge on the benefit of biomass stove. Effective awareness campaigns are still needed in Rwamagana for the population around to get a chance to understand better the benefits of improved stoves. The findings agree with (Wozniak, 1993) who said that constant flow of information about the new innovation to users has a bearing on the diffusion of innovations and sustained adoptions.

The third statement Mean is strong, which means that Information about the biomass stove at households is effective. The majority of the population in Rwamagana District has heard about the cana rumwe stove. This as an impact can boost the adoption rate of the stove as the population is aware about the product. This finding disagrees with Carr (1982) findings that there is definite lack in appropriate technology information in the rural areas and more so among women than men. He further states that majority of cases of rural women are completely unaware of the existence of improved technologies which could help them. He further added that women information does not trickle down to the village level. It is usually the men who receive it. This is not the case from the findings of the study.

The fourth statement had a strong Mean, which means that poor user involvement in the innovation leads to low acceptance. During the interview, respondents said that they were not adequately involved when it came to considering their views in the design of the stove. Most respondents complained about the size of the stove, saying that it is small comparing to utensils they use. The findings agree with (Hoffmann, 2007) who said that users of newly invented products go through a process of discovery as they use and interact with their new products. Communication between developers and users is therefore crucial if innovation is to diffuse sustainably.

4.5 Adoption of improved biomass stove

To test the strength of factors under adoption of improved biomass stove, respondents were asked if the adoption was characterized by the actual usage rate and to also give their opinion on the relationship between adoption of improved stove and environment protection. Using a questionnaire, the respondents clarified the extent to which they agreed with the statements reflected in table 4.6.

Table 4.23: Statements under adoption status of the household variable

The study further sought to test the strength of the following statements among the respondents. The following statements in the table were tested using:
1. Strongly disagree 2. Disagree 3. Undecided 4. Agree 5. Strongly agree

N°	Adoption of improved biomass stove	5		4		3		2		1		Total		Mean	Standard deviation
		F	%	F	%	F	%	F	%	F	%	F	%		
1	Increased usage rate of the biomass stove is an indicator for adoption	144	77.0	12	6.4	0	0	31	16.6	0	0	187	100	4.44	1.117
2	Adoption of biomass stove leads to forest sustainable use	57	30.5	0	0	0	0	31	16.6	99	52.9	187	100	2.39	1.772
3	Indoor air pollution is reduced as adoption increases	88	47.1	56	29.9	0	0	23	12.3	20	10.7	187	100	3.90	1.388
4	Increased usage rate of biomass stove leads to more saving	74	39.6	28	15.0	0	0	66	35.3	19	10.2	187	100	3.39	1.535

Source: Primary data, 2016

From the Table 4.6, according to Aggresti (2009), a mean of 1.00-2.49 is very weak, a mean of 2.50-3.49 is weak, a mean of 3.50-4.49 is strong and a mean of 4.50-5.00 is very strong. Based on the range above, the first statement Mean is strong which means that increased usage rate of the biomass stove is a strong indicator for adoption.

The second statement Mean is very weak, which means that adoption of biomass stove does not lead to forest sustainable use. During interview, respondents said that wood fuel is not the biggest contributor of deforestation but instead urban demand for wood is the biggest contributor as they need big amount of wood to use in making furniture and building houses.

The third statement Mean is strong, which means that indoor air pollution is reduced as adoption of biomass stove increases. The majority of the population in Rwamagana District has mentioned that even the cana rumwe stove releases some amount of smoke but comparing to the traditional stove there is considerable improvements.

The fourth statement had a weak Mean, which means that increased usage rate of biomass stove does not lead necessarily to saving of money. This is mostly dependent to the family size and the eating habit of a given family. As the size of the family increases, food amount to be cooked increases and that also influences an increase in the amount of wood fuel to be used to prepare the food. Eating habits can also affect the amount of wood fuel to be used, some families can be comfortable with cooking once in a day and others can have a habit of cooking 3 to 4 times a day. As the family cook more time than the other, it means that it will also use more woof fuel than the rest. Hence increasing the amount of money to be used on purchasing wood fuel.

4.6 Correlation analysis

To quantify the relationship and strength of the relationship between the variables, the study used Karl Pearson's coefficient of correlation. The Pearson product-moment correlation coefficient (or Pearson correlation coefficient for short) is a measure of the strength of a linear association between two variables and is denoted by *r*. The Pearson correlation coefficient, *r*, can take a range of values from +1 to -1. A value of 0 indicates that there is no association between the two variables. A value greater than 0 indicates a positive association, that is, as the value of one variable increases so does the value of the other variable. A value less than 0 indicates a negative association, that is, as the value of one variable increases the value of the other variable decreases.

Table 4.24: Correlation and the coefficient of determination

	Adoption of improved biomass stoves	Social status of the household	Economic status of the household	Cultural believes and practices	Sensitization of the rural households
Adoption of improved biomass stoves (r) (p) Sig. (2 tailed)	1.000				
Social status of the household (r) (p) (2 tailed)	.902**	1.000			
	.000				
Economic status of the household (r) (p) Sig. (2 tailed)	.989**		1.000		
	.000				
Cultural believes and practices (r) (p) Sig. (2 tailed)	.852**			1.000	
	.000				
Sensitization of the rural households (r) (p) Sig. (2 tailed)	.941**				1.000
	.000				

**Correlation is significant at the 0.01 level (2-tailed).

According to the table 4.7, there is a positive relationship between adoption of improved biomass stoves and Social status, Economic status, Cultural beliefs and Sensitization of rural households (0.902, 0.989, 0.852, and 0.941) respectively. The positive relationship indicates that there is a correlation between adoption of improved biomass stoves and Social status, Economic status, Cultural beliefs and Sensitization of rural households in Rwamagana District. This despite, all the factors had a significant p-value ($p<0.05$) at 95%

confidence level. The significance values for relationship between adoption of improved cooking stoves and Social status, Economic status, Cultural beliefs and Sensitization of rural households were all equal to 0.000 which means that there is high positive correlation between determinants and adoption. From the Pearson correlation coefficient, economic status was the most significant determinant and this was followed respectively by sensitization, Social status and Culture. This finding is consistent with Manyan et al., (2009) who found a significant relationship between economic status of rural household and adoption of biomass stoves and also confirms the findings of (Wozniak, 1993) who said that constant flow of information about the new innovation to users has a bearing on the diffusion of innovations and sustained adoptions.

4.7 Regression Analysis showing the influence of determinants on adoption in rural households in Rwamagana district

Table 4. 25: Regression model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.990[a]	.980	.980	.235

a. Predictors: (Constant), Culture , Sensitization , Social status , Economic status

According to results in above table, determinants of biomass stove adoption have strong positive effect on adoption where (R=0.990) with all determinants contributing (98%) to the adoption.

Table 4.26: Regression Analysis showing the influence of each determinant on adoption

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.094	.050		1.887	.061
	Social status	.069	.036	.062	1.923	.056
	Economic status	.824	.040	.850	20.790	.000
	Sensitization	.084	.034	.079	2.449	.015
	Culture	.010	.026	.010	.363	.717

a. Dependent Variable: Adoption

Using linear regression analysis from SPSS data bases, the determinants of improved biomass stoves were regressed to find out how they impacted adoption of biomass stoves.

$Y=0.094+0.069x1+0.824x2+0.084x3+0.010x4+ \varepsilon$.

According to beta and t-values, economic status had the most influence on adoption of biomass stove in Rwamagana district (beta=0.850,t=20.790 and sig=0.000). Following in the degree is the influence of sensitization on biomass stove adoption with (beta=0. 079,t=2.449 and sig=0. 015). Other determinants of adoption of improved biomass stove influenced adoption positively but the influence is not as significant because their values were above the popular significance level of 0.05 or 5% (Social status sig=0.056 and Culture sig=0.717).

5.0 Conclusion

From the findings of the study, it is concluded that social status and cultural practices have a low influence on adoption of improved biomass stoves among the rural households. This study concludes that majority of the households visited had adopted the use of the improved biomass stoves for cooking although the traditional three stone fire place was also being used at times. The household heads revealed that they used the improved biomass stoves because it uses very little fuel comparing to the three stones. The study further revealed that when cooking food to a large number of people for example in a social gathering, they sometimes use the traditional three stone fire place. On the side of gender and adoption, it was revealed that more women household heads had embraced the improved biomass stove technology than men due to its effectiveness in conserving the fuel. Education level of the household head did not matter when it came to adoption of the technology but the benefits of the device.

On the assessment of the level at which economic status of the households influenced the adoption of the improved biomass stove, the study found out that the economic status of the household heads had a considerable influence on adoption of improved biomass stoves. According to beta and t-values, economic status had the most influence the adoption of biomass cooking stove in Rwamagana district (beta=0.850,t=20.790 and sig=0.000).

On cultural beliefs and practices' influence on adoption, it was revealed that cultural beliefs and practices did not hinder adoption of the energy saving cook stove because the significance value was above the popular significance level of 0.05 or 5% (Culture sig=0.717).

On the sensitization level of the rural households, it was revealed that most of the respondents, 66.8% got the information about the improved biomass stoves from their friends and family, therefore the study concluded that information dissemination on this new technology comes second in influencing adoption as confirmed by the following values (beta=0. 079,t=2.449 and sig=0. 015).

5.1. Recommendations

Based on the findings and the conclusions drawn above, this study makes the following recommendations.

1. First and foremost, there should be enough advertisement on the need to adopt improved biomass stoves since the majority does not understand clearly the benefits of the device.
2. Mothers should also be empowered when it comes to the adoption of the improved biomass stoves. If they are empowered, then the next time this study is done, the population might have increased adoption.
3. Stove users inputs must be included in the innovation process to make sure that the technology is driven by demand.
4. The cost of the improved biomass stoves should also reduce to enable subsistence farmers to acquire it at low prices. The government and NGOs should therefore facilitate cost reduction to boost adoption
5. More research on energy saving devices should be carried out and the results implemented for the betterment of the society and conservation of the environment.

5.2. Areas for further research

The study focused on determinants of adoption of improved biomass stoves but did not outline the effects of the improved biomass stoves technology on preparation of different types of foods. Therefore, the study further suggests that another study should be carried out to establish the barriers to energy saving cook stove acceptance among rural households when it comes to preparation of types of food. More data on stove efficiency and emissions under field conditions are required. This study is based entirely on adoption and user acceptability of improved biomass energy technologies for cooking and can therefore not make any reliable statements on actual smoke emissions and efficiency. There is an urgent need to measure cooking performance of stoves such as stove efficiency and emissions under actual-use conditions, to complement the user-focused findings of this study.

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