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# Factors Affecting the Adoption of Fuel-efficient Stove in Dessie Zuria Woreda, Amhara Regional State, Ethiopia

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The three-stone fire stove is inefficient in converting solid fuels to energy and, it only yields 5 up to 20 per cent of the overall thermal efficiency. Fuel-efficient stoves are expected to contribute to the environment, economic and health sectors by achieving sustainability in the energy sector. Therefore, due to the benefits of the fuel-efficient stoves, the need to study factors influencing the adoption of these stoves are becoming more important. The study aimed to assess factors influencing the adoption of fuel-efficient stoves in Dessie Zuria Woreda. Both qualitative and quantitative approach was used. Data was collected through questionaries' in 166 households and interview from 10 key informants. The collected data from questionaries' was analysed by descriptive statistics, independent sample t-test, one sample t-test and binary logistic regression. One sample t-test result showed that the perception of peoples is significantly different from neutral. The independent sample t-test showed that the average time taken to collect fuelwood is significantly different between adopters and non-adopters. Educational level, family size, distance from the city, awareness, access to training, the time is taken to collect fuelwood and membership of social organization group were found to be significant in determining the probability of fuel-

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efficient stove adoption positively at $p<0.05$ level of significance. The main barrier for not adopting fuel-efficient was found to be a lack of awareness about the benefit of the stove and the cost of the stove.

*Keywords: Fuel-efficient stove; adoption; binary logistic regression; fuelwood.*

## 1. INTRODUCTION

Majority of the world population is dependent on wood as their main source of energy [1]. According to the Food and agriculture organization [2], around 60% of the world's population uses biomass especially wood to satisfy their energy need. Biomass fuels are organic materials produced in a renewable manner. Wood is a common example, but the use of animal dung and crop residues is also widespread and the dominant cooking practice is three-stone open fire [1].

Biomass is the most extensively used form of energy in developing countries for cooking, lighting, heating purpose and most of this biomass is inefficiently used by the people in traditional cookstoves [2]. According to Legros et al., [3] cited by Tigabu [4], using stoves which are not efficient is associated with indoor air pollution which is responsible for 2 million deaths per year.

Firewood gathered from communal forests is an important source of domestic energy in many developing countries [5]. It plays an important role in ensuring the food security of millions of people but the environmental damage from fuelwood harvesting can be severe if too many people depend on too few forested areas and the ecosystem services they deliver [6].

Sub-Saharan Africa countries heavily rely on biomass as their major energy sources and the majority of these countries are dependent on traditional three-stone open fire stove for cooking [7]. Even though traditional stoves are associated with risk of health and environment damage, they are still the most used type of stoves in African countries [8]. If actions are not undertaken to minimize the heavy reliance on fuelwood the number of peoples relying on biomass is expected to reach 652 million by 2030 [9].

Over 90% of the domestic energy supply in Ethiopia is derived from biomass [10]. Some reports show the specific relationships between wood shortages, particularly of wood for energy purposes, and deforestation [11]. The annual deforestation rate in Ethiopia is estimated to be 40,000 ha or 0.8% of forests cover [2]. From 1990 to 2000, the annual rate of loss of natural forest in Ethiopia was estimated to be 9% [12]. The major reasons are the increasingly intensive use of land for agricultural, livestock production and tree cutting for fuel-wood and construction materials [13].

Biomass, which covers about 90% of Ethiopia's energy demand, is used inappropriately because most of the households use open fire stoves for cooking and other purposes resulting in many environmental and health damages [14]. Open fire stoves have been used since ancient times, they have come in various types, having been adopted in almost every country for food preparation methods [15].

Lack of clean and affordable energy is an obstacle to country development. To minimize the adverse effects of open-fire stoves have on human health as well as the on the environment and in order reduce energy poverty in the country; the Ethiopian government have implemented several strategies of alternative modern fuels especially improved fuel-efficient stoves.

In 1998 ministry of Agriculture of Ethiopia in collaboration with GTZ, (The German Development Cooperation) launched an improved stove dissemination program to promote biomass energy efficiency in households. The project aims to enhance the efficient use of biomass resources by integrating household energy measures into the development plan [16].

Fuel-efficient stoves can be viewed as a stove which reduces the adverse effect of open fire stoves have on the environment and human health indicating fuel-efficient stove minimize the damages that might have occurred when using three-stone open fire stove [17,18]. Even though the benefit of the fuel-efficient stove is clear and evident the rate of adoption is not as expected and is eventually decreasing throughout the years.

Since this fuel-efficient stoves are expected to contribute to the environment, economic and health sectors, the need to study about factors influencing the adoption of fuel-efficient stoves are becoming more important [19]. Examining the factors affecting the adoption of the fuel-efficient stoves will help to promote and maximize the benefit of fuel-efficient stove program and the stoves contribution to the environment [20].

The fact that the adoption of fuel-efficient stoves adoption is low regardless the benefit they provide implies the need to understand how local communities perceive about the fuel-efficient stoves and factors affecting the adoption of fuel-efficient stoves to guide the production and dissemination of the stoves in the future. Alamir [21] in his researcher recommends further study to be conducted to investigate factors affecting fuel-efficient stoves adoption using important variables.

Therefore, this study investigated factors affecting the adoption of fuel-efficient stoves in the study area. To this end, the study will contribute to the existing knowledge on factors influencing the adoption of the fuel-efficient stove in rural households.

## 2. MATERIALS AND METHODS

### 2.1 Description of the Study Area

The study was conducted in Dessie Zuria Woreda Amhara Regional State, Ethiopia. Dessie Zuria Woreda is among 21 districts of South Wollo Zone and it is located 400 km far away from North of Addis Ababa and 580 km away from Bahir Dar, the capital of the region. Woreda is located within 11°10'19"-11°1'54"latitude on the north and 39°19'59"-39°50'36"longitude in the East. It shares its border with Kalu Woreda from the east, Tenta, and Legambo from the west, Albuko, and Woreilu from the south and Kutaber from the north. The total area of the Woreda is about 96,148 ha and it is subdivided into 32 Kebeles and the total population is counted at 175,136 of which 86,718 are male and 88, 418 were females [22].

### 2.2 Research Design

Research design integrates three main components: philosophical worldwide views, research methodologies (strategies of inquiries) and methods [23]. The researcher used concurrent mixed research design which combines both qualitative and quantitative research. Mixed methods designs are procedures for collecting, analyzing, and mixing both quantitative and qualitative data in a single study or a multiphase series of studies.

Concurrent mixed method design is used because it converges and merges qualitative and quantitative data to provide a comprehensive analysis of the research problem. In a concurrent mixed research design, more emphasis should be given to one type of data [24].

The researcher employed a mixed research design that involves both quantitative and qualitative type of data. Quantitative data is gained from a structured questionnaire while qualitative data are texts (in terms of text messages) collected from key informant interviews.

### 2.3 Data Type and Sources

Both qualitative and quantitative type of data was collected during the study. To collect qualitative and quantitative data, both primary and secondary data source was used.

The primary data was collected from sample households and key respondents through a structured questionnaire and key oral interview.

The primary data obtained from the fieldwork was matched with data obtained from secondary sources to bridge the information gap from primary sources. Secondary sources of information used for this study were collected from Regional Bureau of Agricultural, Dessie Zuria Woreda municipality administration office, research papers, demographic and socio-economic profiles, published materials such as books, journals, official records, census records, project reports, research papers.

### 2.4 Sampling Procedure and Sample Size Determination

The study selected Dessie Zuria Woreda purposively since it is one of South Wollo Zone Woreda where adoption of the fuel-efficient stove is low. Then 3 kebeles from the total of 32 kebeles in Dessie Zuria Woreda was selected using purposive sampling technique. The 3

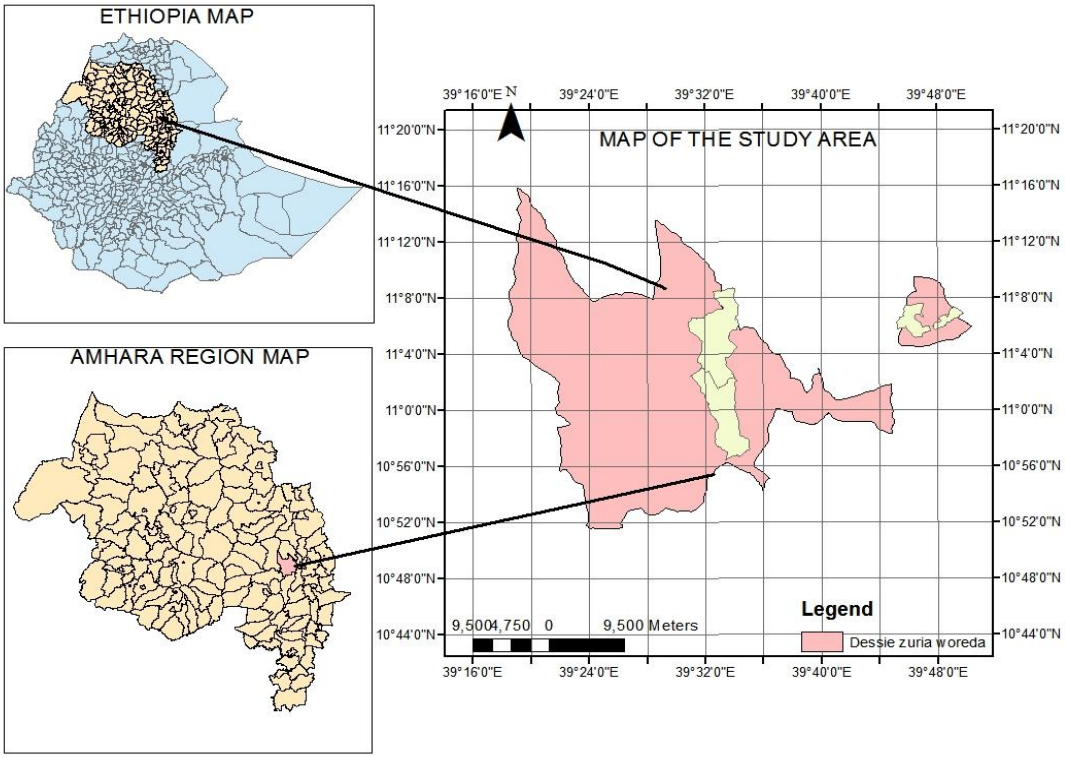


**Fig. 1. Map of the study area**

kebeles were selected because according to the Dessie Zuria woreda energy office the kebeles were where the fuel-efficient stove has been disseminated during the study.

The numbers of sample households as respondents were determined by using the formula provided by Yamane (1967) cited by (Israel, 1992).

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

Where, n=desired sample size, N= number of households and e = level of precision

The appropriate level of precision for social research is 0.05 but due to time and finance, the researcher used 0.075 level of precision. The selected 3 kebeles are Serdum, Kelina, and Abaso. The number of households for Serdum, Kelina, and Abaso is 661, 570 and 1223 respectively which is a total of 2454 households. Therefore, the sample size is

$$n = \frac{2454}{1+2454(0.07\ 5)2} n=166$$

Proportional sampling technique was used to determine the sample size in each Kebele. The formula for each Kebele sample determination will be Kebeles household number x sample size/total household number. Each Kebele sample will be as follow.

**Table 1. Distribution of sample size to each Kebele**

| No | Name of the Kebele | Household size | Sample size |
|---|---|---|---|
| 1 | Abaso | 1223 | 83 |
| 2 | Kelina | 570 | 38 |
| 3 | Serdum | 661 | 45 |
| Total | | 2454 | 166 |

*Source: Own calculated, 2017*

Households for the structured questionnaire were selected by using a systematic random sampling technique in each Kebele from the households' frame. The reason behind using this sampling technique is its simplicity, fast and low cost. In selecting the respondents, the household head was chosen

## 2.5 Data Collection Instruments and Procedure

Both qualitative and quantitative data were collected to counterbalance the limitation of the one by the other. These data were generated through questionnaires, key respondents Interview, and Personal observation to supplement, complement, and validate data obtained from the Household survey.

## 2.6 Questionnaires

Primary data related to the household characteristics of the respondents, energy sources used by the community, perception of peoples toward fuel-efficient stove and determinant factors influencing the adoption of fuel-efficient stoves were collected through structured questionnaires.

The study used the close-ended type of questionnaire which enables respondents to choose from the set of alternatives being offered [25]. The questionnaire covered various aspects of energy sources, adoption of fuel-efficient stoves, demographic and socioeconomic aspects that directly and indirectly affect the use of the fuel-efficient stove.

The questionnaires were prepared in English and translated into the local language which is Amharic. In this research, people's perception and field observation were the major sources of primary data. To ensure the consistency and accuracy of the data collection, the key informant interview was conducted during the collection of primary data. It is a useful technique to characterize and understand the adoption of the fuel-efficient stove.

## 2.7 Key Informant Interview

Key informant interview included energy office workers, natural resource management experts, and local leaders who are assumed to have knowledge and experience about fuel-efficient stove and energy sources. The total numbers of respondents who participate in the interview were 10.

One person was selected from the Woreda energy and water office, 3 from each Kebele energy office, 3 people from Kebele natural resource management office and the remaining 3 are local leaders from each Keble. These key informants were purposively selected from different offices with the help of Dessie Zuria woreda water and energy office expert assuming that they have deep and relevant information from their official responsibilities and continue involvement about the issues.

The questionnaire took 30 minutes on average to fill per person. The key informant's interview focuses on challenges of non-use of the fuel-efficient stove and what should be done to increase the adoption of the stove.

## 2.8 Data Collection Procedure

The data collection took place from February 26 to March 19, 2018. A total of 3 enumerators were involved in the data collection time, the enumerators were trained for one day about who, when and where to collect the data.

## 2.9 Data Analysis and Interpretation

The data gathered from the key oral interview was summarized and described using textual analysis. Quantitative data gathered from the questionnaire were coded and tabulated and analyzed using SPSS software version 20.

## 2.10 Descriptive Statistics

Descriptive statistics of mean and frequency [26] was summarized to characterize the socioeconomic status of the respondents and major energy sources used by the sample households.

## 2.11 Parametric Inferential Statistics

Parametric statistic t-test and independent sample t-test procedure that enables one to conclude a certain type of population-based on samples of those population were used in the study. One sample t-test was used to analyze the perception of peoples towards the benefit of the fuel-efficient stove. Independent sample t-test was used to analyze the mean of adopters and non-adopters based on their age, family size and the average time taken to collect fuelwood.

## 2.12 Econometrics

The binary logistic regression model was used to examine factors influencing the adoption of the fuel-efficient stove. Binary logistic regression was used because the dependent variable is dichotomous for, it was used to determine the influence of the independent variables on the dependent variable.

## 2.13 Operational Definition and Description of Variables

### 2.13.1 Dependent variable

The dependent variable is the adoption of the fuel-efficient stove. The value of '1' is given to households that have adopted fuel-efficient stove and value of '0' is given to households that do not adopt fuel-efficient stoves. Adopters are described as peoples who use the modern fuel-efficient stoves and non-adopters are peoples who do not adopt the fuel-efficient stoves may be due to unwillingness, social factors or institutional factors.

### 2.13.2 Independent variable

Independent variables are variables that determine whether a household adopts or non-adopts a fuel-efficient stove. The researchers have pointed out potential determinants influencing the adoption of fuel-efficient stoves based on previous findings and literature reviews to include:-

a. Education – the level of education of the household head (0=non formal education, 1=educated)
b. Family size – number of family members living in the household (In number)
c. Age – Age of the household head (In number)
d. Number of tropical livestock – total number of livestock owned by the household head (In numbers)
e. Gender – sex of the respondent (0 = male, 1 = female)
f. Headship –the head of the household (0= female, 1=male)
g. Total land size – total land owned by the household head (In hectare)
h. Awareness – the respondent's knowledge about the existence of fuel-efficient stove (0= no, 1= yes)
i. Extension contact – access to agricultural extension (0 = no, 1 = yes)
j. Access to training – the respondent's access to training about the fuel-efficient stove (0=no, 1=yes)
k. Access to microfinance – the respondents access to microfinance (0=no, 1=yes)
l. Distance from the main road – the distance from the house to the main road (In number)
m. Distance from the main city – the distance from the house to the nearest city (In number)
n. Remittance –income gained other than their main occupation (0=no, 1=yes)
o. Land ownership – the land ownership of the respondent (0=no, 1=yes)
p. Social organization member – the membership of the respondent in social organization groups (0=no, 1=yes)
q. Time is taken to collect fuelwood - the amount of time needed to fetch fuelwood from the fields (In numbers)

### 2.13.3 Model specification

Binary logistic regression was used to identify determining factors affecting the adoption of fuel-efficient stoves. This model was used because it is an appropriate statistical model when the dependent variable is a dummy in this case which are adopters and non-adopters of the fuel-efficient stove and when the independent variables are in continuous, categorical and nominal scale.

Binary logistic regression calculates the probability of success over the probability of failure, the results of the analysis are in the form of an odds ratio; also providing knowledge of the relationships and strengths among the variables. Binary logistic regression provides a coefficient 'b', which measures each independent variable's partial contribution to variations in the dependent variable [27].

Binary logistic regression model based on Tabachnick and Fidell, [27] cited by Asfaw [28] has been applied to identify the major factors which determine the adoption of fuel-efficient stoves.

$$(\text{Logit } (P) = \text{Log}\frac{P}{(1-P)}) \quad (1)$$

$$\text{Let Pi= P}(\frac{Y=1}{X=xi}) \quad (2),$$

then we can write the model as

$$\text{Log} = \frac{Pi}{1-Pi} = \text{Logit } Pi = \beta o + \beta i Xi \quad (3)$$

Pi is the probability of adopting or not adopting fuel-efficient stoves (dependent variable) and xi's are independent variables affecting the adoption of fuel-efficient stoves. Therefore, the parameter $\beta_0$ gives the log odds of the households not adopting fuel-efficient stove when (Xi =0) and βi shows how these odds differ for adopters (when Xi=1). We can write the model in terms of odds as

$$\frac{Pi}{1-Pi} = \beta 0 \beta 1 Xi \quad (4)$$

The dependent variable is Adoption where the value 1 is given adopters and the value 0 is given for non-adopter.

## 3. RESULTS AND DISCUSSION

### 3.1 Major Energy Source Used by the Community

**Table 2. Major energy source used by the community**

| Energy source | Frequency | Per cent |
|---|---|---|
| Fuelwood | 164 | 98.8 |
| Charcoal | 2 | 1.2 |
| Total | 166 | 100 |

*Source: Survey data, 2018*

As presented in Table 2 the major energy source is fuelwood which accounted for 98.8% of the questioned household followed by charcoal. This is because the respondents live in a rural area where the availability of modern energy sources is low. This result is consistent with Asfaw [28] and Legesse et al., [29] which also found that fuelwood to be the main source of energy in their respective study areas.

When the respondents were asked why they chose fuelwood as their main source of energy majority of the respondents which is about 65.7% of them replied they use it because it is available whenever they need it while the remaining respondents replied they use it because it is cheap and the other energy sources are expensive respectively.

Most of the respondents said they get the wood from the field for free and some of them buy from merchants. According to the data gathered the main purpose they will use the fuelwood is for cooking Injera, Wot, and heating purposes. The responsibility of collecting fuelwood is mainly done by females (58.4%) followed by children and men which accounted for 16.3% and 12.7% of the total respondents, respectively. This is because the household responsibility for example cooking mainly fall for women.

### 3.2 Perception of Peoples towards Fuel-efficient Stove

One sample t-test was used to examine if the attitudes of peoples on the benefit of fuel-efficient stove vary from the neutral and a significant difference was found in with a p-value of $p<0.001$. All the sample means are significantly greater than the population mean.

A total of 96 respondents out of 166 respondents representing 57.8 per cent of the total respondents strongly agreed to the benefits of the stove saving fuelwood and the highest per cent where they strongly disagree is regarding its benefit in it is easy to use in which 12.2% of the respondent's answer was strongly disagreed. From the result, it can be understood that the perception of people towards fuel-efficient stove is positive. According to the respondents, their source of knowledge about the benefits of the stoves was mainly agricultural extension workers.

**Table 3. Perception of people towards the adoption of the fuel-efficient stove**

| The benefit of the fuel-efficient stove | T | Df | Sig. (2-tailed) | Mean difference |
|---|---|---|---|---|
| it saves fuelwood | 14.990 | 165 | .000 | 1.25301 |
| it is easy to use | 5.363 | 165 | .000 | .56024 |
| it is clean | 6.478 | 165 | .000 | .65663 |
| it saves fuelwood collection time | 6.801 | 165 | .000 | .64458 |
| it reduces smoke | 4.256 | 165 | .000 | .42771 |
| it reduces fire-related accidents | 7.203 | 165 | .000 | .69277 |
| it saves time | 5.166 | 165 | .000 | .51807 |

*Source: Survey data, 2018*

**Fig. 2. Mirt fuel-efficient stove (© survey, 2018)**

**Table 4. Time is taken to collect fuelwood daily**

| | Category | N | Mean | Std. Deviation | t | Df | P-value | Cohen's d value |
|---|---|---|---|---|---|---|---|---|
| Time is taken to collect fuelwood | Non-adopter | 75 | 1.9467 | 1.52929 | 3.487 | 164 | 0.001*** | 0.56 |
| | Adopter | 91 | 1.2297 | 1.00526 | | | | |

*Source: - Survey data, 2018*

*NB: *** indicate the level of significance at 1%*

This result is consistent with Kar [30] that found the perception of peoples toward the fuel-efficient stoves to be positive in Ethiopia. The result of the study is also in line with findings of Asfaw [28] which found the attitude of peoples about the benefit of the stove to be positive in Borena Saynt, Northcentral Ethiopia.

## 3.3 Average Time is taken to Collect Fuelwood

A typical household with three-stone open fire stove spends 500 hours annually on fuelwood collection [31]. The main advantage of the fuel-efficient stove is the minimization of time spent on the collection of fuelwood [28]. Independent sample t-test was conducted to compare the means of fuel adopters and non-adopters on time taken to collect fuelwood. A statistical mean difference was found in the time taken to collect fuelwood between adopters and non-adopters with a moderate effect size of Cohen's d value ($t=7.11$, $N=166$, $df=164$, $p<0.001$).

The result indicates that the time taken to collect fuelwood for adopters is 1.2 hours per day which is statistically less than the time taken for non-adopters to collect fuelwood which is 1.9 hours per day. This result is consistent with Asfaw [28] which also found the mean difference for adopters and non-adopters to be statistically significant indicating the time needed for adopters and non-adopters are not the same.

The result shows that the time needed to collect fuelwood is not the same for adopters and non-adopters, the fuel-efficient stove adopters spent 1.2 hours in the field to collect fuelwood while non-adopters spent 1.9 hours to collect fuelwood. This difference in time may come from since the fuel-efficient stoves can reduce the amount of fuel used during cooking, the amount of fuel will

also be minimized making the time needed for fuelwood collection also minimal.

According to the finding not only the time needed for fuelwood collection is reduced the money spent on fuelwood is also reduced. Even though not all the respondents spent money on fuelwood, the money spent on fuelwood is not the same for adopters and non-adopters. The mean of the adopters was found to be 40.5 the mean of non-adopters was 53. The result shows that fuel-efficient stove adopters spent less money on fuelwood compared to fuel-efficient stove non-adopters. The difference between the mean of adopters and non-adopters may come since fuel-efficient stoves reduce the fuel uptake during cooking hereby also decreasing the money spent on buying fuelwood.

According to the key informant interview, the main advantage of the fuel-efficient stove is saving time for other activities since it saves fuelwood the time to collect fuelwood is reduced. Holmes [32] also found that using fuel-efficient stove reduced the frequency of fuelwood collection as well as the time and money spent on fuelwood. Dewan et al., [33], also found that the time spent on gathering fuelwood for adopters were decreased by 38.2% compared to non-adopters.

## 3.4 Determinants of Fuel-efficient Stove Adoption

In this section, the binary logistic model result is interpreted and discussed.

The omnibus test result is significant at 5% levels of significance which indicate that including predictor variables have positively and significantly increased the ability to predict adoption of the fuel-efficient stove ($x^2$=133.875, df =17, N=166, p<0.001). The statistics of -2 Log-likelihood is 60.649 which is not a high number so it can be said the model is good. Cox and Snell R square shows that 60.8% of the variation in the dependent variable is explained by the binary logistic model. Nagelkerke R square value is .818 which indicates there is a moderately strong relationship of 81.8% between the predictors and the prediction. Hosmer and Leme show test p-value is 0.899 which is greater than the alpha value of significance which indicates that the data fits the model.

According to the binary logistic regression result only education, family size, distance from the city, awareness, access to training, membership of social organization group and time is taken to collect fuel were found to influence fuel-efficient stove adoption significantly. Other variables such as age, sex, land size, headship, the total number of livestock, access to extension, access to finance, land ownership, source of remittance and distance from the main road were not found to influence the adoption of fuel-efficient stove significantly.

### 3.4.1 Education

Education is found to be associated with the increased use of fuel-efficient stove the more the household head is educated, the probability of adopting new technology is likely to increase [34]. As Table 5 indicates, the educational level of the respondent significantly affects the probability of adoption of the fuel-efficient stove with an odds ratio of 1.684 and p-value of 0.006.

The odds ratio can be interpreted as the level of education of the respondents increase by 1 class the probability of them adopting fuel-efficient stove increase by 1.684 times. The Wald test value of the level of education is 7.512, which show educational level being among the strongest individual predictors of adoption of the fuel-efficient stove. This implies that as the level of education increase, the probability of adopting the stove is also increasing in the study area.

This finding is consistent with previous works of Alamir [21], which also found out that the education level of the household head is an important factor influencing the adoption of the fuel-efficient stove. This result is also similar to Damte & Koch [35] which found education to positively influence the rate of the adoption of the stove.

The result is also consistent with the result of Puzzolo et al. [34] which also found education to be an important factor affecting the uptake of improved cookstoves. However, this result is not consistent with Adhola [36] which found that educational level to be non-significant predictor variable in the adoption of the fuel-efficient stove. Kanangire et al., [20] explained the educational status of respondents does not have a significant influence on the adoption of the fuel-efficient stove. However, this argument was not supported by this study.

**Table 5. Binary logistic model result**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Aginye | .036 | .040 | .800 | 1 | .371 | 1.036 |
| Sex(1) | 1.328 | .983 | 1.826 | 1 | .177 | 3.774 |
| Edu2 | .521 | .190 | 7.512 | 1 | .006 | 1.684 |
| Famsize | .783 | .269 | 8.469 | 1 | .004 | 2.188 |
| Lasize | .783 | .649 | 1.458 | 1 | .227 | 2.188 |
| Headship(1) | 1.226 | 1.064 | 1.327 | 1 | .249 | 3.407 |
| Awarness(1) | 2.420 | .983 | 6.055 | 1 | .014 | 11.245 |
| Citdisatnce | -.814 | .357 | 5.186 | 1 | .023 | .443 |
| Acesstoextension(1) | .903 | 1.300 | .482 | 1 | .487 | 2.466 |
| Acesstotraining(1) | 2.583 | .860 | 9.019 | 1 | .003 | 13.238 |
| Acess to finance (1) | .620 | .890 | .486 | 1 | .486 | 1.859 |
| Ownership(1) | 2.151 | 1.608 | 1.789 | 1 | .181 | 8.597 |
| Remittance(1) | .798 | .921 | .750 | 1 | .387 | 2.220 |
| Timtocollfue | -1.109 | .341 | 10.558 | 1 | .001 | .330 |
| TLU | -.125 | .122 | 1.045 | 1 | .307 | .883 |
| Roaddistance | -.322 | .475 | .459 | 1 | .498 | .725 |
| Socialorg | -3.417 | 1.732 | 3.895 | 1 | .048 | .033 |
| Constant | -6.987 | 3.813 | 3.359 | 1 | .067 | .001 |

*NB: ** and *** indicate the level of significance at 5% and 1%, respectively*

### 3.4.2 Family size

The binary logistic regression result indicated that family size significantly affects the adoption of fuel-efficient stoves with p-value and odds ratio of 0.004 and 2.118 respectively. The odds ratio value shows as the family size of the respondent's increases by one the probability of adopting fuel-efficient stove increase by 2.118. The Wald value of family size is 8.469 which indicate family size to be a strong predictor only by itself. The result shows that high family size is associated with higher opportunity to adopt fuel-efficient stove.

The finding of the study is similar to the study of Adhola [36] which found a family size to be a determinant factor in the adoption of fuel-efficient. The study is also in line with Legesse et al., [29] which also find that family size to influence the adoption of the stove. However the result this finding is not consistent with Alamir [21] which found family size not to be a significant variable in determining the likelihood of Mirt stove adoption decision.

### 3.4.3 Awareness

The binary logistic regressions shows that level of awareness positively and significantly influences the propensity of adopting fuel-efficient stove with a p-value of 0.14 and odds ratio of 11.245. This indicates that the probability of peoples who have awareness about fuel-efficient stove adopting the stove is 11.245 times higher than the peoples who do not have awareness about the stove. The Wald value is also 6.055 which show awareness is an important individual predictor among other variables.

The finding of this study is similar to previous work of Puzzolo et al. [34] that found the awareness about the fuel-efficient stove is a significant factor in determining the adoption of improved cookstoves. The finding is also consistent with the study of Tigabu [4] which also found that awareness is an important factor influencing the use of improved cookstoves.

The findings also agree with the study of Holmes [32] which found that households which have an awareness about the stove through training adopted the stove more than the peoples who do not know the stove. This finding also supports the diffusion of innovation theory which pointed out awareness as one of the major factors that determine the rate of new technology adoption.

### 3.4.4 Distance from the city

Table 5 shows that the distance from the city influences the probability of adopting fuel-efficient stoves negatively with a p-value of 0.023 and odds ratio of 0.443. The odds ratio can be interpreted as the odds of people living close to the city from the city adopting fuel-efficient stove is 0.443 higher than the peoples living far away

from the main city. The Wald value is 5.186 which indicate that the variable distance from the main city is an individually strong predictor.

The result indicates that as the distance from the main city decrease by 1 unit, the probability of adopting fuel-efficient stove increases by 44%. This result agrees to the study of Legesse et al. [29] which found that the probability of respondents living near the city adopting fuel-efficient stoves is 0.10 greater than the peoples living far away from the city.

The result of this study is also consistent with the findings of [32] which found that distance from the main city has a negative relationship with fuel-efficient stove adoption, which indicates that the probability of peoples living near the city is higher than peoples living far away from the city.

#### 3.4.5 Access to training

The binary logistic model result shows that access to training affects the adoption of fuel-efficient stove significantly with p-value and odds ratio of 0.003 and 13.238 respectively. The odds ratio shows that the odds of peoples who have training about fuel-efficient stoves are likely to adopt the stoves 13.238 higher than the odds of the peoples without training about the fuel-efficient stove adopting the stove. The Wald value is 9.019 indicating that access to training is amongst the strongest individual indicator.

This is because training about the fuel-efficient stove enables the local community to know more about the advantages of the stove, as a result, making them adopt the stove.

#### 3.4.6 Time taken to collect fuelwood

Table 5 indicates that the variable time is taken to collect fuelwood negatively influence the adoption of the fuel-efficient stove with a p-value of 0.001 and odds ratio of 0.330. The Wald value is 10.588 which shows the time taken to collect fuelwood is a strong individual predictor. The result shows that as the time is taken to collect fuelwood decrease the probability of fuel-efficient adoption increase and as the time is taken to collect fuelwood increase the probability of adopting fuel-efficient stove decrease.

#### 3.4.7 Membership of social organization

Membership of social organization group was found influence the adoption of fuel-efficient stove negatively and significantly with a p-value of 0.048 and odds ratio of 0.33. The result shows that peoples who are not a member of the social organization group are 0.33 more likely to adopt fuel-efficient stove than peoples who are members of a social organization group.

### 3.5 Reasons for not Adopting Fuel-efficient Stove

From Table 6, majority of the respondents ( 37.9% of out of the total respondents) reported lack of awareness about the benefit of the stove as the main reason for not adopting fuel-efficient stove and 15.1% indicated that the main reason for not adopt fuel-efficient stove is lack of information about the existence of the stove, while14.5% attributed higher price of the stove as the main obstacle for not adopting followed by the reasons of shortage of fuel efficient stove, family reluctance and the problem of separate kitchen which covers 13.3%, 12%, and 7.2% respectively. The result shows that lack of awareness about the benefits of the stove is the main obstacle faced by the respondents in the study area.

The interviewed key respondents also identified lack of awareness about the benefit of the stove as a major obstacle faced by the rural community in order not to use the fuel-efficient stove because there is are no trained extension agents

**Table 6. Reasons to do not adopt fuel-efficient stove**

| Reasons for not adopting | Frequency | Per cent |
|---|---|---|
| Lack of awareness about the benefits of fuel efficient stove | 63 | 37.9 |
| Family reluctance (e.g. spouse's lack of willingness) | 20 | 12.0 |
| Higher price of the stove | 24 | 14.5 |
| Problem of separate kitchen | 12 | 7.2 |
| Shortage of fuel efficient stove | 22 | 13.3 |
| Lack of information about the existence fuel efficient stove | 25 | 15.1 |
| Total | 166 | 100 |

*Source: survey data, 2018*

assigned to teach them about the benefit of the stove. This obstacle may come from since there are no alternative energy source experts at the Kebele level. The key informants also identified the price of the stove as also a major barrier for not adopting the stove. This may be due to since the majority of the respondents are farmers instead of gaining cash they have money placed on their livestock's and their crops.

The finding of the study is similar to the previous study of Tigabu [4] which also found about the potential benefit of the fuel-efficient stove is one factor that hinders the use of fuel efficient stoves. This finding supports the study of Michelle (2010) which found that even though awareness about the stove was established the cost of the stove was the barrier for not using the stove.

## 4. CONCLUSION

The major energy source in the study area is fuelwood. This is mainly due to the absence of modern energy sources and availability of fuelwood everywhere whenever the community needs it. Females are mainly responsible for the collection of fuelwoods as well as the use of fuel for cooking. From this, females are more prone to indoor air pollution and fire-related hazards caused by fuelwood.

Independent t-test result showed that there is mean difference in time spent for fuel collection by adopters and non-adopters ($t=7.11$, $df=164$, $p<0.01$) and the time needed to collect fuelwood daily. The result indicates fuel-efficient stove adopters are advantageous with respect to the time taken to collect fuelwood since they need less fuelwood compared to non-adopters. From the results, it can also be concluded that fuel-efficient stoves contributes to reducing the deforestation rate as well as time by minimizing the uptake of fuel during cooking.

The t-test also revealed that there is positive attitude towards the benefit of the stove. This is because of the presence of natural resource experts in the study area. Age of the respondent, marital status, source of remittance, distance from the market, land size, headship, land ownership, total number of livestock, access to extension, and access to micro finance was found not to be significant in adopting fuel-efficient stove. Educational status was found have a positive relation with fuel-efficient stove adoption, which indicates the more the educational level the more the adoption of fuel-efficient stove. Family size was also found to be an important variable in determining the adoption of the fuel-efficient stove. From this result, it can be concluded that adoption of the fuel-efficient stove largely depends on the socioeconomic and demographic status of the respondents.

On the other hand, respondents who have training about the fuel-efficient stove were found to adopt the stove compared to peoples who do not have training about the stove. Access to training positive relationship with the adoption of fuel-efficient stove indicates that training about the existence of the stove could boost the effectiveness of fuel-efficient stove adoption. The adoption of the fuel-efficient stove was found to be inversely related to distance from the city and time taken to collect fuelwood.

Government officials and NGOs should increase awareness about the benefit of the stove by advertising the benefit of the stove by posters, Radio, and Televisions so more people would have access to the stove which will eventually lead to the adoption of the stove.

The main barrier for not adopting the fuel-efficient stove was found to be lack of awareness about the benefit of the fuel-efficient stove and the price of the stove. This may be due to since the majority of the respondents are farmers instead of gaining cash they have money placed on their livestock's and their crops.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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