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# Socio-Economic Factors Influencing Adoption of Energy–Saving Technologies among Smallholder Farmers: The Case of West Pokot County, Kenya

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**Abstract**

Fuel wood provides the main source of energy for cooking and space heating for over 80 percent of households living in Kenya. The heavy reliance on the biomass energy has exerted an imbalance in demand and supply consequently resulting in adverse environmental effects in Kenya. As part of innovation efforts, several energy-conserving technologies have been developed. A unique cook stove named Maendeleo was developed and promoted in Kenya and more so, West Pokot County, northern of Kenya, with the goal of reducing the quantity of wood households use for energy, and ultimately reduce pressure on local forests. However, despite the demonstrated technological multiple benefits and the institutional promotional efforts of the Maendeleo stove technology; the adoption level of this innovation has remained low. An important question investigated in this study was what makes potential users not utilize such valuable innovations? Socio-cultural, economic, political and institutional barriers are considered to contribute to low uptake of such innovations. This study therefore, sought to assess socio-economic factors influencing the adoption of the Maendeleo stove in the rural setting of Kapenguria Division. A survey research methodology with ex-post facto design was employed. The results showed that the age of the respondents had the highest influence on the non-adoption of the Maendeleo stove. Given the relatively low adoption level of Maendeleo stove in the county, and the projected increase in the number of people relying on biomass, this study recommends that the government and development partners put in place a programme for the promotion and dissemination of Maendeleo stove. There should be further investigation into the adoption behaviour of the respondents on the reasons for non-adoption and discontinuance of use of the Maendeleo stove.

*Keywords:*
*Adoption, Smallholder, Energy-saving technologies*

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## INTRODUCTION

In most developing countries, biomass-based energy accounts for more than 90% of all household energy consumption (FAO, 2010; Field, 2010). The dependence of the world's population on biomass fuels for domestic energy consumption has a negative impact on the social well-being of the users and the rural environment (United Nations, 2009; Inayat, 2011). The use of biomass in inefficient ways increases fuel wood demand of a household, yet energy needs of the developing world have to be met in a sustainable manner (Ndung'u, 2009). The invention and diffusion of improved cook stoves in developing countries is one of the strategies perceived as instrumental in combating the negative effects related to the use of traditional hearths (Rwiza, 2009). There have been several improved stove programs facilitated and implemented for communities in different parts of the world with support from governments, organizations, scientific institutions and funding agencies, for more than five decades (Reddy, 2008).

The adoption and continued use of improved cook stoves in the developing countries is of social, economic and environmental concern (Inayat, 2011). In particular such innovations have potential for delivering triple dividends: household health, local environmental quality, and regional climate benefits (Lewis and Pattanayak, 2012). Although the social, economic, and environmental benefits of the improved stove programmes seem to be rather clear, the rate of adoption of technologies promoted is not as fast as initially anticipated (FAO, 2010). However, there may be a range of personal, social, cultural and economic factors, as well as the characteristics of the innovation itself that prevent the technology adoption, notwithstanding the argument by scholars that the poor economic conditions in developing countries should encourage innovations in new technologies (Lundvall, 2007).

A number of socio-economic factors such as lack of knowledge about the costs and benefits of improved cooking technology (Muneer and Mohamed, 2003; Bikram, 2008), income level of the household, and lack of proper monitoring systems of the stove programs are responsible for slow adoption rates. Maendeleo stove is a stove that was developed in Kenya in the 1980's as one of the strategies to reduce fuel wood consumption. The basic component is the stove liner, (made of a pottery cylinder fired in a kiln), which incorporates a door for fuel and air intake and pot supports on the stove liner, built into a mud and stone surrounded stove in the kitchen or in a metal cladding (Mandeleo portable). Research findings by Ndung'u, (2009) show the stove could provide fuel wood savings of up to 43 per cent and producing up to 60% less smoke compared to a three-stone fire commonly used. With proper use; a fuel wood saving efficiency of up to 50% is achievable. Despite the fact that the Maendeleo stove technology has been promoted in Kenya for nearly twenty years and has been produced on a more commercial basis, the stove has remained at a low level of use within rural communities-only 4% of the targeted populations is using this stove (Ingwe, 2007). A number of farmers' characteristics, attributes of the technology and institutional factors are hypothesized as influencing adoption of these technologies.

Much emphasis has been placed on several socio-economic factors as being the most important factors influencing adoption of the Maendeleo stove technology– namely age of the target respondents, level of their education, household in, household size and farm size. These are some of the variables that have varying degrees of influence over the adoption of influence over the adoption of practices or technologies being promoted for uptake. Karin *et al.* (2007) observed that the socio-economic factors Were positively correlated with the adoption of the energy-saving cook stoves. Demographic factors such as age, education, household income, household size and land size, all have varying degrees of influence over the adoption of changed practices e,g (Jeanette *et al.,* 2010).

The age of a potential adopter has been found, with mixed results to influence adoption of innovations. A farmer's age is expected to increase Maendeleo stove technology adoption in the sense that older farmers over time have gained knowledge of the Maendeleo stove technology and experience in the use of the stove and are better able to evaluate technology information than would do younger farmers. An analysis of

this study shows that age of the respondent is associated with the adoption of the Maendeleo stove technology. However, there is conflicting evidence on this relationship, with some researchers finding no significant relationship between age and adoption rates of improved stove technologies (for example; Cary *et al.,* 2001, 2002; Lockie and Rockloff, 2004). Other researchers have found a more direct relationship between adoption rates and an adopter's age. The younger the farmer, the more likely he is to adopt innovations early in his life cycle (Diederen *et al.,* 2003).

Education helps the transformation of information (processed data) to knowledge (information that is modeled to be useful) which in turn influences adoption. Farmers who have adequate information about knowledge of technology use are likely to adopt it (Abebaw and Belay, 2001; Rogers, 2003). Traditionally, educated people were expected to understand the benefit of the innovation in question at a faster speed than the uneducated (Makame, 2007; Rollins, 2009). Educational status is assumed to influence the adoption decision of many technologies because with higher level of education the farmer would be in a position to technically and economically assess the new technology to clear doubts and uncertainties associated with it, and enhance its adoption (Aneani *et al.,* 2012). The more aware (educated) respondents were, the more likely they were to use efficient cooking technologies (Inayat, 2011). In the present study, level of education was hypothesized as a proxy for more awareness about the pros and cons of using the Maendeleo stove technology. Although it is not necessary that more education equates to greater awareness, it is assumed that more educated people have more knowledge about benefits of Maendeleo stove technology than do un-educated people. Awareness of the Maendeleo stove technology in which the respondents had been introduced in the study area was high, the main sources of information being family members, farmer to farmer contact, community group and extension staff. In this context, awareness has been identified as a major factor impacting the adoption of the Maendeleo stove technology. Technical information and the frequency of exposure to this information are important in influencing adoption of Maendeleo stove technology and other technologies (Fernandez-Cornejo *et al.,* 2007). In the study area, the more educated respondents may be assumed to be more aware of the environmental and health effects of using biomass fuels, and therefore, formal education may increase the speed of adoption. There was a significant difference in the years of schooling of the respondents among the young and the older respondents, with the former being more educated. There was no significant difference observed between respondents with formal education and non-formal education in terms of gap between adopters and non-adopters. Adopters had significantly higher contact with extension visits than did non-adopters.

Household income is an indicator of prosperity and may be expected to have positive effect on adoption of technologies as wealthier households may have higher probability of investing in and using improved stoves (Inayat, 2011). Household income has a unidirectional, linear relationship with the household's type of fuel used as energy source and type of cook stove (Rwiza, 2009). Household income of a household was measured as total sum of money in Kenya shillings the household earns per year. the present study focused on the cost of the Maendeleo stove technology; this refered to the economic purchasing power and installation ability of the stove of the user. Cost of adopting a new technology remains a very important factor influencing the decision to adopt the technology (Huh and Kim, 2008). It follows that if a stove is too expensive, adoption decisions will be negatively affected. Rogers (2003) assumed that economic motivation is one of the main thrusts for adopting an innovation, especially if the idea is expensive in both the initial and running costs. The study revealed that cost of the Maendeleo stove was affordable as none of the respondents found the stove to be expensive. Technology with low initial cost is more likely to be adopted than would be technology with high initial cost. Low initial cost has a positive influence on the rate and speed of technology adoption. This perceived cost therefore, may be expected to increase adoption of the Maendeleo stove technology unless other attributes of the

technology or other extraneous variables negatively influenced utilization of the technology.

Household size was expected to have a positive influence on the adoption of the Maendeleo stove technology. Family size is expected to have a positive influence on the model of the stove used (Inayat, 2011). It is assumed that larger households will cook more food for the household members requiring use of large pans and more fuel wood hence will be more inclined to adopt the Maendeleo stove technology. It is expected, therefore, that a larger household size will affect positively the decision of adopting the Maendeleo stove technology.

Land size is one of the first and most widely used factors on which the empirical adoption literature has focused. Most studies find a positive relationship between farm size and adoption. Farmers with larger farms are more likely to adopt relatively new innovations (Diederen, *et al.*, 2003). Thus, it can be assumed that a household with large landholding will be more likely to adopt improved cook stoves than would households with small landholdings (Field, 2010). The importance of including this variable in the model was the fact that acquisition of land is an important determinant of socio-economic status in West Pokot County. It was expected that a household with large landholding will be more likely to adopt Maendeleo stove technology. In the present study, farm size may be expected to influence a farmer's ability to set aside a portion of the land for wood production which in turn may affect availability of fuel and hence the ability to use energy saving Maendeleo stoves. It was expected that a household with large landholding would be more likely to adopt improved cook stove technology.

Although the social, economic, and environmental benefits of the improved stove programmes seem to be rather clear, the rate of adoption is not as fast as hoped and anticipated. A literature review on the diffusion of innovations reveals possible explanation about the slow diffusion process of technologies. Factors that may have influence on the adoption of Maendeleo stove include: socio-economic factors (i.e. age, education, household income, household size, land size); stove-related factors (cost, size, perceived benefits, biomass flexibility, operatability and quality) and, finally institutional factors (access to extension services, land tenure, membership to groups). These factors were used to examine issues in the context of the Maendeleo stoves in the study area. The purpose of this study was to determine the influence of socio-economic characteristics on adoption of the Maendeleo stove among small-scale farmers in Kapenguria Division of West Pokot County. The null hypothesis was: $H_{01}$: farmers' socio-economic characteristics have no statistically significant influence on adoption of Maendeleo stove.

## MATERIALS AND METHODS

The study employed an ex- post facto survey research design. This design was found to be suitable for this study as the dissemination of Maendeleo stoves had already occurred and is on-going and the factors influencing adoption could only be studied retrospectively.

The survey was conducted in West Pokot County which lies along Kenya's western border with Uganda between latitudes 240 40'N and 107'N and between longitudes 34037'E and 35049'E. It covers an area of 2317.5sq km, which is approximately 5% of the area of Rift Valley Province. The county varies greatly in geographical features. The southeast part falls within the mountainous Cherangani Hills, which reaches up to 2550 metres above sea level, the lowest is 1550metres above sea level. The county has a bimodal rainfall pattern which is normally unevenly distributed ranging from 700mm to 1600mm per annum. The temperatures range from a minimum of 15 degrees centigrade to a maximum of 34 degrees centigrade. The County has four divisions namely: Kapenguria, Kongelai, Chepareria and Sook; 23 locations with 82 sub-locations.

Kongelai and Sook's residents are purely pastoralists; Chepareria residents are agro pastoralists and those of the larger part of Kapenguria practice mixed farming.

The study was conducted in 2 locations namely; Kaibos and Talau (with 2 sub-locations each) Kaibos, Kipkorinya, Chepkoti and Talau respectively; of Kapenguria Division, West Pokot sub-county. The four sub-locations had many similarities in terms of their farming sys-

tem and the socio-cultural environment. The agricultural sector in the region is dominated by smallholder farmers. The division covers an area of 335.6 sq km with 9 locations and 28 sub-locations. The accessible population of this study comprised of 82,057 people with a total of 16,131 households. The division is a cosmopolitan, rural-urban setting with a rapid increase in population because it is a high potential area agriculturally and also due to influx of new comers from the drier areas of the district. The fast growing population has accelerated the rate of destruction of trees because there is a high demand for fire wood to use for cooking with highly inefficient open fire stoves.

The sampling frame consisted of a list of households which was generated from the four sub-locations with the help of the Agricultural Extension staff and the local leaders. From the sampling list 160 households were selected through simple random sampling using computer randomizer program. A structured questionnaire was administered to adult female respondents who are in charge of cooking for the household because cooking and taking care of children is almost done entirely by women. Studies indicate that women have a central stake when it comes to the adoption and use of improved stoves.

The distribution of the respondents in the study areas is depicted in table 1.

The analytical tools employed in this study were both the descriptive and inferential statistics. The descriptive statistics used were frequency counts, percentages and means, while the inferential statistical tool used was the logit regression model. The logit model is a standard method for understanding the association between explanatory variables and a binary dependent variable (Greene, 2008; Hosmer and Lemeshow, 2000). The objective of the research was to understand the degree and the trend of the relationship between dependent and independent variables in terms of adoption of Maendeleo stove technology. Since the adoption of Maendeleo stove technology is a dichotomous or binary dependent variable, with the option of either adoption or non-adoption, the binary logistic regression model was applied as the most appropriate tool to investigate how each independent variable affects the probability of the occurrence of events (Long and Freese, 2006). The logistic regression model explores the socio-economic factors influencing the adoption of Maendeleo stove technology. Thus it helps to explore the degree and direction of relationship between dependent and independent variables in the adoption of Maendeleo stove technology at the household level. Accordingly, Maendeleo stove technology in the study area is influenced by a set of independent variables and is specified as follows:

$$Y_i / 1- Y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + ..... + \beta_k x_{ki}.$$

Where the subscript i means the ith observation in the sample. Y is the probability that a household adopts the Maendeleo stove technology and (1-Y) is the probability that a household does not adopt Maendeleo stove technology. $\beta 0$ is the intercept term and $\beta 1, \beta 2, \ldots\ldots\ldots, \beta k$ are the coefficients of the independent variables X1, X2,……., Xk.

In the analysis of the hypothesis of this study adoption of Maendeleo stove was considered in relation to the five explanatory variables in the socio-economic characteristics; namely age, level of education, household income, household size and farm size.

The model can then be expressed as follows: $Yi = \beta_0 + \beta_1$ ($x_1$= Age (in years); $+ \beta_2$ ($x_2$= Education (level of education attained); $+ \beta_3$ ($x_3$= Household income (shillings); $+ \beta_4$ ($x_4$= Farm size (in acres)

Table 1: Distribution of respondents by location and sub-location.

| Location | Sub-location | No. of Respondents |
|---|---|---|
| **Kaibos Location** | Kaibos Sub-location | 39 |
| | Kipkorinya Sub-location | 41 |
| **Talau Location** | Chepkoti Sub-location | 43 |
| | Talau Sub-location | 37 |
| **Total** | | 160 |

$+\beta_5$ ($x_5$ = Household size (persons).

Age was measured in years. Highest education level attained by the household was coded as 1 = non-formal education 2 = primary 3 = secondary, 4 = tertiary. Four dummy variables representing the level of education attained by the farmer were used, where non-formal education was used as a reference category variable. Household income is a continuous variable measured in Kenya shillings based on estimates of the last 12 months. Household size is a continuous variable measured by the number of persons living in the household and land size is a continuous variable measured in acres.

## RESULTS AND DISCUSSION

### Socio-economic characteristics of the respondents

### Age of the respondents

The respondents were asked to indicate their age in years. Table 2 summarizes the results with regards to age of the respondents.

Findings revealed that the minimum age of the respondents was 19 years while the maximum was 69 years with a mean of 42 (±0.903) years. The respondents were grouped into six age categories as shown in Table 2. The majority (83%) of the respondents were in the age category of 31-60 years while the rest (17) were in the age group of 30 years and below. Observations from the study revealed that the respondents in the age category of 31–60 years adopted the Maendeleo stove technology.

The observed results indicate that the older respondents had prior exposure to the benefits of the Maendeleo stove technology having been promoted in the county in the last 30 years through the extension services. These findings are consistent with research work done by Mignouna *et al.,* (2011) which indicated that a farmer's age is expected to increase technology adoption in the sense that older farmers over time have gained farming knowledge and experience and are better able to evaluate technology information than younger farmers. Okunade (2007) in a study of Nigerian women farmers found a significant positive relationship between age and adoption of farm technologies. He concluded that the older the farmers were, the more their years of farming experience and hence the better the decision the farmer would make in adopting new technologies.

The younger generations on the other hand were aware of the Maendeleo stove technology but, lacked information on the benefits of the Maendeleo stove technology, due to the limited technical information about the Maendeleo stove technology by the agricultural extension

Table 2: Frequency distribution of the respondents by age.

| Age categories (Years) | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| <21 | 5 | 3.1 | 3.1 |
| 21 – 30 | 23 | 14.4 | 17.5 |
| 31 – 40 | 47 | 29.4 | 46.9 |
| 41 – 50 | 43 | 26.9 | 73.9 |
| 51 – 60 | 33 | 20.6 | 94.4 |
| >60 | 9 | 5.6 | 100.0 |
| **Total** | **160** | **100.0** | |

Mean 42.31, se 0.903, median 42, mode 49, std dev 11.43, minimum 19 maximum 69.

Table 3: Level of education attained by the respondents.

| Level of formal Education | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| No formal education | 11 | 6.9 | 6.9 |
| Primary | 118 | 73.8 | 80.6 |
| Secondary | 17 | 10.6 | 91.3 |
| Tertiary | 14 | 8.8 | 100.0 |
| **Total** | **160** | **100.0** | |

Mean 42.31, se 0.903, median 42, mode 49, std dev 11.43, minimum 19 maximum 69.

agents. This was accelerated by the un-availability of the Maendeleo stoves in the study area and lack of confidence that the stove is durable as the respondents feared the stove would not work or would break quickly. As a result; the respondents opted for the alternative improved stoves like the chepkube brooder, rocket stoves etc.

**Level of education of the respondents**

The respondents were asked to indicate the highest level of formal education that they had attained.

The level of education of the respondents ranged from no formal education at all, primary education, secondary education and tertiary education, the findings were as indicated in Table 3. The findings indicated that only a minority (6.9%) of respondents had never received formal education while a higher percentage (73.8%) of the respondents had attained primary level education. Educational status is assumed to influence the adoption decision of many technologies because with higher level of education the farmer would be in a position to technically and economically assess the new technology to clear doubts and uncertainties associated with it and enhance its adoption (Aneani *et al.,* 2012). In the study area, the respondents with formal education may be assumed to be more aware of the environmental and health effects of using biomass fuels, and therefore, formal education may increase the speed of adoption. The respondents with no formal education however, were aware of the benefits of the Maendeleo stove technology having gotten the technical information through the agricultural extension pathways.Technical information about the energy-saving Maendeleo stove technology are disseminated through the agricultural extension pathways such as farmers' field days, demonstrations, farmers' trainings among others, by the Home Economics Officers in the State Department of Agriculture. Access to information through extension services reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time thereby facilitating adoption. Technical information through extension services is critical in promoting adoption of modern agricultural production technologies because it can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies (Kubok, 2007). However, the study findings indicated that the level of education is not a major determinant of adoption of the Maendeleo stove technology since households who adopted the Maen-

Table 4: Frequency distribution of the household size.

| Number of Members | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| 1-3 members | 10 | 6.3 | 6.3 |
| 4-6 members | 55 | 34.4 | 40.7 |
| 7-9 members | 55 | 34.4 | 75.1 |
| 10-12 members | 31 | 19.4 | 94.5 |
| Above 13 | 9 | 5.5 | 100.0 |
| **Total** | **160** | **100.0** | |

Mean 7.5; SE 0.239; median 7, mode 8, std dev 3.033, minimum 1 and maximum 18.

Table 5: Frequency distribution of the land size. (n=160).

| Size of Land( in acres) | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| <1.0 | 64 | 40 | 40 |
| 1.0-5.0 | 88 | 55 | 95 |
| 5.1-10.0 | 6 | 3.8 | 98.8 |
| 10.1-15 | 2 | 1.2 | 100.0 |
| **Total** | **160** | **100.0** | |

Mean 4.0 ±0.297, median 3, mode 1, minimum 0, and maximum 17.

deleo stove technology cut across all the levels of education.

**Distribution of household size**

The household size referred to the number of all the people living within that household. The respondents were asked to indicate the number of people living in their homes and their responses were summarized in Table 4. The study findings indicated that household sizes ranged between 1 and 18 members. The average number of people living within the households was eight. The majority (75.1%) of households had nine or fewer members while the rest (24.9%) had ten or more members in the households. In the study area, household size was expected to have a positive influence on the adoption of the Maendeleo stove technology as it may be assumed that families with a large number of members have a higher demand for energy fuel and may be more inclined to adopt improved cook stoves.

Fuel savings are roughly proportional to baseline fuel use. Thus, it was also expected that adoption of energy-saving cook stove would be higher for those with higher baseline fuel use and expenditures and with larger families (Ostrom, 2010). The study findings indicated that households with more household members did not use the Maendeleo stove technology though they retained it, instead returned to their former inefficient stove design. Their reason was that the Maendeleo stove technology had pot holders of specific diameter. They could not use the Maendeleo stove technology when they wanted to use a pot whose diameter was larger than the holder's. Another reason why some respondents used both the traditional and Maendeleo stove technology was because of the inflexibility nature of Maendeleo stove technology with one pot holder. This makes respondents who want to cook two pots of food simultaneously to make fire on the traditional stove as well.

To solve the problem of holder-pot incompatibility the respondents re-deployed the traditional three-stone fires but, the few households that had adopted the Maendeleo stove technology had either modified the pot rests or used pot holders while cooking ugali which they had difficulty cooking using the Maendeleo stove technology. Therefore incompatibility between a stove and utensils may lead some users to keep their traditional stove as it does not have this problem. The acceptance or abandonment (return to former stove design) was dictated by the number and sizes of pots the stove could accommodate (Rwiza, 2009).

**Distribution of farm size**

The respondents were asked to indicate the size of land they owned as a household. Table 10 shows the average size of land owned by the respondents.

An analysis of the data showed that the mean land area owned by the households was four acres and ranged between zero and seventeen acres. The majority (95%) of the households had farms that were below five acres while a minority (5%) owned land that was more than five acres. Farm size may be expected to influence a farmer's ability to set aside a portion of the land for wood production which in turn may affect availability of fuel and hence the ability to use energy saving stoves (Makame, 2007).

It was expected that households with small landholding would be more likely to adopt the Maendeleo stove technology because of the high cost of buying or gathering fuel and the in-

Table 6: Annual household income. (n=160).

| Income categories (KShs.) | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| >50,000 | 58 | 36.3 | 36.3 |
| 50,001-100,000 | 50 | 31.2 | 67.5 |
| 100,001-150,000 | 21 | 13.1 | 80.6 |
| 150,001-200,000 | 13 | 8.2 | 88.8 |
| >200,000 | 18 | 11.2 | 100.0 |
| **Total** | **160** | **100.0** | |

Mean 116,438 ± 8,801; median 100,000; mode 50,000; std dev 111,330; minimum 5,000 and maximum 18,630,000.

Table 7: Logistic regression analysis of socio-economic factors influencing adoption of Maendeleo stove (dependent variable 1=adopter of MS; 0=non-adopter).

| Variable name | β | S.E. | Wald | Sig. | Exp(B) |
|---|---|---|---|---|---|
| Age of respondent | 0.046 | 0.017 | 7.022 | 0.008 | 1.047 |
| Primary education dummy | 0.572 | 0.704 | 0.660 | 0.417 | 1.771 |
| Secondary education dummy | 0.881 | 0.889 | 0.983 | 0.321 | 2.414 |
| Tertiary dummy | 1.385 | 0.974 | 2.022 | 0.155 | 3.994 |
| Income dummy | 0.132 | 0.152 | 0.752 | 0.386 | 1.141 |
| Household size | -0.032 | 0.063 | 0.251 | 0.616 | .969 |
| Farm size | 0.113 | 0.094 | 1.449 | 0.229 | 1.120 |
| Constant | -2.733 | 1.149 | 5.652 | 0.017 | 0.065 |
| Number of observations | 160 | | | | |
| Overall percentage prediction | 51.9 | | | | |
| -2 Log likelihood | 205.211 | | | | |
| Cox & Snell R Square | 0.097 | | | | |
| Nagelkerke R Square | 0.130 | | | | |
| Chi-square | 16.371 | | | | |
| Significance | 0.22 | | | | |

Mean 116,438 ± 8,801; median 100,000; mode 50,000; std dev 111,330; minimum 5,000 and maximum 18,630,000.

adequate land to establish woodlots for fuel wood. Despite the fact that they had later realized the benefits of the Maendeleo stove technology and accepted it, they could not have the stove because of unavailability of the Maendeleo stoves. Households with large landholdings likewise were expected to adopt the Maendeleo stove technology since they had adequate space for establishing wood lots for fuel wood compared to their counterparts but, to the contrary because they still felt they had no fuel wood shortage.

**Household income**

Household income was measured as total sum of money in Kenya shillings as earned by all members of the household per year. Data on household incomes was categorized and presented as given in table 6.

The average annual income for the households was KShs. 116,438 (± 8,801), with a minimum of KShs. 5,000 and a maximum of KShs. 18,630,000. The majority (80.6 %) of the households earned less than KShs. 150,000 while the rest (19.4%) had an income of more than KShs. 150,000. Household income is an indicator of prosperity and may be expected to have positive effect on adoption of technologies as wealthier households may have higher probability of investing in and using improved stoves (Inayat, 2011). Although income is the most important pointer of the economic status of a farmer, it is difficult to collect reliable information on income from the respondents as most consider it confidential. The study revealed that all the respondents irrespective of their income level found the Maendeleo stove technology less costly and affordable. Technology with low initial cost is more likely to be adopted than that with technology with high initial cost (Rogers, 2003). Low initial cost has a positive influence on the rate and speed of technology adoption. This perceived cost therefore, may be expected to increase adoption of the Maendeleo stove technology unless other attributes of the technology or other extraneous variables negatively influenced utilization of the technology.

## RESULTS

The study investigated the hypothesis that farmers' socio-economic characteristics have no significant influence on adoption of Maendeleo stove. The results are indicated in table 7. The -2log likelihood estimate of 205.211 with a statistically significant chi-square of 16.371 ($P < 0.05$) indicated that the independent variables jointly determined the adoption decision of the small-scale farmers.

The model as a whole explained between 9.7

percent (Cox and Snell R square) and the pseudo R-squared was estimated to be 0.130 implying that about 13.0 per cent of the variation in the dichotomous dependent variable (adoption of Maendeleo stove) was explained jointly by the predictors. The results further demonstrated that 51.9 per cent of the cases were correctly predicted by the model. The intercept of the model was significant ($P < 0.05$).

The socio-economic model indicated that the significant determinant of adoption was age of the respondent ($P < 0.05$). This means that age influenced the likelihood of the respondent adopting the Maendeleo stove. As the respondent got older by one year, the log of the odds ratio increased by 0.046 which led to an increase in the odds ratio by 1.047 times.

The positive and significant contribution of age suggests that adoption of Maendeleo stove was higher among older respondents than younger ones. The observed results indicate that the older respondents in this study may have had prior exposure to the benefits of the Maendeleo stove technology having been brought up in the area more than twenty years ago unlike the younger respondents who were not sensitized on the same. These findings are consistent with research work done by Mignouna *et al.* (2011) which indicated that a farmer's age is expected to increase technology adoption in the sense that older farmers over time have gained farming knowledge and experience and are better able to evaluate technology information than younger farmers. Okunade (2007) in a study of Nigerian women farmers found a significant positive relationship between age and adoption of farm technologies. He concluded that the older the farmers were, the more their years of farming experience and hence the better the decision the farmer would make in adopting technologies.

These findings differ from those of Wambugu (2006) in his study of fodder shrubs farmers who reported no relationship between age of farmers and their adoption behavior. However, the studies by Aneani *et al.* (2012) on adoption of some cocoa production technologies by cocoa farmers in Ghana, reported a statistically negative relationship between age and adoption. As the age of the farmer increases the physical strength declines thereby reducing the farmer's ability to use new technology also older farmers may be more conservative, less flexible and more skeptical about the benefits of Maendeleo stove. Akudugu *et al.* (2012) and Marchionni and Ritchie (2007) concluded that the adopter of a new technology is typically younger as younger people are more likely to adopt improved technological practices as they are risk takers and that since they are still accumulating economic resources they would opt to adopt more technologies.

According to the findings of the analysis, the level of education, household income, farm size and household size tended to be less probable in influencing the decision of a farmer to adopt the Maendeleo stove. Though from research findings by Inayat (2011), household size is expected to have a positive influence on the model of the stove used; this is contrary to the results from the study. Though it may be assumed that families with a large household will be more inclined to adopt the improved stoves to minimize on the fuel use, this was not the case since larger households use bigger utensils to cook which are not able to fit well on the stoves. While education is critical in enabling a technology user to assess the usefulness of a new technology (Makame, 2007), this is inconsistent with the this study findings since use of the Maendeleo stove is dependent on meeting a basic need of cooking fuel by the households.

Much empirical adoption literature focuses on farm size as the first and probably the most important determinant of adoption of different agricultural innovations and technologies (See for instance Doss and Morris, 2001; and Daku, 2002). This is because farm size can affect and in turn be affected by the other factors influencing adoption. The effect of farm size on adoption could be positive, negative or neutral. There are mixed findings in the literature on the influence of landholding size on households' decisions whether or not to adopt new technologies as shown by inconsistent results in the studies by Kassie *et al.* (2009); Waithaka *et al.* (2007). Fernandez-Cornejo, (1996) and Kasenge (1998) found farm size to be positively related to adoption.

However, findings from the current study indicate that farm size had a negative relationship with the adoption of the Maendeleo stove

technology since cooking fuel to meet the energy demand for the household can be met using a small portion of the farm for the supply of required fuel wood. These findings are consistent with findings by Yaron *et al.* (1992); and Harper *et al.* (1990) who found negative relationship between adoption and farm size. Household income, from the findings, show that it is not a factor influencing use of the stoves as they are affordable to the potential users and the income level may not limit affordability.

## CONCLUSION

The level of adoption of the Maendeleo stove among the small-scale farmers surveyed was low because about half of the respondents who had adopted the cook stove had abandoned using it and returned to their former stove design. The respondents quoted various reasons that prompted them to abandon the stove and among the reasons given were: the stove could not accommodate a large number and sizes of pots, the stove design could not allow for other non–cooking attributes (heat, light, insect repellent, etc.), and lack of confidence that the stove is durable. The rest of the respondents had no Maendeleo stove technology at all although they were aware of the stove due to lack of technical information on the benefits of the Maendeleo stove technology and non-availability of the stoves.

Agricultural extension services provided by the Ministry of Agriculture are the major source of agricultural information in the study area. Access to extensions services therefore creates the platform for acquisition of the relevant information that promotes technology adoption. In the last 30 years many organizations such as the Ministry's of Agriculture and other stakeholders have been disseminating and promoting the Maendeleo stove technology. Delivery of extension services in Kenya by the main extension service providers in the government and NGOs has been declining over the years. However, technology transfer through the extension service appears to have been slow and inefficient. The implication of these findings is that extension visits are important to technology adoption. The greater the degree of contact of farmers with extension personnel, the greater is the possibilities of farmers being influenced to adopt agricultural technologies. Frequent visits to the farmer by the extension agent would provide the farmer with necessary information about the availability of needed resources, market and prices as well as the profitability status of the Maendeleo stove technology to clear any doubts and uncertainties concerning it to increase the probability of its adoption.

The focus of the study was to determine the socio-economic factors influencing adoption of the energy-saving Maendeleo stove technology among smallholder farmers. Among the socio-economic characteristics considered only the respondent's age, had a significant association with adoption of the Maendeleo stove technology. Other socio-economic characteristics (level of education, household income, household size, and farm size) had no significant influence on adoption of the Maendeleo stove technology. The findings are important as they show that none of these features prevents smallholder farmers from adopting the Maendeleo stove technology. Rich and poor, educated and uneducated, young and old; all appear to be potential adopters.

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