CHAPTER III

PROPERTY RIGHTS, INSTITUTIONS AND CHOICE OF FUEL WOOD SOURCES IN RURAL ETHIOPIA

Abstract

This study examines the relationship between property rights, defined by land tenure security, the strength of local-level institutions, and household demand for fuel wood, as measured by the source from which fuel wood is collected. A multinomial regression model is applied to survey data collected in rural Ethiopia. Results from the discrete choice model indicate that active local-level institutions reduce the dependency on community forests, but, otherwise, increase household dependency on open access forests. However, land tenure security and local level institutions do not increase demand for fuel wood collected from private forests. The results suggest that there is a need to bring more open access forests under the management of the community and increase the quality of community forestry management in order to realize improvements in forest conservation.

1. INTRODUCTION

Like many other developing countries, biomass resources such as fuel wood, dung and agricultural crop residues are the most important energy sources in both rural and urban Ethiopia. According to the Woody Biomass Inventory and Strategic Planning Project (2004), over 90% of the country's total energy for household cooking is derived from biomass fuels – 78% from firewood – while 99.9% of the total rural population make use of woody and other traditional biomass resources, such as animal dung and agricultural residues (Zenebe, 2007). Such heavy reliance on biomass energy sources has resulted in serious forest degradation; between 1990 and 2010, Ethiopia lost an average of 140,900 ha - 0.93% of its initial forest coverage area – each year.[29] Given that all major forests in Ethiopia are state-owned, while the government, like those in many other low-income countries, has neither the capacity nor the incentive to properly regulate these forests, such rates of forest degradation may not be that surprising.[30] There is *de facto* open access to all forests, which is expected to aggravate the degradation and deforestation problems in the country.[31] Fortunately, the problem has been recognized and there is keen interest within government to alleviate or reverse the situation, and increase forest cover in Ethiopia.

In April 2007, the Ministry of Agriculture and Rural Development's (MoARD) Forest Development, Conservation and Utilization Policy and Strategy was approved. According to MoARD (2007), one component of the policy is the provision of seedlings and the granting of certificates of ownership to lands designated for forest development. Another policy instrument contained in MoARD (2007) is the continued extension of land tenure security, since tenure security reduces investment risk and should promote increased forest sustainability.[32] The provision of seedlings is one of the supply-side strategies adopted by the current government to reduce the pressure on forests and minimize problem of land degradation, while the granting of certificates harnesses both demand-side and supply-side

[29] See http://rainforests.mongabay.com/deforestation/2000/Ethiopia.htm. Fuel wood collection, together with land clearing for agriculture, overgrazing and other shocks (such as fires) also contribute to the unsustainable use and misuse of forests in Ethiopia.
[30] Mekonnen and Bluffstone (2008) note that the regulation incentive is particularly low in Ethiopia, because forests produce goods used mainly by local villagers.
[31] Forest resource degradation and the misuse of forest resources in Ethiopia, due to the fact that those resources have been primarily state-owned, is one more example of Hardin's (1968) tragedy of the commons.
[32] Modelled on an effort in Tigray during the late 1990s, an initial program on land certification was undertaken in the country's main regions in 2003, with the objective of reducing tenure insecurity and its negative impact on investment (Deininger et al., 2008).

strategies. However, the success of these policies hinges, in part, on whether or not households reduce their demand for fuel wood from, especially, open access forests, when private sources are available, as well as whether or not private ownership and seedlings incentivize better forest stewardship.

Recent Ethiopian studies have focused on the impact of land certification on investment and productivity in agriculture (Deininger et al., 2008; Deininger et al., 2009; Holden et al., 2009, Mekonnen, 2009). Deininger et al. (2009), for example, assess the effects of the low-cost land registration program in Ethiopia on soil and water investment, finding that, despite policy constraints, the program has resulted in increased soil and water related investment. Holden et al. (2009) provide further evidence on the effectiveness of land certification on investment. They use a unique balanced household and plot-level panel dataset covering the five main zones of the Tigray region in northern Ethiopia to assess the investment and productivity impacts of the recent low-cost land certification. Their findings indicate that land certification has significant positive impacts, including improved maintenance of soil conservation structures, increased investment in trees, and increased land productivity. Mekonnen (2009) analyses the roles of tenure insecurity and household endowments in explaining tree growing behaviour in Ethiopia, where farmers cannot sell or mortgage land and factor markets are imperfect. However, Mekonnen used perceived expropriation of land in the five-year period after the survey as an indicator of land tenure insecurity. The results of Mekonnen's (2009) analysis suggest that land tenure insecurity influences the decision to grow trees, but not the number of trees households grow.

Although the initial program has received some attention in the literature, that focus has been on the investment effects of the land certification policy. To date, no study has considered the possible impacts of the program on forestry use, which is the purpose of this research. Specifically, this research seeks to provide empirical evidence related to the determinants of household fuel wood source choices, with a focus on tenure insecurity and local-level institutions.

A number of different fuel wood sources are available in the rural parts of the country. Private trees or farm forests, state or open access forests, community forests, and markets are the major sources of fuel wood and other forest products. In terms of use, the wood supplied from open source forests is mainly used for fuel wood, fencing and construction. However, as

previously described, government policy has attempted to provide incentives for better forestry use and to involve local people in the management and use of forests and forest products, leading to the development of community forests. Thus, for the government to achieve its objectives – increasing the contribution of forests to the economic development of the country, maintaining the ecological balance, as well as conserving and enhancing biodiversity through the sustainable utilization and development of forest resources – it is necessary to examine and understand the factors that drive rural households to collect fuel wood from a given source, and, especially, determine patterns of substitution across sources.

Though there are some studies on the relationship between biomass production and property rights regimes in developing countries, the available empirical evidence on household fuel wood source choices is rather limited. Some of these studies, for example, Jumbe and Angelsen (2006), who consider Malawi, show a high correlation between the specific attributes of fuel wood collection sources (such as area, species, distance to the forest, etc.) and the household's choice of fuel wood collection source. Among the three types of fuel wood sources: customary, plantation and forest reserves, in their study, customary forests and forest reserves are substitutes, while substitution is more limited between plantation forests and forest reserves. However, Jumbe and Angelsen (2006) do not examine the role of private sources; markets sources were also not incorporated into the analysis.[33]

Unfortunately, only a few researchers have examined the role of private trees. Heltberg et al. (2000) find evidence of substitution between forest fuel wood and private energy sources (like dung, residues and homestead trees) in India. Based on the findings from India, Nepal, and Ethiopia, Cooke et al. (2008) indicate that private trees and trees in common forests are substitutes in the production of fuel wood for rural households, at least for households owning land. Mekonnen (1999) studies biomass consumption and production in the East Gojam and South Wollo zones of the Amhara region of Ethiopia and concluded that consumption of other biomass energy sources, such as dung and crop residues, will not decrease, when more fuel wood is available.

The available empirical literature focuses on rural energy consumption and production and is geographically limited, with more emphasis on Asia, particularly India and Nepal. Moreover,

[33]Linde-Rahr's (2003) Vietnamese study, which is similar to Jumbe and Angelsen (2006), finds strong substitution between open access and plantation forests.

the available empirical evidence does not emphasize the impact of local-level institutions and tenure security on farmer forestry resource use in Africa. Similarly, Ethiopian studies focus on the role of tenure security on the farmer's long-term investment, with a focus on land related investments, and not on forestry use. Therefore, the purpose of this study is to add to the empirical literature by considering the determinants of household demand, measured by the choice of fuel wood source, focusing on tenure insecurity and local level institutions, providing policy implications related to the management and conservation of forests.

In this study we examine the importance of local-level institutions and land certification on source of fuel wood choices, in order to provide information to policymakers. Our estimation results indicate that active local-level institutions reduce dependency on community forests, but increase the probability of collection from open access areas. However, tenure security does not have impact on household decision to collect fuel wood from private sources. The results from this study provide valuable insight for Ethiopia's current demand-side and supply-side strategies for addressing rural energy problems and halting the unsustainable use and exploitation of those resources. The policy implications, gleaned from the results, are that there is a need to bring additional open access forests under the management of the community and increase local awareness related to the rules associated with forestry management, as well as benefits of improved conservation.

The remainder of the paper is organized in the usual fashion. Section 2 outlines the empirical approach, which is based on the random utility model and its estimation, via the multinomial logit regression. The data and study areas are described in Section 3. Empirical results and a discussion of these results are provided in Section 4, while Section 5 presents concluding remarks.

2. METHODOLOGY

Consider a household choosing between five different possible sources of fuel wood for their energy needs: private (or own sources), community forests, the market, open access forests, or a variety of sources. Households are assumed to select the fuel source option that maximizes their expected utility, and, therefore, the household chooses a fuel source based on

their preferences and other factors associated with their options. For the i^{th} household faced with J choices, utility of choice j can be written as:

$$U_{ij} = X_{ij}\beta_j + \varepsilon_{ij} \quad (1)$$

The preceding structure of household *i*'s utility for choice j is the standard random utility model, where U_{ij} is the utility derived from $j's$ choice of fuel wood source, X_{ij} is a vector of explanatory variables that affect the choice of fuel wood source, $\varepsilon_{ij}$is a disturbance term and β_j is the vector of parameters, coinciding with the variables that are deemed to influence utility for choice *j*. Assuming that choice *j* is the preferred fuel wood source, it is assumed that the random utility associated with choice *j* exceeds the random utility associated with any other choice *h* that is not *j*.

$$U_{ij} > U_{ih}, j \neq h \quad (2)$$

Depending on the distribution of the disturbance terms, various empirical structures can be applied. The analytical model followed here is the multinomial logit regression framework.[34] Therefore, the probability that *j* is chosen is the probability that the random utility of choice *j* exceeds that of all other choices.

$$Pr(U_{ij} > U_{ih}) \forall j \neq h \quad (3)$$

Equation (3) can be further re-arranged, as shown by McFadden (1974).

$$Pr(X_{ij}\beta_j + \varepsilon_{ij} \geq X_{ih}\beta_h + \varepsilon_{ih})$$

$$Pr(\varepsilon_{ih} - \varepsilon_{ij} \leq X_{ij}\beta_j - X_{ih}\beta_h)$$

Let Y_i be the unordered categorical dependent variable that takes on a value of zero or one, for each of the *J* choices. Assuming that$\varepsilon_{ih} - \varepsilon_{ij}$has a logistic distribution, the probability for choice of fuel wood source can be specified as:

[34]Because of the need to evaluate multiple integrals of the normal distribution, the probit model has found rather limited use in this setting (Greene, 2003). The logit model, in contrast, has been widely used in empirical research, due to its relative ease of estimation. However, the one drawback of the model is the assumption used to derive its formulation, that all choices are independent of irrelevant alternatives. However, since the dependent variables do not vary across alternatives, IIA is not a significant problem. It is a much bigger problem in the case of conditional logit models, in which there are choice-specific dependent variables.

$$P_{ij} = \frac{\exp(X_{ij}\beta_j)}{\sum_{h=1}^{J}\exp(X_{ih}\beta_h)} \quad (4)$$

Where $X_{ij}$and X_{ih} are case-specific regressors and $\beta_j$and β_h are vectors of coefficients for each fuel wood source. In this model, the regressors do not vary over choices, such that the model is consistent with a multinomial logit regression. Since, $\sum P_{ij} = 1$, a restriction is needed to ensure model identification. Hence, we set $\beta_J = 0$, so the remaining coefficients can be interpreted with respect to category *J*, the base category. Due to the complex nonlinearity of the multinomial regression model, the estimated coefficients are difficult to interpret. Therefore, interpretation is based upon the marginal effects of the explanatory variables on the probabilities. Marginal effects for the k^{th} variable in *X* are derived as:[35]

$$\delta_{jk} = \frac{\partial P_j}{\partial x_k} = P_j\left[\beta_{jk} - \sum_{h\neq j\in J} P_h\beta_{hk}\right] \quad (5)$$

The marginal effects measure the expected change in the choice probability with respect to a unit change in the requisite explanatory variable. In the case of a binary independent variable, marginal effects are determined by the probability with the binary indicator turned on net of the probability with the binary indicator turned off.[36]

3. DATA SOURCE AND DESCRIPTIVE STATISTICS

3.1. Nature and source of the data

The data for the analysis was collected in 2007 from a sample of rural households in the East Gojam and South Wollo zones of the Amhara region of Ethiopia. This data is part of a longitudinal survey conducted through a collaborative research project between Addis Ababa University and the University of Gothenburg, and financed by the Swedish International Development Cooperation Agency/Swedish Agency for Research Cooperation (Sida/SAREC). The selection of the sites was deliberate, and ensured variation in the characteristics of the sites, including agro-ecology and vegetative cover (Mekonnen, 2009).

[35]For a detailed derivation, see Greene (2003, pp 721-722).
[36] It is possible that the signs of the coefficients and the marginal effects differ, as the latter depends on the signs and the magnitudes of the other coefficients.

Households from each site were then selected randomly.[37] A total of 1760 households from 14 sites were interviewed, as part of the survey.

The data includes information on household characteristics, household perceptions regarding land certification and registration, energy collection and consumption, assets, credit, off-farm activities, the nature and type of forests and other relevant information. More specifically, in this study we have included household characteristics such as the age, the sex and the education level of the household head. We also include family size, household access to credit, land holdings and livestock ownership. Land holdings was originally reported in local units and converted into a standard measure (ha). Similarly, we measure ownership of livestock in terms of tropical livestock units (TLUs). The effect of gender of the household head enables us to examine whether male- or female-headed households are more dependent on private, community, open access or other sources of fuel wood. Access to credit is a dummy variable that refers to whether the household can immediately borrow money from any source (for example, from banks, micro credit institutions, friends, private lenders, etc). It is also clear that efficient use of biomass through improved cook stoves affects the time spent in collection of fuel wood, and, hence, household preferences for different sources of fuel wood. Therefore, a dummy variable denoting ownership of an improved stove is included.

Community surveys were also conducted, which enabled us to use additional information in the empirical analysis. Villagers' perceptions about the use and management of natural resources such as forests, grazing land and water, as well as the use and availability of technologies in local agriculture and land management, the situation regarding infrastructure and services, etc., were gathered during the field survey. This data was then restructured into three community-level variables: a dummy variable for region, allowing us to capture agro-ecological differences; the average distance, in hours, of the kebele (village) from the nearest forest; and a variable indicating the strength of local institutions.

As an indicator of tenure insecurity, a dummy variable, accounting for whether the household has been awarded a land certificate, is included. In addition to the examination of tenure insecurity, we also consider the effect of local level institutions, especially community-level forestry institutions, on fuel wood source choices, using an index constructed from a series of

[37]The sample sites were selected purposively and households from each site were then selected based on simple random sampling technique.

questions related to the household's understanding of the institutions and perceptions of enforcement related to those institutions. Households were asked to rate their perceptions regarding forestry rules and regulations on a five-point scale, which was then averaged to create a household-level index, which is further aggregated across questions and rescaled to remain within the five-point range. Finally, the rescaled index is then categorized as either relatively strong, if the rescaled index is greater than or equal to three, or relatively weak, if the rescaled index is below three.[38] Our expectation is that households, operating within a strong forestry management setting, are constrained in their ability to collect fuel wood from community forests, and, therefore, are forced to make use of other sources. Deininger et al. (2009) used the same data to assess the effects of a low-cost land registration program in Ethiopia, finding that these institutions increased land-related investments. In our analysis, we use the data to determine whether or not the institutions affect the source of fuel wood collection source.

3.2. Descriptive Statistics

The primary interest in this analysis is the location from which households are accessing their fuel wood, which is assumed to be affected by household, community and institutional variables. In the areas in which data were collected, there are a number of different places fuel wood can be gathered or collected. Although the majority of households accessed only one location, there were households that accessed more than one. Therefore, in addition to open access forests, community forests, private forests or market sources, we included multiple sources as a collection option.[39] The source choices, as a proportion of households, are noted in Table 3.1.

Table 3.1: The proportion of households by fuel wood collection source

Source	Mean	SD
Private Forest	0.723	0.45
Community Forest	0.077	0.27
Open Access Forest	0.086	0.26
Market Source	0.073	0.28
Multiple Sources	0.041	0.20

[38]The lists of the questions used for the purposes of creating this index are indicated in Appendix B. The mean values of each index are indicated at both the household and community level.
[39]Primarily, these are households that used two sources, although a small number of households access more than two sources (only 0.2 % of the sampled households).

As can be seen in Table 3.1, the majority of the sampled households (72.3%) collect their fuel wood from private sources, while 7.7% collect from community forests and 7.3% of the collect from open access (OA) areas. Furthermore, some households satisfy their fuel wood demand from the market (8.6%). As should be expected, most of the households buying fuel wood from the market are those without land or with land holdings too small to both plant trees and grow crops for their livelihood (see Table 3.2, below).

Table 3.2: Summary of Descriptive Statistics of Variables by sources of fuel wood

	PRIVATE (N=1117)		COMM (N=119)		MARKET (N=113)		OA (N=133)		MULTIPLE SOURCE (N=63)	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age of HH Head	52.43	14.46	50.36	15.84	43.35	12.44	50.57	16.17	50.06	14.16
Sex of HH Head (1 if male, 0 if female)	0.84	0.37	0.79	0.41	0.71	0.46	0.73	0.45	0.87	0.34
Education of HH Head(1 if the head has attended any kind of education, 0 otherwise)	0.50	0.50	0.41	0.49	0.56	0.50	0.35	0.48	0.44	0.50
Family Size	6.75	2.37	6.45	2.67	5.49	2.46	6.29	2.40	7.13	2.29
Access to Credit	0.86	0.35	0.91	0.29	0.88	0.32	0.88	0.33	0.87	0.34
Landholdings (HA)	1.35	0.91	1.64	1.19	0.82	0.59	1.04	0.63	1.60	1.20
Distance from town (in hours)	1.21	0.88	1.18	0.70	0.93	1.08	1.64	0.95	1.31	0.83
Uses Improved Biomass Cookstove	0.80	0.40	0.82	0.39	0.81	0.39	0.68	0.47	0.67	0.48
Livestock owned in TLU	4.12	3.04	3.77	2.90	1.86	2.31	3.03	2.69	3.98	3.07
Dummy variable if a HH posses land certificate for his holding, 0 otherwise	0.82	0.39	0.80	0.40	0.67	0.47	0.67	0.47	0.87	0.34
Dummy variable for region (1 if East Gojam, 0 if south Wollo)	0.44	0.50	0.78	0.41	0.48	0.50	0.53	0.50	0.60	0.49
Average distance of forest in hours	2.44	2.18	2.10	1.94	2.67	2.23	2.84	1.94	2.07	1.74
Dummy variable for institutions(1 if it is relatively strong, and 0 if it is weak	0.54	0.50	0.25	0.44	0.61	0.49	0.56	0.50	0.49	0.50

The remaining summary statistics, as well as definitions of independent variables, for the participating households are presented in Table 3.2, by source of fuel wood. Summary statistics that are not separated by source are available in Table 3.3. From table 3.2, it can be inferred that the characteristics of the independent variables vary by collection source. However, given the relative closeness of the means and the size of the standard deviations, across collection source, the calculated means lie reasonably comfortably within two standard deviations of each other.[40] Descriptively, the largest means for the analysis variables are observed within the private source collection group for the age of the household head. For community forest source, the largest analysis variable means are observed for households with access to credit, landholdings and households using improved biomass cook stoves, while the lowest mean is observed for the community forest institutional index. For market purchases of fuel wood, the largest means for the analysis variables are observed for the education of the household head, while the lowest means are observed for the sex of the household head, the size of the family, landholdings, distance to town, livestock ownership, and land certification. The largest analysis variable means are observed for households accessing open forests, for distance to town and for distance from the nearest forest, while the smallest means are observed for the education of the household head and land certification. Finally, within the multiple sources group, the largest means are observed for the gender of the household head, the size of the family and land certification, while the lowest means are observed for the use of an improved biomass cookstove and for the distance from the community forest.

[40]For that reason, it was not deemed necessary to separately test differences in means across the groups. It is, however, possible to test for differences in means, either group by group, or through the application of analysis of variance methods. One-way analysis of variance (ANOVA) is usedto determine whether there are any significant differences between the means of three or more independent (unrelated) groups.Overall there is sufficient evidence that the mean values of most of the explanatory variables are statistically different across the sources of fuel wood (see Appendix C).

Table 3.3. Summary of Descriptive Statistics (N=1545)

Variable Description	Mean	S.D.	Min	Max
Household characteristics				
AGEHH Head	51.35	14.75	15.00	97.00
SEXHH Head	0.82	0.38	0.00	1.00
Education of HH Head	0.48	0.50	0.00	1.00
Family Size	6.61	2.42	1.00	20.00
Acess to Credit	0.87	0.34	0.00	1.00
Landholdings(ha)	1.32	0.93	0.04	6.72
Distance from town (in hours)	1.23	0.90	0.00	4.67
Uses Improved Biomass Cookstove	0.78	0.41	0.00	1.00
Livestock owned in TLU	3.83	3.02	0.00	31.59
Dummy variable if a HH posses land certificate for his holding, 0 otherwise *	0.80	0.40	0.00	1.00
Community characteristics				
Dummy variable for region (1 if East Gojam, 0 if south Wollo)*	0.48	0.50	0.00	1.00
Average distance of forest in hours	2.45	2.13	0.74	9.85
Dummy variable for institutions	0.52	0.50	0.00	1.00

4. RESULTS OF ECONOMETRIC ANALYSIS

The main purpose of the analysis is to provide insights into demand-side effects, as measured by the choice of fuel wood source, of land tenure security and community forestry management institutions, and this was undertaken via multinomial logit regression. The empirical estimation enables us to understand the effects of these variables on household's substitution patterns amongst the various fuel wood sources. The results of the regression are presented in Tables 3.4 and 3.5. Since the estimated coefficients are difficult to interpret, marginal effects are discussed, rather than the parameter estimates.[41]

As noted earlier, Mekonnen (2009) and Deininger et al. (2009) examine the relationship between tenure insecurity and long-term investments in private trees and land, respectively. However, no studies have, yet, considered the impact of insecurity on forest use. Although we expect that greater security will improve land management, as has been previously shown in the literature, it is not obvious that improved management has, yet, led to reduced demand for open access forest products, or increased use of privately owned forests. Our measure of security is based on household answers to a survey question regarding whether or not they

[41]The base category in the regression is private sources of fuel wood, and the results are not sensitive to the choice of base category.

had a certificate for their land. Contrary to our expectation, tenure security is not a significant determinant, in terms of marginal effects, on the use of private sources (although the sign is positive), community sources or the market (although the signs for the latter two are both negative). However, there is evidence that land certification does reduce demand pressures on open access forests – the marginal effect estimate is -3.7% and significant at the 10% level – and does raise the probability that households make use of multiple sources – the marginal effect estimate is 2.3% and is significant at the 5% level.[42] One possible explanation for the limited effect observed in this analysis is that private sources require an initial and sustained investment in forests that has not, yet, led to significantly increased stocks that can be used by households. A less positive explanation, though, is also plausible: security has not impacted investments in private forests enough to alleviate the demand for open forest products for reasons that cannot be observed in this analysis. For example, high levels of poverty could be associated with high discount rates (not available in the study), and high discount rates would lead to low levels of investment. However, given Mekonnen's and Deininger et al.'s findings, the latter explanation is less likely. Regardless, additional empirical research on the role of land certification, farmers' long-term investment decisions and household demand for forest products, by source, may be required to supplement these findings.

Our results also support the hypothesis that stronger community forestry institutions reduce demand-pressures on community forests (-5.7%), while increasing pressure on, especially, open access forests (4.7%) and multiple sources (1.9%). However strong institutions are not significant determinants, in terms of marginal effects, of either private forest use or market purchases of fuel wood. In terms of policy, the unintended consequences of expansion of community forests, in tandem with strong local-level institutional control, will not help reduce the depletion and degradation of forests and forest products, because it diverts households away from community forests, which can be properly managed, towards open access forests. A caveat, however, is necessary. If all open access forests are turned into community forests, and those community forests are properly managed, our results imply that it is possible that forest degradation can be alleviated.

[42]The land certification coefficient estimate for open access sources is negative and significant at the 5% level, and for multiple fuel wood sources is positive and significant at the 10.5% level.

Table 3.4: Parameter Estimates from Multinomial Logit of choice of fuel wood source

Variables	Community	Market	O.A.	Multiple Source
AGE of HH head	-0.007	-0.034***	-0.012*	-0.018*
	(0.01)	(0.01)	(0.01)	(0.01)
SEX of HH head	-0.235	-0.211	-0.285	0.330
	(0.28)	(0.28)	(0.24)	(0.42)
Education of HH head	-0.342	0.233	-0.674***	-0.445
	(0.22)	(0.24)	(0.21)	(0.28)
Family size	-0.050	-0.039	0.057	0.088
	(0.05)	(0.05)	(0.05)	(0.06)
Access to Credit	0.769**	0.167	0.291	0.016
	(0.34)	(0.34)	(0.30)	(0.41)
Landholdings (ha)	0.029	-0.856***	-0.381**	0.165
	(0.12)	(0.24)	(0.17)	(0.16)
Distance to town (in hours)	-0.274**	-0.509***	0.514***	0.151
	(0.13)	(0.15)	(0.12)	(0.17)
Uses Improved Biomass Cook Stove	-0.111	-0.092	-0.754***	-0.836***
	(0.26)	(0.27)	(0.21)	(0.29)
Livestock owned in TLU	-0.059	-0.333***	-0.126***	-0.105*
	(0.04)	(0.06)	(0.05)	(0.05)
Dummy variable if a HH possess Land certificate for his holdings, o otherwise	-0.101	-0.082	-0.499**	0.740
	(0.33)	(0.29)	(0.25)	(0.46)
Dummy variable for region (1 if East Gojam, 0 if South Wollo)	1.249***	1.117***	0.478*	1.058***
	(0.32)	(0.32)	(0.27)	(0.38)
Average distance of forest in hours	-0.084	0.097*	0.040	-0.064
	(0.07)	(0.06)	(0.06)	(0.09)
Dummy variable for local institutions	-0.853***	0.286	0.716***	0.550
	(0.30)	(0.31)	(0.27)	(0.35)
_cons	-1.411*	1.027	-1.252*	-3.355***
	(0.84)	(0.81)	(0.70)	(1.05)

Table 3.5: The Marginal Effects from Multinomial Logit of choice of fuel wood source

Variable	Private	Community	Market	Open Access	Multiple
AGE of HH head	0.003***	-0.000	-0.001***	-0.001	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SEX of HH head*	0.027	-0.013	-0.007	-0.019	0.012
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Education of HH head*	0.060***	-0.016	0.011	-0.041***	-0.014
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Family Size	-0.002	-0.003	-0.001	0.004	0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Access to Credit*	-0.051*	0.034***	0.004	0.014	-0.002
	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
Land Holdings (ha)	0.039***	0.005	-0.029***	-0.023**	0.008
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Distance to town (in hours)	-0.005	-0.017**	-0.018***	0.035***	0.005
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Uses Improved Biomass Cook Stove*	0.086***	0.000	0.001	-0.053***	-0.034**
	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)
Livestock owned in TLU	0.022***	-0.002	-0.011***	-0.007**	-0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Dummy variable if a HH possess Land certificate for his holdings, o otherwise *	0.021	-0.005	-0.002	-0.037*	0.023**
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Dummy variable for region (1 if East Gojam, 0 if South Wollo)*	-0.154***	0.068***	0.034***	0.019	0.033**
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Average distance of forest in hours	0.001	-0.005	0.003*	0.003	-0.002
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Dummy variable for local institutions *	-0.019	-0.057***	0.009	0.047***	0.019
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)

(*) dy/dx is for discrete change of dummy variable from 0 to 1.

Using the correlation matrix and the VIF (found to be less than 5), we found no severe multicollinearity problem.

The remainder of the estimation results examine other potential determinants of fuel source choices, such as those related to various demographic, socioeconomic and environmental factors. Household demographic and socioeconomic characteristics, such as the age, the gender, and the education of the household head, affect the choice of fuel wood source differently. The age and education of the household head significantly raise the probability of fuel wood collection from private sources, but education significantly reduces the probability of collecting fuel wood from open access forests – reducing the probability of collecting from OA areas by 4.1%. Possibly, educated household heads are more aware of the importance of forest conservation and its use in maintaining soil fertility and mitigating against climate change. Household head age and gender reduces the probability of fuel wood purchases from the market, though the latter is not significant, while gender does not significantly determine the choice of fuel wood source. Contrary to Jumbe and Angelsen (2006), household size, in our analysis, has no significant influence on the choice of fuel wood source.

Household economic indicators were also included in the analysis. Household assets affect production capabilities and preferences, and most studies of this nature include some measure of household wealth, such as landholdings (Edmunds, 2002) and livestock ownership. We chose to include two additional measures: credit opportunities (whether the household can immediately borrow money from any source) and the use of improved biomass cook stoves. Regardless of the measure of wealth used in the various studies, each finds that most poor households cannot afford to buy fuel wood from market. Poverty, especially related to total land under control, implies that poor households do not have enough land to enable them to plant trees. Therefore, we expect poor households to depend more on forests owned by government (*de facto* open access) or community forests in order to satisfy their energy demands. Our results show that a one-unit (hectare) increase in land holdings reduces the probability of fuel wood collection from open access forests and the market by 3.4% and 2.9%, respectively. On the other hand, also as expected, a one-unit increase in land holdings significantly raises the probability of fuel wood collection from private sources by 3.9%. Heltberg et al. (2000) draw similar conclusions in their analysis conducted in India – larger landowners collect less fuel wood from the commons and produce more fuel wood privately. Similarly, Cooke et al. (2008) argued that households with little or no land are less able to produce fuel wood themselves. With respect to livestock ownership, the direction of the wealth effect was generally the same as that for land, although the magnitudes were generally

lower.[43]Specifically, a one-unit (TLU) increase in livestock ownership was associated with a significant increase in the probability of collecting fuel wood from private sources (2.2%), but was associated with a significant reduction in the probability of collecting fuel wood from open access forests (-0.7%) and a reduction in the probability of market purchases (-1.1%). Improved cook stoves provide qualitatively similar results to both land holdings and livestock ownership. Ownership of these stoves is associated with an increased probability of privately sourced fuel (8.6%), and is associated with a reduced probability of openly sourced fuel (5.3%). Credit opportunities, on the other hand, do not have the same effect as other sources of wealth, possibly because they signal a current wealth shortage, although they might also signal borrowing for investment purposes. We find that credit access reduces the probability of using private sources by 5.1%, but raises the probability of accessing community forests for fuel wood by 3.4%.

In addition to the preceding set of variables, a number of location-specific variables, such as the household's distance to the nearest town and distance to the nearest forest, as well as a region-specific dummy variable were also included in the analysis. As most markets are located in or near towns, it is not surprising that the distance to town reduces the probability of fuel wood purchase from the market by 1.8% per unit.[44] Similarly, households located farther from town have a lower probability of collecting fuel wood from community forests (1.7% per unit). We also find that the distance from town raises the probability of fuel collection from open access forests by 3.5% per unit. On the other hand, the household's distance from the nearest forest significantly increases the probability of purchases from the market, although by an economically miniscule 0.3% per unit; however the distance from the forest does not have any significant effect on other sources of fuel wood collection. Overall, these results provide little evidence in support of other studies (e.g, Heltberg et al., 2000) that people tend to substitute fuel wood from forests with private fuels as distance to forest increases. In terms of the regional coefficient, it was significantly related to all sources, other than open access forests. We find that households in East Gojam are less dependent on private sources (15.4%), but more dependent on community forests (6.8%), market purchases (3.4%) and multiple sources (3.3%), compared to households in the South Wollo regions.

[43]Magnitudes are, unfortunately, relative, as hectares and tropical livestock units are not directly comparable.
[44]Note that distance to town is measured in terms of walking distance (in hours) from the household's residence to the nearest town.

5. CONCLUSION

In this paper we have examined the determinants of rural households' preferences for source of fuel wood using a discrete choice model, multinomial logit regression, developed within the context of random utility. The model has been employed to examine whether socioeconomic and environmental factors affect rural Ethiopian household choices, with a specific emphasis on institutional factors related to the community forestry program that is available in the region. The analysis was undertaken using data collected from the East Gojam and South Wollo zones of the Amhara region of Ethiopia.

The primary purpose of the analysis was to consider the importance of local-level institutions and land certification on these choices, in order to provide some information to policymakers, since the current government of Ethiopia and other organizations working on natural resource conservation are promoting the transfer of forests to the local people. In terms of the analysis, institutions do play a role in household choices. Better institutions are associated with a reduced probability of collecting fuel wood from community forests, primarily for those households that are not part of the community forestry management programme, while raising the probability of collecting fuel wood from open access forests and collecting from multiple sources. With respect to policy, the results are positive, in the sense that the demand for community forest resources appears to be lowered by community forestry institutions, the results are also negative, in the sense that the demand for open access forest resources rises, in the face of better community forestry institutions. In other words, there is a need to bring additional open access forests under the management of the community and increase local awareness regarding the use and rules associated with forestry management.

Land certification, on the other hand, is associated with reduced collection probabilities in open access forests and increased collection probabilities for multiple sources for fuel wood collection. However, although the literature (Deininger et al., 2009; Holden et al., 2009) suggests that land certification is responsible for increased investment in the land's productivity, through better soil conservation and planting of trees, our results suggest that these investments have, as yet, not resulted in significantly increased use of private forests for fuel wood. The lack of significance is likely due to a long investment lag – it is unlikely that trees planted within the last few years have grown big enough for harvest – however, in terms of policy, the reduced probability of collecting from open access forests is a positive result,

suggesting that land certification should be furthered. Additional empirical research on the role of land certification, as well as farmers' investment and use decisions may be required to supplement these findings.

A number of additional implications can be developed from the analysis. Firstly, the results suggest that household characteristics, such as: age, gender, and the education of the household head affect the choice of fuel wood source differently. For example, education is negatively correlated with the probability of fuel wood collection from open access forests, suggesting that improving education could lead to improved forest conservation by reducing the demand for fuel and other forest products from open access areas. This also implies education makes collection of fuel wood from open access areas unprofitable and hence households substitute fuel wood from open access areas by private sources. The current extension system in Ethiopia may have a role to play in this regard, if the extension system can undertake useful education interventions related to forest management and conservation.

Secondly, the choice of fuel wood source also varies between regions, depending on agro-ecological factors, suggesting that there is a need to consider regional variation when examining household choices. Thirdly, households with large landholdings and greater livestock ownership are more likely to collect fuel wood from their own private sources and are less likely to collect from either open access forests or purchase from the market. Regarding policy, interventions related to forest conservation, especially in open access areas, would be more likely to succeed, if the interventions are capable of targeting the poorer households in the region.

Finally, distance matters, particularly with respect to market purchase of fuel wood. The probability of market purchase is increased when the forest is farther away, and when households are closer to town, suggesting that people will depend more on the market as forests become more inaccessible. We have little evidence to argue that households tend to substitute fuel wood from forests with private fuels, as forest becomes inaccessible. Similarly, the probability of collection from open access areas is increased for households located farther away from town. Therefore, policies designed to increase the supply of fuel wood, or at least increase access to fuel wood – e.g. through improved transportation networks – will help reduce fuel wood expenditures and environmental pressures on open access forests.

The results from this study can provide valuable insight for Ethiopia's current demand-side and supply-side strategies for addressing rural energy problems, especially policies related to forests and forest resource conservation, as well as halting, and hopefully reversing, the unsustainable use and exploitation of those resources. Future studies in this area are necessary, and can provide further information related to the long-term effect of land tenure security (land certification) on farmers' investment decisions, and the implication of these decisions on rural energy demand and forest degradation in the region. Although this study provides a number of meaningful insights with respect to forestry conservation and management, focusing on an application to rural Ethiopian households, it is likely that the results and policy implications can be generalized to other developing regions. Importantly, many developing regions have similar forestry structures, in that forests are owned by the government, and suffer from many of the same problems, such as forest degradation that is continuing (or even accelerating) on a pace that is likely to be unsustainable. Therefore, even though the analysis focuses on a very specific region of one country, the similarity of structures and problems suggests that there is scope for developing or extending these policies in other similar countries.