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DETERMINANTS OF COOKING FUEL CHOICE AMONG HOUSEHOLDS IN WOLAITA ZONE, SOUTHERN ETHIOPIA

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ABSTRACT

The quality of household energy usage has a link with sustainable development. In order to increase the use of clean energy sources of the household, it is better to understand households' decisions their fuel consumptions. This paper therefore aims to examine factors that determine households' cooking fuel choice in rural and semi urban area of Wolaita Zone. This study is conducted based on cross sectional data collected from 205 household by using simple random sampling technique. The data was collected through structured questioner and has been analyzed by both descriptive and econometrics analysis. A multinomial logit (MNL) model was used to estimate determinates of cooking fuel choice. Results show that education, total household income, location, perception, Age of household head, sex of household head and ownership of clean fuel stove are important factors that determined household cooking fuel choices. In order to improve the use of clean fuels by the households, the government should focus on significant variables of this research.

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INTRODUCTION

Energy plays a crucial role as a global commodity and as a cornerstone of socio-economic development. Access to energy is fundamental to human welfare. We need energy to cook our food and heat our homes. There are three billion people, or 40% of the world, that still relies on biomass for cooking, lighting, and heating (WHO, 2014). This has led to a significant burden for the planet and for those living on it. Globally, the proportion of biomass energy will reach 50% by 2050 in terms of consumption (Mondal and Denich, 2010). Biomass, a combination of different organic compounds, is mainly derived from three sources: agricultural residues, forest residues, and energy crops (Guta, 2012). Generally, biomass refers to rice husk, crop residues, jute sticks, wood, leaves and forest residues, animal waste. Cooking with polluting fuels is a major global health issue, with the World Health Organization estimating in 2016 that some 4.3 million premature deaths each year are linked to inhaling carbon monoxide and particulate matter from traditional biomass cook stoves, primarily among women and children.

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In many regions (such as South Asia and parts of Sub-Saharan Africa), indoor air pollution exposure has become the most risky factor for health conditions even greater than risks by unsafe water and sanitation. Mortality from indoor air pollution exposure in Sub-Saharan Africa already exceeds tuberculosis, is roughly on par with malaria, and could approach the level of HIV/AIDS by 2030 (Smith *et al*., 2013, cited in AFREA, forthcoming). Severe impacts on health are not the only effects of the use of biomass fuels. Biomass fuels also require people to cut down a lot of trees for fuel wood, which leads to deforestation, forest degradation and, ultimately, global warming. Inefficient biomass burning also adds to outdoor ambient air pollution and affects climate change by releasing methane, carbon monoxide, and black carbon into the atmosphere (Lewis & Pattanayak, 2012). This situation is not evenly distributed across the world. Rather, energy poverty, described by Bonan *et al*. (2017) as the "lack, scarcity or difficulty in accessing modern energy services by households," in particular affects rural areas in developing countries in Africa, Asia, and South America. Lack of energy access presents a formidable, but not insurmountable, challenge to African development. Energy poverty afflicts nearly 620 million people in Africa, limiting economic opportunities and creating health risks through the use of low-cost, alternative energy sources, such as wood fuel (IEA 2014). Under the 2016 World Energy Outlook's New Policy

Scenario, around 2.3 billion people across Africa and Asia are projected to continue to rely on traditional uses of biomass for cooking in 2030. Ethiopia's population is currently 84 million people and with a growth rate of 2.6 per cent per annum it will reach 103 million by 2020 (Central Statistical Agency, 2012). Access to energy is among the key elements for the economic and social developments of Ethiopia. The energy sector in Ethiopia can be generally categorized in to two major components: traditional and modern (traditional biomass usage and modern fuels i.e. electricity and petroleum). As more than 80% of the country's population is engaged in the small-scale agricultural sector and live in rural areas, traditional energy sources represent the principal sources of energy in Ethiopia. Household energy demand from traditional fuels is fulfilled by wood, charcoal, branches, dung and agricultural residues, which all produce smoke and harmful emissions when they are burned (Beyene *et al*. 2013). Every year, nearly 150,000 hectares of land, 1.1% of forest area is deforested in an effort to collect wood (FAO, 2010). Biomass in its various forms accounts for significantly more than 80 per cent of total energy consumed in the country. The three-stone stove, which has about 90 per cent energy loss, is used by around 80 per cent of the population (Ministry of Water and Energy, 2013a). In general wood fuels dominate both urban and rural total household energy consumption of the country.

The idea of Green Growth is enshrined in the GTP and at the UN Conference on Climate Change in 2015 (COP21), the Ethiopian government pledged to cut emissions by an ambitious 64 per cent by 2030 Addis Standard (2013). The fuel choices of developing country households are a crucial factor for the adoption of modern energy services and the introduction of decentralized and less carbon□intensive energy systems. In order to increase the use of clean energy sources, one has to understand how households decide on which fuels to consume. This paper therefore aims to examine factors that determine households' cooking fuel choice in rural and semi urban area of Wolaita Zone. This study analyzes household fuel choice and factors that determine choice of a particular fuel type, using a multinomial logit model by grouping consumers into three categories. The category 'traditional fuel', as the name implies, refers to energy sources such as firewood, charcoal, dung and crop residues. Clean energy users are those households who use electricity, gas and kerosene as their main energy source for cooking. The other categories used in this study are mixed. The term 'mixed fuel' refers to combination of clean and biomass fuels. There are households that are using a combination of clean energy types such as electricity and gas for one type of cooking activity and biomass fuel such as firewood and/or charcoal for other types of cooking.

Energy consumption patterns vary with the locations of the study area: urban, suburban, and rural and the proximity to forest areas (Heltberg, 2005; Rahut *et al*., 2014). Most of the researches conducted in Ethiopia are focused on determinant of cooking fuel choice of household in urban areas. As far as my reading is concerned, there are very few researches conducted on rural and semi-urban part of the country. Therefore, the concern of this research is to investigate the determinants of cooking fuel choice in rural and semi-urban areas of Wolaita zone. Understanding of key determinates of household cooking energy consumption is important for the design and implementation of effective policies to enhance access to clean cooking fuels. Another function of this research will be, for policy makers and environmental as well as natural resource experts to formulate projects to related cooking fuel choice. Finally, this research can serve as a spring board for other researchers who are going to conduct a research on similar issues.

Literature

Theoretical literature: Household fuel choice is often based on the 'energy ladder' model and the associated notion of 'fuel switching'. The "energy ladder" is a commonly used concept in models of domestic fuel choices in poor countries (Heltber, 2004; Alam and Barnes 1998; Campbell *et al*. 2003; Davis 1998; Hosier and Dowd 1987). The current energy discourse frequently differentiates among "modern" and "traditional" fuels, assuming that there is a linkage between the income level of households and their fuel choice; this is generally referred to as the "energy ladder hypothesis". Petroleum products such as kerosene and LPG as well as electricity are considered to be modern fuels at the top of the energy ladder whereas traditional fuels such as wood fuels and agricultural waste end up at the bottom. Charcoal is often considered as a transition fuel, being that it is a marketable commodity with a higher level of convenience than traditional fuels.

The energy ladder depicts a process by which households, as their income rises, move away from traditional fuels (e.g., biomass), first to adopt intermediate fuels (kerosene, coal), and then to use modern fuels (gas, electricity) Heltberg (2005), Chambwera and Folmer (2007), Lay *et al*. (2013). As a consequence, as their income increases, households shift to more sophisticated energy carriers and simultaneously give up less sophisticated alternatives Kowsari and Zerriffi (2011), Rahut *et al*. (2014). The scope of the "energy ladder" hypothesis, which states that households switch their fuel use from biomass to modern energy sources as a country develops and income increases, implying that firewood is an inferior good (Arnold *et al*., 2006). The complexity of the fuel switching process thus suggests that there is a multiplicity of factors, besides income, that may affect fuel use. This led some authors to delve into more sophisticated modeling approaches.

Thus, instead of moving up the ladder step by step as income rises, households choose different fuels as from a menu. They may choose a combination of high-cost and low-cost fuels, depending on their budgets, preferences, and needs (World Bank 2003). This led to the concept of fuel stacking (multiple fuel use), as opposed to fuel switching or an energy ladder (Masera *et al*. 2000; Heltberg 2005). On the other hand, according to energy stacking (energy Mix) hypothesis, households in developing countries do not switch to modern energy sources but instead tend to consume a combination of fuels (Masera *et al*. 2000). Instead, they note that fuel stacking is common in both urban and rural areas of developing countries. Fuel stacking corresponds to multiple fuel use pattern where households choose a combination of fuels from both lower and upper levels of the ladder. Indeed, modern fuels may serve only as partial, rather than perfect substitutes for traditional fuels (van der Kroon *et al*., 2014).

Empirical literature: Information at households' disposal about the various fuels influences their decisions which are driven by households' economic and non-economic constraints. The economic factors may include availability and market price of fuel, household income and expenditure, while the non-economic factors may include socio-economic characteristics such as household size, age, gender, house ownership, type of dwelling, location of residence, distance to fuel source, and access to electricity (Masera, 2000). Income is a key factor in explaining energy use behavior and the substitution from private fuels to commercial energy source. Bansal *et al*. (2013) in rural India, Chaudhuri and Pfaff (2003) in Pakistan, Heltberg (2005) in Guatemala and Nlom and Karimov (2014) in northern Cameroon find that household income is one of the main factors in choosing fuels for cooking. All these studies seem to corroborate the energy ladder concept, which emphases income in explaining the transition from 'inferior' traditional fuels to 'normal' modern fuels. However, a few empirical studies present evidence against energy ladder hypothesis households' move towards modern energy sources as their income rises. For example, Sehjpal *et al*. (2014) in rural India finds that household income is less significant compared to other social and cultural factors in choosing cleaner fuels. Apart from income, several other socio-economic factors also influence household's cooking fuel choices. One important factor is education or awareness. Pundo and Fraser (2006). Find that education level of wife significantly influences the probability of switching from fuel wood to charcoal or kerosene in rural Kenya. Similar findings are reported by Heltberg (2004) in eight developing countries. In particular, Pandey and Chaubal (2011) finds that number of educated females between 10 and 50 years of age and average household's level of education had a positive and significant impact on probability of using clean cooking fuels in rural India. Manning and Taylor (2014) consider rural labor market failure and substitution between firewood and gas. Finally, Muller and Yan (2014) propose a fully-fledged non-separable decision model that simultaneously links fuel use decisions with agricultural production, domestic technology, fuel collection technology and rationing of fuel.

METHODS

Description of the Study Area: Wolaita zone is one of the 13 zone administration of the South Nations, Nationalities and people region in Ethiopia which is located 327 kilo meteres of the South of Addis Ababa. It is bordered on the south by Gamo Gofa Zone, on the west by Omo River which separate from Dawro Zone, on the north by Kembata-Tembaro, on the north by Hadiya Zone, on the east by Bilate River which separates it from Sidama Zone. The average temperature varies from 15^0 c to 30^0 c (wolaita Zone, 2015).

Data Collection and Sampling: The data was obtained from primary sources which is collected 2018 through cross sectional data. The data contains several socio-economic variables at the household level. The data collected from rural and semi urban area of Wolaita zone. In the first stage, this study selected three wordas (Humbo, Kindo Didaye and Damota Pulasa) by using simple random sampling technique. In the second step from each woreda two rural kebeles and one semi urban kebele have been selected randomly. Finally each sample respondent from each kebles (i.e. lowest level of local administrative unit) selected by using simple random sampling method. Totally, the data collected from 3 semi-urban and 6 rural kebeles. In this study, basically quantitative data has been used. This quantitative data has collected by distributing 230 questioners. From these questionnaires, only 205 have been valid and used in the study while the remaining one excluded due to omission of main variable.

Empirical model: The dependent variables I focus on this paper are energy types chosen by households as their main cooking fuel. The categories include traditional fuel, clean fuel and mixed fuel users. Explanatory variable of the study are sex household head (i.e. it is a dummy variable 1 for male, 0 for female), Age of the household head, education level of the household head (i.e. represent by years of attend in school), Family size of the household, Total annual income of the household, perception (i.e. it is household perception to ward relative price of clean fuel relative to traditional one. It is dummy variable 1 for their perception is expensive, 2 when they perceive fair price and 3 for low price of clean fuel), ownership of clean fuel stove (it is dummy variable 1for owner and 0 for non owner), location (it is respondent geographical location. It is dummy variable 1 for rural and 0 for semi urban) and electricity (it is dummy variable 1 for access to electricity and 0 for not access electricity).

Energy Choice Model Estimation Methods: The analysis of what determines the most important combinations of cooking fuels was carried out using multinomial logit (MNL) model for rural and semi urban households of wolaita zone. The main assumption of the model is that household makes such a fuel choice that maximizes utility. The multinomial logit model estimates the effects of explanatory variables on dependent variables with unordered response categories. The model examines choice between a set of fuels for cooking such as traditional fuel, mixed fuel and clean fuel. The traditional fuel is used as base category. The MNL model is expressed as shown below:

$$P_{ij} = \frac{\exp(X_i B_j)}{\sum_{k=1}^{n} \exp(X_i B_k)} \quad (1)$$

Where X_i is a vector of explanatory variables postulated to influence a household's choice of fuel type B is the set of regression coefficients associated with outcome (*j,k*).The marginal effects are computed by differentiating (1), as expressed in (2) below:

$$\frac{dP_{ij}}{dX_i} \quad (2)$$

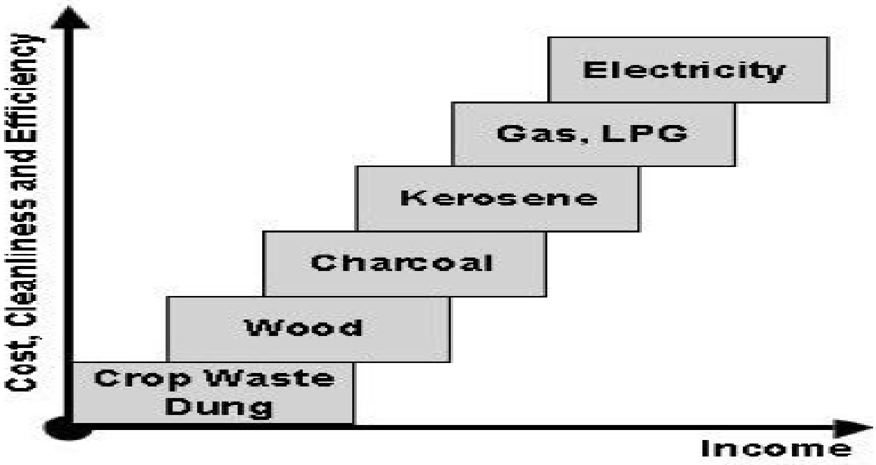
Descriptive Analysis: Figure 2 show that households' main cooking fuel choices among traditional fuel, clean fuel and mixed fuel. From the total of 205 respondents, majority of the households' choice is traditional fuel as main cooking fuels type (i.e. 58.5% or 120 household). Besides this among 120 traditional fuel users only 21 live in semi urban area. On the other hand, among 19 clean fuel user households, 17 are live in semi urban area of wolaita zone. From this, one can understand that households living in semi-urban areas have better access to use clean fuel compared to households living in rural areas. From the total respondents, 83.41% are male household head and the rest 17% only female household head. Table 1 show that the average age of household head is 43 years while the average number of year of school attended is 7years. The average household family size is 5.45 and the average annually income is 21884.65 birr or 754.64$ per year. Table 2 shows that perception of household for relative price of clean fuel as compared to traditional fuel. A person who is living in rural area perceive that relative price of clean fuel is expensive as compared to traditional fuel. Majority of the respondents (91), who perceive relative price of clean fuel, is more expensive than traditional fuel. Even though majorities of the respondents (82.44%) have access to electricity, about 58.6% of them use traditional fuel as their main cooking fuel. A person who lives in rural has no access to electricity as compared to those who live in semi urban area of the study area. From the total respondents, 55.61% of them have no clean fuel stove whereas, 44.4% have their own clean fuel stove. Besides this majority of the respondent (64 from the total of 84) who lived in semi urban area have their own clean fuel stove. From 119 rural household respondents only 27 or 22.6% have clean fuel stove.

Econometrics Analysis: Regression results for determinate of household cooking energy choice in rural and semi urban area of wolaita zone has been as follow. The MNL model was estimated by using STATA12 software program. The result of chi-square test shows that the likelihood ratio statistics are highly significant. In this case, Mc Fadden's pseudo R^2 gives R^2 a value of 0.7351. In other word, 73.5% of energy choices of the households of the study area explained by the exogenous variables selected. This value of the pseudo-R^2 suggests a reasonable efficiency of the model. Regression results for determinants of the household cooking energy choice in rural and semi urban area of wolaita zone are presented in table 4 and table 5. Table 4 shows the estimated coefficients while table 5 presents marginal effects of the results. In this study, traditional fuel is a base category due to large frequency of respondent or majority of the household choice is traditional fuel as main cooking fuel. Table 5 presents the results of multi nominal logit model. Results show that education, total household income and location are statistically significant for both mixed and clean fuel as compared to traditional fuel. Variable perception2 and perception3 are statically significant only for clean fuel relative to traditional fuel. Age of household head, sex of household head and ownership of clean fuel stove are significant only for mixed fuel as compared to the base category.

Now let see each variables in detail: Sex of household head has a positive and statistically significant at 5% confidence level for mixed fuel choice than traditional fuel. This indicates that male headed households' heads are more likely to use mixed fuel than female household head as compared to biomass fuel sources. The marginal effect of sex show that male household head have a positive effect on probability of choosing mixed fuel increases by 38.53% and the probability of using traditional fuel decreases by 38.53%. So, we can conclude that female household head choice traditional fuel than male household head. It is coincided with the finding of Link *et al* (2012). This could be due to female household heads are more responsible for collecting fuel and cooking than male household heads. So, since they can access traditional fuel with lowest cost than other fuel, their choice is traditional fuel. The estimated coefficient for the household head's age is positive and statically significant for the probability of household choice of mixed fuel and insignificant for clean fuel compared to traditional fuel. This implies that an increase in the age of household head is more likely to influence the choice of mixed fuel than traditional fuel. The result shows that one year incensement in the age of the household head, increases the probability of adoption of mixed fuel for cooking by 1.3% and decreases the probability of choice of traditional fuel by 1.3%. Older household heads are more likely to prefer modern fuel than biomass fuel. This might be due to lack of physical strength to collect biomass fuel and to use this fuel for cooking. The result is in the agreement with the works of Guta (2012) and Lay *et al* (2013). The estimated coefficient of household head's year of education is positively significant at 1% for both clean and mixed fuel. This implies that an increase in the household head's education is more likely to influence the choice of clean and mixed fuel than traditional fuel. The marginal effect suggests that one year increases in household head education increase the choice of mixed fuel by 7.7% and decreases the choice of traditional fuel by similar percent. Higher education associated with a higher probability of using mixed and clean fuel. This is due to an increase in the level of education improves household income, knowledge of attributes and preference for modern clean fuels. Different studies approves about the positive influence of education in switching traditional fuels to clean fuel Baijegunhi (2014) and Onyekuru (2011).

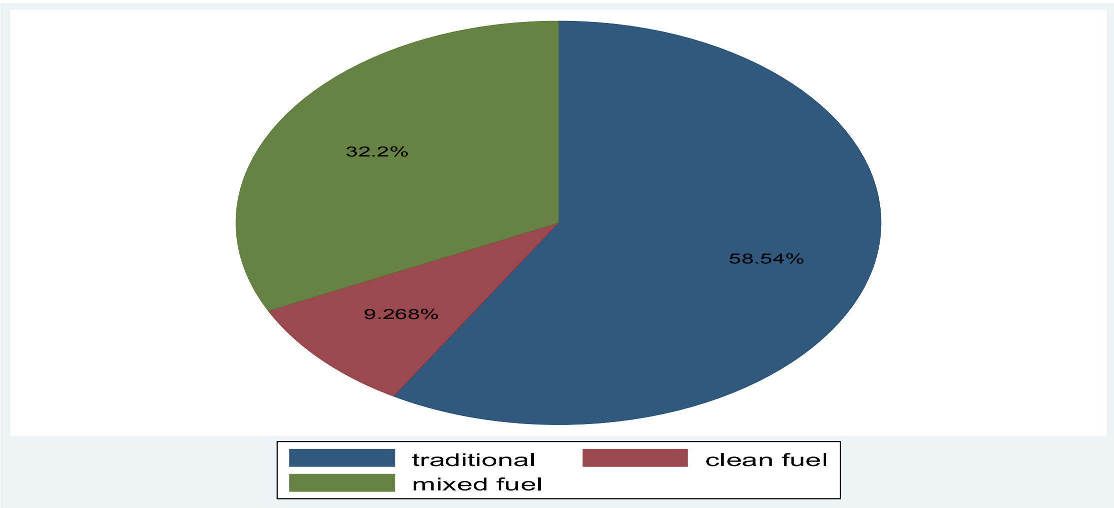
Increased household income has positive influence on the choice of both clean and mixed fuel. As income of household head increases, the demand for traditional fuel decreases, while the demand for clean and mixed fuel increases. When their income as a household increases, their life standard will improved and they can have the ability to use clan fuel. This result confirms the consensus of the previous studies in favor of a positive relationship between income and clean fuel demand. This finding is in line with the works of Baiyegunhi and Hassan (2014), Demuger and Fournier (2011) and Lay *et al*. (2013). The coefficient of the ownership of clean fuel stove is positive and significant for mixed fuel and insignificant for clean fuel as compared to traditional fuel. When ownership of clean fuel stove increases by one percent, the household are less likely to use traditional fuel and more likely to use mixed fuel by 57.25%. This implies that, owner of clean fuel stove household demands more mixed fuel than traditional fuel. Ownership of modern cooking appliances is necessary conditional for adopting higher grade energy source. It is similar with finding by Manning and Taylor (2014). The coefficient of dummy variable for perception of the household towards relative price of clean fuel relative to perception1 perception 2 and perception 3 is significant and positive for clean fuel while it is insignificant for mixed fuel. This implies that when a household head perceives that the relative price of clean fuel is fair and low they will increase their demand for clean fuel and will decrease their demand traditional fuel. The dummy variables for location of the respondent indicates that both mixed fuels and clean fuels are more likely to be chosen in semi urban area relative to rural when traditional fuel is the base category. A household, who lives in rural area, increases a probability of using traditional fuel by 32.24% while a household who lives in semi urban areas decreases the demand for traditional fuel with similar percent. The reason could be access to electricity, access to market and difficult to get zero cost traditional fuel in semi urban area than rural.

Conclusions and Policy Implications: This study aims at identifying various factors that determine household fuel choices in rural and semi urban area of wolaita zone. It has been conducted based on cross sectional data collected in 2018 from three selected woreda of Wolaita zone. Majority of the households are using traditional fuels as their main source of energy for cooking.



Source: Smith (2000)

Figure 1. The Energy Ladder



Source: From calculation of author's survey, 2018

Figure 2. Household Cooking Fuel Choices

Table 1. Summary of continuous Variable at the Household Level

Variable	Mean	Std. Dev.	Min	Max
Age	42.92195	11.60687	20	81
Family_siz	5.44878	2.077791	1	12
Educ	7.141463	5.126296	0	17
Total_HH_I~e	21884.65	21313.83	1750	131325

Source: From calculation of author's survey, 2018

Table 2. Household Perception and Cooking Fuel Choices

	Household perception to ward relative prices of clean fuel			
Cooking Fuel	Expensive	Fair	Low	Total
Traditional	91	21	8	120
Clean	1	5	13	19
Mixed	19	40	7	66
Total	111	66	28	205

Source: From calculation of author's survey, 2018

Table 3. Show That Access to Electricity and Ownership of Clean Fuel Stove

	Access to Electricity			Ownership of Clean Fuel Stove		
Cooking Fuel	No	Yes	Total	No	Yes	Total
Traditional	31	89	120	103	17	120
Clean fuel	0	19	19	3	16	19
Mixed fuel	5	61	66	8	58	66
Total	36	169	205	114	91	205

Source: From calculation of author's survey, 2018

Table 4. Multi Nominal Logit Analysis

	Clean fuels			Mixed fuels		
Variable name	coefficient	Sig.	P value	coefficient	Sig.	P value
Sex	2.24		0.284	8.442	**	0.043
Age	.152		0.115	.064	*	0.060
Family size	-0.09		0.812	-.066		0.717
Educ	1.22	***	0.002	.3697	***	0.000
Total HH income	0.002	***	0.000	0.0006	**	0.019
Perception 2	3.345	*	0.097	.7335		0.327
Perception 3	9.431	***	0.003	1.497		0.122
Ownership of clean fuel stove	5.732		0.278	2.880	***	0.000
Location	-4.338	**	0.041	-1.520	**	0.016
Access to electricity	11.092		0.995	.814		0.378

Source: From calculation of author's survey, 2018; Number of observation=205, Prob>chi2=0.000, Pseudo R^2=0.7357; Note: ***p < 0.01, **p < 0.05, and *p <0.10 denote significance at the 1%, 5% and 10% levels, respectively.

Table 5. Marginal Effects

Variable name	Traditional	Mixed fuel
Sex	-.3882**	.3882**
Age	-0.013*	0.013*
Family size	0.014	-0.014
Educ	-0.077***	0.077***
Total HH income	-0.0009**	0.0009**
Perception2	-.1609	.1609
Perception3	-.3511	.3511
Ownership	-.5743***	.5743***
Location	.3247**	-.3247**
Electricity	-.1516	.1516

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.
Note: Marginal effect of clean fuel not include due to insignificant of all variable

As compared to semi urban household, in rural areas people are using more traditional fuels than clean fuels. This is because of lack of clean fuel accessibility, unavailability of electricity, accessing traditional fuel with zero price and knowledge gap about the use of clean fuels. This study used multi nominal logit model to identify determinates of cooking fuels choice in the study area. Empirical results of multi nominal model show that total household income, education level, location, sex, age, ownership of clean fuel stove and perception of the household are statistically significant to influence households' choice of cooking fuels. Income is not the only factor in the fuel switching and fuel stacking process. In general, the observed patterns in the data are consistent with both the energy ladder theory and fuel stacking theory. The result shows that when income increases the demand for consumption of mixed and clean fuel also increases while decreases the demand for traditional fuels. The quality of households' energy use is linked with sustainable development. Having the right strategy is the promotion of energy transition requires a good understanding of the driving factors that influence energy choice. The result suggest that education is a key variable to promote fuel switching as higher education levels are associated with a higher probability of clean fuel use and a lower incidence of traditional fuel use. When people are educated, they can fill their knowledge gaps in accessing and using clean fuel, they can have better job opportunities and they can generate income that can assist them to buy clean fuels. Other key variable that affect household fuel choice is ownership of clean fuel stove. Most of traditional fuels users have no clean fuel stove. So, government should focus on dissemination of improved clean fuel stove with subsidize price. From my observation as part of the community and from the data collected from households, it is seen that financial limitation of households affects the use of clean fuel; the households by expansion and creating more job opportunities. Finally, coordination of agricultural and energy policies would be desirable in the case of rural area energy transition.

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