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Determinants of Adoption of Improved Stove Technology in Dendi district, West Shoa, Oromia Regional State, Ethiopia

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Biomass is common fuel in Ethiopia and it mainly burned in inefficient open fires and traditional stoves. As a consequence, this leads to massive deforestation, land degradation and desertification. Hence, introduction of improved stove to rural household is crucial thus fuel efficient improve stove adopter households 60% reduced relies on biomass fuels and deforestation through improve speed of baking and fuel saving. This study was developed with the aim to understand the determinants of adoption of improved stove in reducing burden on biomass energy source at rural household level in Dendi district. Data was collected from 150 household heads randomly sampled using survey questionnaire and interview checklist. Data collected were analyzed using descriptive statistics and econometric model. Major findings show that family size/household size, age, energy sources, ownership of livestock and proximity to agriculture extension center, health extension center, main road and market services were positively associated with adoption for instance, household size has statistically significant effect for the household to adopt improved stove at 1% level of significance. Similarly, the proximity from household's home to market services significant effect on the decision of adoption of improved stove at 1% level of statistically significance. However, the influence of marital status, educational, occupation, credit service, firewood availability, kitchen service and land ownership and sex was not statistically significant this implies that no significant relationship with adoption. Based on the findings, it was concluded that improvement in resource-use efficiency through improved stove is vital however still application is in an infant stage. To enhance adoption of improved stove it was recommended that: all stakeholders (government and development partners) should plan different strategies to its use through demonstrations, posters, and a radio/TV advertisement is vital.

Key Words: Biomass fuels, improved stove, deforestation, firewood, Dendi district

Introduction

Safe energy supply coverage in the rural areas of Ethiopia is at infant stage. When a nation intends to measure the level of its development, energy is one that comes to the top priority. Development attained through efficient household energy consumption is long lasting and serves the best interest of sustained development. However, this ideal issue is not the case for many of the rural population due to a number of factors such as inadequate access to modern energy sources, lack of awareness and weaker propensity to adopting improved technologies and so on. Efficient energy supply coverage in the rural areas of Ethiopia is very marginal. The coverage still remains low because of limited progress in energy supply activities in these areas. The major problem is that biomass, which covers 70-80% of Ethiopia's primary energy demand, is used in a very inefficient way (Heimann, 2009). This leads to deforestation and environmental problems like soil erosion.

Ethiopia had an initial forest cover of about 13,000,000 hectares, but between 1990 and 2000, it lost an average of 140,900 hectares of forest per year which amounts to an average annual deforestation rate of 0.93% (Rhett, 2006). The cause of Ethiopia's deforestation is poverty and overpopulation, manifested in a frenzied scramble for farmland and fuel wood (Teketay, 2001). The population has increased from about 43 million in 1984 to about 90 million now (CSA, 2007). Similarly, in Ethiopia, 90% of forest removal is associated with firewood and the production of 3.2 million tons of charcoal, which increasingly contributes to the country's overall deforestation rates of 141,000 hectares per year (INBAR, 2008). There exist other alternatives to biomass use like petroleum which is used by only 5% of the population, electricity, used by only 1% of the population plus solar and biogas that are used at even lower levels by households. These alternatives are not affordable to the low income groups, so there use is limited access (GTZ, 2005).

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Biomass is very common in Ethiopia; fuels are mainly burned in inefficient open fires and traditional stoves. In many cases the demand for biomass fuels far exceeds sustainable supply. This leads to massive deforestation, land degradation and desertification (Heimann, 2007). Similarly, indoor air pollution due to open fires from cooking activities is a major attributable factor for health problems in developing countries. Especially women, children and aged people are victim indoor pollution since mostly spend their time indoor cooking activities (WHO, 2006; Karekezi, 2004).

The energy sector in Ethiopia is classified in two big blocks: traditional and modern energy. The largest portion of the population is heavily dependent on traditional sources of energy and very few people have access to modern energy like electricity. Hence, wood and biomass account for about 93% of the total energy consumption of the country (Girma, 2000). In short, coverage of safe energy still remains very poor because of limited progress in energy supply activities. Factors affecting the continued use of the outcome of safe energy supply projects are not well studied. This requires a systematic investigation as to how the energy players: users, environment, alternative energy technologies, and the overall provision interact with in the domains of efficient energy supply. Moreover, for achieving sustainability in rural development with emphasis on livelihood and the means of enhancing the economic well being of the poor households, it is necessary that access to energy is provided to the households. Gender issues also need to be addressed with adequate focus in the context of energy use (Yianna & Grazia, 2006).

Energy for cooking remains a major concern of household consumers and policy makers in Ethiopia. Yet there have been few systematic studies of available on determinants of adoption of improved stove. As a result, the result obtained from this study could be utilized in many ways. In the first place to aware the policy maker of ministry of energy, obstacles of households' adoption of improves energy technologies, community, governmental and non-governmental institutions. Moreover, little research had been done on the subject and in the study area hence by addressing the issue, the results of the study will serve as baseline information (will fill the knowledge gap) for other researchers who want to conduct further research on sustainable energy options in rural Dendi district.

The main objective of the study was to assess the determinants of adoption of improved stove to reduce burden on biomass energy source at rural household level and to propose possible solution in the study district. The specific objectives of the study were: to examine the existing opportunities of using the improved stove as an energy saving technology, and to analyze factors affecting adoption of improved stove at household level in the study area.

In light of the aforementioned research objectives this study strives to answer the following key research questions: 1. what are the existing opportunities of using improved stove as an energy saving technology? 2. What are determinants of adoption of improved stove in energy consumption at household level?

Research Methodology

Description of the Study Area

Dendi district is one of the eighteen districts of the West Shoa zone of Oromia regional State. The district capital city Ghinchi is located 77 kilometers west of the Addis Ababa-Naqamte road, 30 kilometers before Ambo. Dendi has a land area of 1,078.75 square kilometers with a population of 209,555, of which 50.61% are male. There are 20,215 households, of which 16,092 (79.6%) are male-headed households while the remaining 4,123 (20.4%) are female-headed. The average family size per household varies between 5 and 7 persons. The economically active work force over 15 and below 65 years of age is estimated to be 49%. The district has 48 rural kebele and 5 urban/semi-urban kebele, out of which two towns Ghinchi and Welenkomi (locally known as Olankomi) have municipal status (Dendi District Report, 2013).

The Chilimo Natural Forest is located at coordinates 09°05'N 38°10'E, on Altitude 2,300-3,000, near Ghinchi, the capital city of Dendi. It covers a land area of 2,400 hectares, with dominantly mountain broad leaf and coniferous trees. Local communities use this forest as a grazing land for their cattle. This forest is also home to some 150 bird species, of which five are Ethiopian endemics, and many more are Afro Tropical Highlands' biome species (Gemechu, 2012).

Sampling Techniques

In this study, multistage sampling procedures were used to select the survey areas and the sampling unit frame of household heads. At the first stage, Dendi district was purposively selected for the for the following reasons: known for prevalent practice of cutting trees for charcoal purposes, its proximity to Chilimo Natural Forest and its access to improved stove. In the second stage, five Kebeles (i.e Wamraseqo 31 household heads from 483 household heads, Workaqori 27 household heads from 416 household heads, Worqawebo 30 household heads from 471 household heads, Awashibeleto 34 household heads from 538 household heads, Ginchi02 28 household heads from 427 household heads) were selected randomly through simple lottery method in order to accommodate household heads. Finally, 150 household heads were selected based on Probability Proportional to Size (PPS).

Sources of Data and Collection Methods

Relevant literatures and documents from Dendi district of energy concerning household energy consumption were consulted and reviewed. However, the primary data was gathered from household heads and knowledgeable & skillful key informants in the study area as follows:

a) Use of questionnaire for household head
b) Use of interview checklist for key informants (i.e Kebele leaders, Dendi district energy office experts, development Agents)

Methods of Data Analysis

In this study, both descriptive statistics and econometric model were used for analysis of data collected. Descriptive statistics was used to describe relevant aspects of observable facts about the variables thereby providing detailed information about each relevant variable. Specifically: percentage, mean, standard deviation, maximum and minimum values of the required variables were computed. The statements from scheduled interview were used to substantiate the responses of quantitative findings. For quantitative Probit model and t-test was used to analyze determinants of adoption of improved using STATA software.

Model Specification

The probit model was used to identify and quantify factors that affect adoption of improved stove at household level. This model was appropriate because the dependent variable was discrete (i.e. binary yes=1, otherwise=0) as it measures whether one had adopted use of improved stove or not. It was preferred to other model because authors anticipate to drawing their sample from normal distributed population (such that the error term is normally distributed) (Maddala, 1983). Below was the probit model to be used:

$$Y_i = \beta_0 + \sum_{j=8}^{k} \beta_j X_{ij} + e_i$$

Where: Y=Adoption of improved stove (1= yes, 0= otherwise)
X_1=Sex of household head (male-headed and female-headed)
X2= Age of household head (age in years continuous)
X3= Marital status of household head (Married/Unmarried /Divorced/Widowed)
X4= Household size (age in years continuous)
X5= Household head's education level (education years)
X6= Occupation of household head (Farming/non-farming)
X7= Household annual income size (Birr).
X_8= Distance from agricultural extension center (kilometers)
X9= Distance from health extension center (kilometers)
X10= Distance from main road (kilometers)
X11= Distance from market service (kilometers)
X12= Access to credit service (yes or no)
X13= Source of energy cooking (Modern or traditional)
X14= Owner of planted trees (yes or no)
X15= Owner of livestock (yes or no)
X16= Accessibility of fire wood (yes or no)
X17= Distance traveled to collect firewood (km/ week)
X18= Time taken to collect firewood (hour/week)
X19= Accessibility of dung (yes or no)
X20= Distance traveled to collect dung (km/ week)
X21= Time taken to collect dung (hour/week)
X22= Households Awareness on improved stove (continuous codes constructed depending on level of awareness)
X23= Kitchen service (Separate or open space)
X24= Land ownership (yes or no)

RESULTS AND DISCUSSION

Discussion on Descriptive Statistics of the Survey Result

Occupation and Education of Household Heads

Figure 1 Bellow, clearly indicates that the primary occupation of household heads in the study area is farming (75.3%) in more than three-four of the households. As such as have indicated that the educational status has a direct implication to the primary occupation of the sample households with greatest number of households are being employed on farming activities. It is expected that the household heads who are employed out of farming activities could use more modern source of energy and adoption improved technologies than who are employed in farming activities. One supported study finding by (Masera, Saatkamp and Kammen, 2000) indicated that households that remained as fuel wood-only users showed no or a small positive change in a stable main occupational structure; all households also remained in the same income group.

Majority of respondents had grade 1-8 (67.4%) with only 5.3 percent were bachelor degree holder.

While about 13.3 percent of respondents are found could not read and write/illiterate. Education is expected to affect the adoption decision of improved stove. In this study, educated member of households were aware of the environmental and health effects of using biomass fuels (firewood, dung, crop residues) and, as a result, expected that education played a great role of increasing consumption of modern sources of energy as well as adoption of improved stoves in the area of energy consumption. Similar study by Gebreegziabher (2007) had shown that the education of household members significantly and negatively influenced the decision to consume wood implies the less likely would the household consume wood the higher level of education. And also supported by other recent research (Barnes, Khandker and Samad, 2010) had shown that education is negatively related to traditional energy source use and this would probably mean that they are more aware of the benefits of switching to modern cooking fuels or conserving biomass energy.

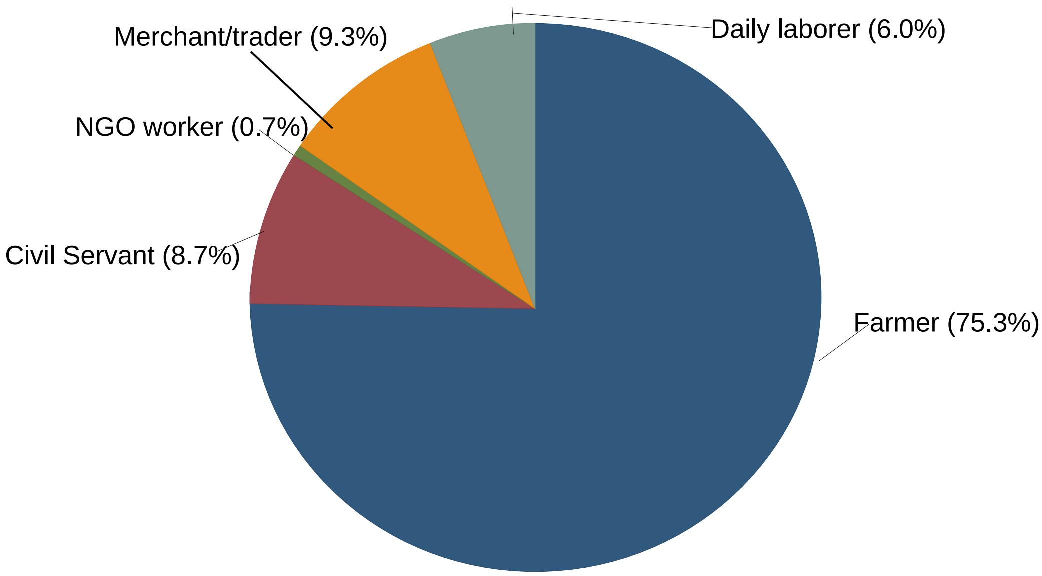

Figure 1: Overall primary occupations of heads of household

Household Energy Consumption

Firewood remains a key source of energy for households in developing countries, contributing to forest degradation and deforestation (Edwards & Langpap, 2005). consequently, according to Beyene & Koch (2013) agreed that the heavy dependence and inefficient utilization of biomass resources have contributed to the depletion of forest resources in Ethiopia and also use of traditional cooking technology has also been linked to indoor air pollution and poor health. So this implies that adoption of new cooking technologies is vital for reducing socio-economic and environmental problems. Moreover, recent study by Sesan (2014) indicated that in rural household widespread practiced burning solid biomass fuels in traditional stoves and open fires as constituting environmental, health and climate-related challenges to development.

In this section, key variables of interest that characterize households' energy consumption patterns are presented. Larger proportion (91.6%) of rural households are dependent on traditional fuels (biomass) while some (8.4%) used modern source of energy such as electricity and kerosene for purpose of cooking, lighting, baking *injera*[1] and heating home (see Figure 2). Support by previous research (Mekonnen and Kohlin, 2008), in Ethiopia rural households have been dependent for centuries on two main solid fuels: woody biomass and dung with kerosene used for lighting however electricity, and liquefied petroleum gas are possible alternative energy sources, they are hardly used at all in these rural areas due to high prices and lack of access. In the same way by previous study Breyer *et al.*(2009) revealed in Ethiopia, firewood and charcoal were widely used in rural areas thus nearly all of 80% of Ethiopians living in rural areas have no access to electricity. Therefore, in rural Ethiopia households dependent on biomass source of energy consumption for various reasons mainly due to inadequate availability of modern energy sources supply and widespread. Even though, there is effort form Ethiopian government improvement energy consumption progress such as access to electricity and distribution of improved stove for rural communities however the study was revealed that majority rural communities rely on traditional energy sources for the purpose of cooking food. Reliance of rural households on firewood their fuel needs is a significant cause of deforestation and forest degradation, resulting in growing fuel scarcity (Gebreegziabher *et al*, 2012). As a result, heavy reliance on wood fuels can result in a range of negative environmental impacts like deforestation and soil erosion.

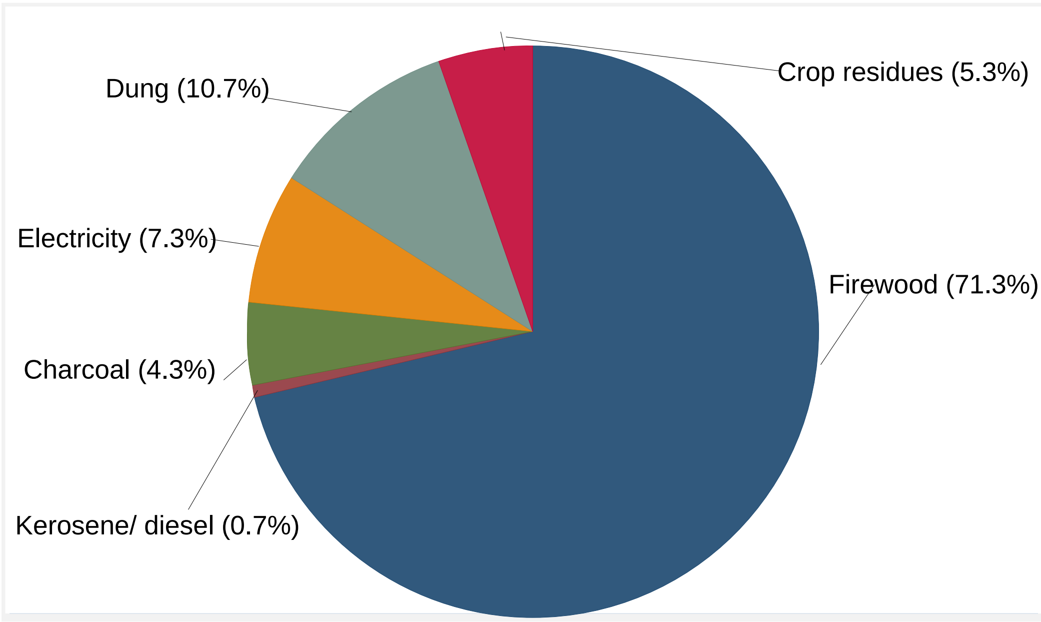

Figure 2 Proportions of household's major energy consumption in the study area

Household access to information about improved stove

Improved stove is a solution to reduce deforestation through introducing fuel-efficient stoves in relied heavily on fuel wood for cooking, thus reducing fuel wood consumption and ultimately leading to a reduced pressure on forests (Gill, 1987; García-Frapolli *et al.*, 2010; Venkataraman *et al*, 2010).

As it can be seen from (Table 1), the study shows that household with access (52.7%) nearly equivalent to with no access (47.3%) to information on improved stove however households with access to information (aware) slightly greater than households with no access to information on improved stoves. In the study area non-governmental organizations like GTZ and private cooperatives were the main provider of information about improved stove hence 36.4 percent and 33.8 percent respectively. And also development agents (22.1%) and *kebele* leaders (7.8%) were provider of information about improved stove.

However, the survey result shows that among who were aware households about the benefits of improved stove only 32.0 percent of households were adopted. In other words, majority (68%) of informed households about improved stoves did not adopt. The ways of household obtain improved stove were by cash, credit from producer, non-governmental organization/GTZ and free gift. Moreover, GTZ was the major provider of information about improved stove for rural households in the study district. Besides, way of obtained of improved stove cash was the main means in the study district. Furthermore, a key informant interview response shows that even though households were aware the importance of improved stoves larger proportion (82.3%) of rural households were not willing to adopted improved stoves.

Table 1: Household's access to information about improved stoves in the study area

Variables	Households access to information about improved stove (%)
Yes	52.70
No	47.30

Available Opportunities for Using Improved Stove as an Energy Saving Technology

A study in rural Mexico indicated that improved cook stoves reduce fuel consumption and address the health effects of indoor air pollution (Troncoso, K. *et al*, 2007). For instance, a study conducted at Pakistan an average biomass using household consumes 2325 kg of firewood, 1480 kg of dung and 1160 kg of crop residues per annum. Thus adoption of improved stove in Pakistan 12–28% efficient for conserved traditional energy sources (Mirza *et al.*, 2008).

Similarly, Table 2 bellow, revealed household's perception of benefit of improved stove, larger proportion of adopter households understood that very high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy (fuel saving) and reduces smoke/ashes. On the other hand, the data shows that improved stove adopter households were more advantages than non-adopter households hence the respondents' found/observed high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ashes. This implies that adoption of improved stove was contributed reducing deforestation, land degradation and increasing agricultural productivity who are adopting improved stove households. Supported by recent research (Damte and Koch, 2011) in Ethiopia, distribution of more efficient stoves was help reduce pressure on biomass resources, increase land productivity by reducing crop residue and dung usage for fuel and improve family health. Moreover, the intervention was benefits women and children, in particular, by reducing fuel collection workloads and limiting exposure to flame hazards and the emission of harmful pollutants.

Table 2: Improved stove adopter household's perception on advantage of improved stove

Advantage of improved stove	Speed of baking (%)	Contribution to reducing burden on biomass (%)	Fuel economy (fuel saving) (%)	Reduce smoke/ashes (%)
Very high	60.00	54.30	60.00	77.80
High	33.30	39.10	35.60	20.00
Moderate	2.20	4.30	1.30	2.20
Low	0.00	2.20	0.00	0.00
None	4.40	0.00	0.00	0.00

Factors Affecting adoption of improved stove at household level

Slaski and Thurber (2009) stated that the determinant of adoption of a new technology is inherent incentive or motivation because of human beings by nature resistant which is connected with the perceived value of the new product or service. Likewise, despite the economic benefits of improved stove, progress in achieving large-scale adoption and use remarkably slow (Jeuland & Pattanayak, 2012).

Although improved stove adoption at household level has a lot of advantages but as it can be seen from bellow Table 3 larger proportions of households have seen hotness of external surface problem (29.20%) followed by durability (25.00%) and installation problem (20.80%). Moreover, households have identified local availability and affordability limitation of improved stoves. Despite the limitation of improved stove, majority of households strongly agreed that use of improved stove benefits greater than its limitation since nearly all improved stove adopter sample households recognized that it helps to very high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ ashes.

Table 3: Improved stove adopter household's perception towards to the limitation of improved stove

Variables	Limitation
Hotness of external surface	29.20%
Durability problem	25.00%
Installation problem	20.80%
Local availability problem	16.70%
Affordability	8.30%

Improved Stove Adopters and Non-adopter Households

As we can be seen in below Table 4 concerning the demographic characteristics of households, average age is 39.82 and 42.98 years old for adopter and non-adopter improved households respectively; this difference is statistically significant at 10%. This implies that younger age household head is better than older age household head in adopting improved stove for rural household's energy consumption in the study district.

Table 4 also indicated that concerning public services like agricultural extension center, health extension center, market, access to main road and so on services directly and indirectly has contribution for adoption of improved stove. Hence, the average distant from the household's home to the agriculture extension center for improved stove adopter and non-adopter households is 1.90 km and 3.00 km respectively; this mean difference is highly statistically significant at 1%. We can concluded that improved stove adopter households are close to agricultural extension center as result, have better opportunity to acquire the services than non-adopter improved stove households. In similarly way, the mean distant from the households' home to the health extension center for improved stove adopter households is about 1.79 km; the mean distance traveled by about non-adopter improved stove households is about 3.24 km. Similarly this difference is highly statistically significant at 1%. In the same way, this implies that improved stove adopter households are close to health extension center as result, have better opportunity to acquire the services than non-adopter improved stove households.

Similarly, the average distance from the household's home to the main road is 1.20 km for improved stove adopter households; the mean distance traveled by about non-adopter improved stove households is 2.35 km. This difference is highly statistically significant at 1%. This implies that improved stove adopter households are close to main road as result, have better opportunity to acquire transportation facilities than non-adopter improved stove households. In similarly way, the average distant from household's home to market services for improved stove adopter household is 4.70 km, while the mean distance traveled by access to non-improved stove adopter households is 5.10 km. This difference is also statistically significant at 10%. So we can concluded that improved stove adopter households have access to marker opportunity, have better opportunity to acquire market opportunity than non-adopter improved stove households. In similar fashion, the mean time taken fuel wood collection is 56.25 minutes and 62.84 minutes for improved stove adopter households and non-adopter improved stove households respectively. Similarly way, this is also statistically significant at 5%. Therefore, improved stove adopter households are close to agriculture extension center, health extension center, road and market as result, have better opportunity to acquire the services than and non-adopter improved stove households in the study area.

Table 4: Demographic, economic and access to facilities characteristics of sample households decision on improved stove adoption

Variable Name	Adopter		Non-adopter		t-test	P-value
	Mean	Std. Dev.	Mean	Std. Dev.		
Age of household head	42.98	11.66	39.80	9.638	1.76	0.06*
Family size	6.27	2.17	6.27	2.36	0.01	0.62
Distance from agricultural extension center (Km)	1.90	2.02	3.00	3.49	-2.03	0.00***
Distance from health extension center (Km)	1.79	1.95	3.24	3.41	-2.73	0.00***
Distance from main road	1.20	0.98	2.35	2.81	-2.74	0.00***
Distance from Market (Km)	4.70	3.29	5.10	4.02	-0.59	0.06*
Time spent for fuel wood collection (min)	56.25	43.45	62.84	42.10	-0.88	0.04**
Fuel wood collection distance (Km)	1.53	1.32	1.60	1.54	-0.28	0.44
Cow dung collection distance (Km)	1.89	2.00	1.81	1.83	0.23	0.90
Time spent for dung collection (min)	62.50	44.93	65.91	45.38	-0.43	0.72

*, **and *** indicate significant at 10%, 5% and 1% level respectively.

Results of econometric analysis on determinants of improved stove technology

Despite improved stove having multiple economic, social, environmental, and health benefits; the improved stove dissemination programs failed to capture worldwide recognition. Mainly, due to socio-cultural, economic/finance, political, policy, technology and institutional barriers contributes to the low adoption rate of such programs. Education and household income are the most significant factors that determine a household willingness to adopt improved biomass stoves (Jan, 2012, Bhattarai & Risal, 2009).

As indicated in the below Table 5, the age of the household head had significant effect on the decision of adoption of improved stove negatively at 1% level of significance. When household head's age is increased by one; the probability of adoption of improved stove will decrease by 10.0%. However, family size/household size had positively significant effect for the household to adopt improved stove at 1% level of significance. This implies that family size increases by one, the probability of adoption of the improved stove will increase by 70.0%. This implies that the bigger household size, the higher the chances that improved stove will be adopted in the study area. Distant from the household's home to the agriculture extension center had significant but negative effect on household adoption of improved stove at 10% level of significance. This implies that the distant from the household's home to the agriculture extension center increases by one, the probability of adoption of the improved stove will decrease by 50.0%. In similar way, the distant from household's home to market services had significant effect on the decision of adoption of improved stove negatively at 1% level of significance. When household head's market distance is increased by one; the probability of adoption of improved stove will decrease by 10.0%. This implies that household access to market opportunity is vital to adopt improved stove.

Table 5 bellow, indicated that household source energy for purposes of cooking (stew, soup, making tea and coffee and likes), could be traditional energy sources (firewood, dung, crop residues), or transitional energy sources (charcoal and kerosene) or could be modern energy sources (electricity and LPG) had positively significant effect on household on adoption of improved stove at 5% level of significance. This implies that when household's source of energy move upward from traditional to transitional to modern energy sources increases by one, the probability of adoption of the improved stove will increased by 12.0%. However, household's main energy source had significant but negative effect on household adoption of improved stove at 5% level of significance thus the survey result had shown that majority of household dependant on traditional energy sources.

It is also evident; (from Table 5) livestock ownership has significant impact on adoption of improved stove positively at 10% level of significance. This implies that as livestock ownership increased by one tropical livestock unit (TLU), the probability of adoption of improved stove will increase by 0.70% in households because of livestock is an asset.

As it may be clearly presented in Table 5, the time taking from the head of the household home to firewood collection have negative effect on the adoption of improved stove decision of households at statistically significance level of 10%. As time taking from the head of the household home to firewood collection increased by one minute, the probability of adoption of improved stove will be decreased by 0.02%.

Similarly as it is clearly presented in Table 5, household's access with information about the importance improved stove has positive effect on the adoption of improved stove decision of households at statistically highly significance level of 1%. As household access information about the important improved increased by one, the probability of adoption of improved stove will be increased by 81.70%. This implies that household access information about the important of improved stove is vital on the decision of adoption of improved stove.

The model fitness, the variability of the variances of error term and the multicollinearity is tested and the result shows that the model has 93.33% predicting power and it is free from hetreoscadesticity and multicollinearity.

Table 5: Probit regression of the adoption of an improved stove in the study area (n=150)

Explanatory Variable	*Coefficient*	*Std. Err.*	*Z*	Marginal effect (dy/dx)
Sex of household head	-0.898	1.229	-0.73	-0.26
Age of household head	-0.098	0.032	-3.06***	-0.10
Marital status of household head	0.140	0.329	0.42	0.10
Family size	0.710	0.211	3.36***	0.70
Educational level of hhh	0.220	0.205	1.07	0.20
Occupation of hhh	0.083	0.229	0.36	0.08
Distance from agricultural extension center	-0.547	0.299	-1.83*	-0.50
Distance from health extension center	1.048	0.389	2.69***	0.10
Distance from main road	0.626	0.331	1.89*	0.10
Distance from Market	-0.754	0.217	-3.46***	-0.10
Credit service	0.872	0.641	1.36	0.19
Source of energy cooking *wot* and so on	1.245	0.531	2.34**	0.12
Main energy source of hh	-0.452	0.196	-2.30**	-0.40
Owner of planted trees	-0.985	0.901	-1.09	-0.16
Owner of livestock	1.554	0.950	1.64*	0.70
Fire wood availability in the last five year	-0.002	0.602	-0.00	-0.002
Distance traveled to collect firewood (km/ week)	-0.021	0.228	-0.09	-0.02
Time spent to collect firewood (hour/week)	-0.017	0.007	-2.25*	-0.02
Dung availability in the last five year	0.202	0.616	0.33	0.20
Distance traveled to collect dung (km/week)	-0.200	0.188	-1.06	-0.20
Time spent to collect dung (hour/week)	0.001	0.008	0.16	0.001
Household with access information on improve stove	7.594	1.901	3.99***	0.817
Kitchen service	0.401	0.372	1.08	0.40
Land ownership	-1.770	1.280	-1.38	-0.085
Constant	-0.223			

*, **and *** indicate significant at 10%, 5% and 1% level respectively.

Conclusion and Recommendation

Based on the information gathered and analyzed the findings of the study was be summarized in the following lines. In Dendi district, larger proportion of households were dependent on firewood and dung source of energy consumption due to inadequate availability of modern energy sources even though there is improvement in access to electricity and distribution of improved stove for rural communities.

Improvement in resource-use efficiency through improved stove is vital however still application in the study district is in an infant stage. Hence, among majority of sample households selected with access information about improved stove adopters are only 32.00%. With respect to improved stove adopter households are more advantages in terms of high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ashes as compared to non-adopters. This implies that improved stove could contribute reducing deforestation, land degradation and increasing agricultural productivity. Moreover, adoption of improved stove is expected to benefit women and children, in particular, by reducing fuel collection workloads and limiting exposure to flame hazards and the emission of harmful pollutants. However, improved stove adopted households had seen external surface hotness, durability, installation, affordability and local availability limitation of improved stoves.

The heavy dependence and inefficient utilization of biomass resources of energy have resulted in high depletion of firewood, crop residue, dung and charcoal in Dendi district. To solve this, development planners should be encouraged the community to plant community forest and also adoption of improved stove could contribute to reducing burden on biomass.

Similarly, larger proportions of households are reliant on traditional fuels (biomass) for purpose of cooking, lighting, baking *injera* and heating home due to inadequate access to modern energy sources. To overcome this, efficient utilization of household energy is vital because other researchers also indicates that 90% of the forest is removal associated with firewood and the production of charcoal so adoption of improved stove could helps improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ ashes. To fill this knowledge gap, different strategies should be planned to introduce and disseminate the alternative technologies through demonstrations, posters, and radio/TV advertisements is crucial.

Moreover, although improved stove adoption at household level has a lot of advantages but larger proportions of households have seen hotness of external surface, local availability, durability, installation and affordability limitation of improved stoves. To solve this problem, development partners need to assist improved stove producers through providing incentives like information, training and credit service is fundamental to improve products.

Notes

1. Kebele is an equivalent with lowest administrative units
2. Injera, made from teff, is the staple bread in Ethiopia

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