Property Rights, Institutions and Source of Fuel Wood in Rural Ethiopia

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Abstract

This study examines the relationship between property rights, defined by land tenure security and 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 increase household dependency on open access forests, while land security reduces open access forest dependence. However, local-level institutions are found to reduce the role of private fuel wood sources, while tenure security has not, at least yet, had any impact on private fuel wood source collection activities. 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.

Key words *property rights, institutions, fuel wood, rural, Ethiopia*

1 Introduction

As in 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.[1] 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

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[1] 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.

not be that surprising.[2] There is *de facto* open access to all forests, which is expected to aggravate the degradation and deforestation problems in the country.[3] 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.[4] The provision of seedlings is one of the supply-side strategies adopted by the current government to reduce the pressure on forests and minimize the problem of land degradation, while the granting of certificates harnesses both demand-side and supply-side 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 MoARD 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

[2] Mekonnen and Bluffstone (2007) note that the regulation incentive is particularly low in Ethiopia, because forests produce goods used mainly by local villagers.

[3] 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.

[4] 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).

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.[5]

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, concluding 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, 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 increase the probability of collection from open access areas, but reduce collection from private sources. However, although tenure security does reduce the demand for open access fuel wood, tenure security does not impact household decisions 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 main policy implication, gleaned from the results, is 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.

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

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 household i faced with J choices, utility of choice $j \in J$ can be written as:

$$U_{ij} = X_i\beta_j + \varepsilon_{ij} \tag{1}$$

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 the choice, X_i is a vector of explanatory variables that affect the choice of fuel wood source, ε_{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.

$$U_{ij} > U_{ih}, j \neq h \tag{2}$$

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.[6] Therefore, the probability that j is chosen is the probability that the random utility of choice j exceeds that of all other choices.

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

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

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

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

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:

$$P_{ij} = \frac{\exp(X_i\beta_j)}{\sum_{h=1}^{j} \exp(X_i\beta_h)} \tag{4}$$

Where X_i are individual-specific regressors and β_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. In this analysis, that category is private fuel wood. Due to the complex nonlinearity of the multinomial regression model, the estimated coefficients are difficult

[6] 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 (IIA). 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. Hausman tests for IIA were considered for each of the reported multinomial logit regressions. The underlying condition of the test, that the variance matrix is positive semi-definite, however, was violated. In other words, IIA is not testable, and, therefore, we report our results under the assumption that IIA is not a problem in the analysis.

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:[7]

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

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.[8]

3 Data source and descriptive statistics

3.1 Nature and source of the data

The data for the analysis were collected in 2007 from a sample of rural households in the East Gojam and South Wollo zones of the Amhara region of Ethiopia. The data are 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). Households from each site were then selected randomly.[9] 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.

[7] For a detailed derivation, see Greene (2003, pp 721-722).

[8] 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.

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

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. A number of different measures were used in the analysis in order to examine robustness. Households were asked to rate their perceptions regarding forestry rules and regulations to four different statements on a five-point scale. Institutional response A refers to any system that might be in place to control fuel wood collection from communal lands. Institutional response B refers to limitations that might be placed on fuel wood collected from communal lands. Institutional response C concerns whether or not kebele officials follow the people and products being removed from communal lands. Finally, institutional response D is concerned with penalty structures that might be in place for dealing with collection beyond quotas. Using these responses, categorical dummy variables related to perceptions – strongly disagree, disagree, neutral, agree and strongly agree – were created. Each response was considered in the analysis, although only two are reported here; see Footnote 12. In addition, an index was constructed from this series of questions. The responses were aggregated, allowing us to create an average response, as well as an index. The index is based on a categorization of the average, either relatively strong, if the average is greater than or equal to three, or relatively weak, if the average is below three.[10] 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 choice of fuel wood collection source.

3.2 Descriptive statistics

The primary interest in this analysis is the choice of location from which households are accessing their fuel wood, i.e., the determinants of collection source choices. Although household-level variables are assumed to influence the choice, the analysis focuses on tenure security and institutions related to community forestry management, to determine whether these policies and institutions have affected collection activities at the household level. Similarly, the analysis provides some insight related to substitution patterns between fuel wood collection sources. 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.[11] The source choices, as a proportion of households, are noted in Table 1. The majority of the households (72.3%) collect their fuel wood from private sources, while 7.7% of the sampled households collect from community forests and 8.6% of the sampled households collect from open access (OA) areas. Furthermore, some households satisfy their fuel wood demand from the market (7.3%). As should be expected, most of the households buying fuel wood from the market are those with minimal land holdings, as those households are unable to both plant trees and grow crops for their livelihood (see Table 2).

The remaining summary statistics for the participating households are presented in Table 2, by source of fuel wood. Household-level variables include the age (in its natural log) of the household head, a dummy variable capturing whether or not the household head had received any formal education, another dummy variable capturing the sex of the household head, and a measure of the size of the household (also in its natural log). In addition to household-level variables, institutional

[10] Principal Components Analysis was also considered; however, due to the fact that there are only four different questions, it was determined that separate categorical variables could be accommodated, instead.

[11] 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).

variables and land certification, a number of wealth and forestry or market access variables were included. Wealth variables include a dummy for immediate access to credit (through financial institutions or friends), a dummy capturing whether or not the household was using an improved biomass cook stove, the size of the household's land holdings (in the natural log, measured by hectares), and livestock ownership (also in its natural log, measured in tropical livestock units). Access variables include the household's distance from the community forest (in its natural log, measured in walking time) and the household's distance from the nearest town (also in its natural log, measured in walking time). From Table 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. 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 used to 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 Table A1).

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. The analysis was undertaken via multinomial logit regression. As there are a number of potential measures of institutions, a series of similar empirical specifications were considered, differing only by institutional measure. Table 3 contains the land security marginal effects from those specifications, while Table 4 contains the institutional marginal effects from each of the five specifications. Finally, Table 5 contains the marginal effects related to the other variables included in the analysis for only one of the models, as the remaining model results were qualitatively similar. Complete marginal effects estimates from the multinomial logit models are presented in Appendix Tables B1 through B5.

4.1 Land certification

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 considered the impact of security on forest use. Although we expect that greater security will improve land management, as has been shown previously in the literature, it is not obvious that improved management has led to reduced demand for open access forest products, or increased use of privately owned forests. In the reported analysis, security is based on whether the household reports having a certificate for its land. The natural log of landholdings is also included in the analysis to control for the availability of private forests.

Contrary to our expectation, tenure security does not have a significant impact on the household's demand for fuel wood from its own sources. One possible explanation for the observed limited effect 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. 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 (2009) and Deininger et al.'s (2009) findings, this 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.

The certification results also support a less stringent hypothesis. It may, instead, be the case that land certification has not impacted investments enough to allow households to rely solely on their own sources. According to the results in Table 3, tenure security does increase the probability that households make use of multiple fuel wood sources, with the estimated marginal effect ranging from 2.4% to 3.0%. Although land security has not had a massive impact on the demand for fuel wood from private sources, it has had a significant and beneficial impact on the demand for fuel wood from open access forests, a benefit that is especially positive in terms of forest degradation. According to this analysis, tenure security significantly reduces demand pressures placed on open access forests. The estimated land security marginal effect ranges from -4.0% to -5.4%, depending upon which institutional measure is included in the analysis.

The size of the household's farm or plantation is also an important determinant of the household's fuel wood choice. Larger landholdings are found to increase significantly the probability that fuel wood is collected from private sources, while reducing the probability that fuel wood is either purchased from the market or collected from open access forests. Due to the fact that landholdings are included in their natural log, the marginal effects can be interpreted as elasticities, although the resulting elasticities are rather small. In this analysis, doubling land holdings results in a 4.5% to 6.7% increase in the probability of private source collection. On the other hand, a 100% increase in land holdings results in, approximately, a 2.5% reduction in fuel wood market participation, and a 3.6% to 4.7% reduction in the probability of open access collection activities. 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) argue that households with little or no land are less able to produce fuel wood themselves.

4.2 Community forestry institutions

As noted previously, survey participants were asked their views on four separate community forestry institutions. The analysis focuses on responses related to whether or not there was a system in place for controlling fuel wood collection from communal areas (institutional response A) and whether or not there was a penalty system in place for dealing with individuals that collected too much fuel wood from communal areas (institutional response D).[12] Respondents were asked to state whether they strongly disagreed, disagreed, were neutral, agreed or strongly agreed with the statement, and categorical variables related to the strength of agreement or disagreement were included in the analysis. In addition, an average across each of the four responses, see footnote 12, as well as a dummy variable for an average that exceeded three, were considered for purposes of robustness.

Although our results are not uniform across analyses, some generalizations are possible. If the respondent feels that institutions are relatively stronger – the respondent does not strongly disagree with the statement, the average response is higher or the average response leans towards agreement – the probability that the household collects from its own sources is lowered. For example, in Model III, Institutional Response A, a neutral response is associated with a 20% reduction in the probability of collection from own sources, while strong agreement is associated with a 12% reduction. On the other hand, market participation probabilities are generally higher for both the average institute and the institutional dummy, but not related to specific institutional responses. Furthermore, relatively stronger institutions are associated with increased probabilities of collection activities within open access forests. Finally, there is some evidence that stronger institutions reduce the probability that households make use of multiple sources.

The effect of institutions on community forest collection activities is the most difficult to generalize. Neutral responses with respect to institutional response A and institutional response D are associated with increased probabilities of community forest collection participation, and the mar-

[12] We also considered responses related to whether or not the amount of fuel wood collected from communal lands was limited and whether or not kebele officials followed individuals removing forest products from communal lands. These analyses, which are not presented, but are available upon request, find no significant institutional effects.

ginal effect is approximately 10% in both cases. However, when including institutions A and D simultaneously, neutral responses and agreements to institution D are associated with a 7.1% and 12.1%, respectively, increase in the probability of community forest collection, while agreement with institution A is associated with a 3.8% decrease in community forest collection probabilities.

In terms of expectations, the preceding results contain a few surprises. The creation of community forests is expected to create insiders and outsiders, those with access to the community forests and those without. Therefore, it is not surprising to find substitution between community forests and other fuel wood options, and it is not surprising that stronger institutions lead to increased substitution. In that sense, the increased reliance on open access forests and fuel wood markets was expected. The surprise arises from the result that institutional strength is associated with (a) reduced collection from own and multiple sources and (b) increased collection from community sources. In other words, the results support the hypothesis that institutions create substitution away from private sources, rather than from community sources. In terms of policy, the unintended consequences of an 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.

4.3 Other determinants of fuel wood collection source

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.[13] 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 of the household head increases the probability that the household collects from own sources (doubling the age raises the probability by 16.1%), and lowers the probability that households make use of either the market or multiple collection sources (doubling the age lowers each of these probabilities by approximately 4.3%). The education of the household head also raises the probability that households collect from their own sources (by 8.5%), while lowering the probability that households collect from open access forests (by 3.7%). Possibly, educated household heads are more aware of the importance of forest conservation and its use in maintaining soil fertility and mitigating climate change effects. Contrary to Jumbe and Angelsen (2006), household size in our analysis has only positive impacts on the probability of collection from multiple sources, probably because larger households find it easier to take advantage of more collection opportunities.

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), discussed above, and livestock ownership. In addition to these measures, 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 previous studies, each finds that most poor households cannot afford to buy fuel wood from the market. Therefore, we expect poor households to depend more on forests owned by government (*de facto* open access) in order to satisfy their energy demands. With respect to livestock ownership, the wealth effect was generally as expected. Specifically, a 100% (TLU) increase in livestock ownership is associated with a significant increase in the probability of collecting fuel wood from private sources (5.1%), but was associated with a significant reduction in the probability of collecting fuel wood from open access forests and multiple sources (1.5%) and a reduction in the probability of market purchases (1.3%). Improved cook stoves provide qualitatively similar results to livestock ownership. Ownership of these stoves is associated

[13] The marginal effects for each of the remaining models are available in Appendix Tables B1 through B5.

with an increased probability of privately sourced fuel (10.0%), but is associated with a reduced probability of openly sourced fuel (5.3%) and multiple sources of fuel wood (4.2%). 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 7.4%, but raises the probability of accessing community forests for fuel wood by 6.0%.

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 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; a doubling of the distance reduces the probability by 1.2%.[14] Similarly, households located farther from town have a lower probability of collecting fuel wood from community forests (1.9% per 100% increase). We also find that the distance from town raises the probability of fuel collection from open access forests; doubling the distance increases the probability by 4.0%. Surprisingly, the household's distance from the nearest forest has no impact on fuel wood source. 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 forests increase. In terms of the regional effect, 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 (11.9%), but more dependent on community forests (7.4%), market purchases (2.9%) and multiple sources (2.4%), compared to households in the South Wollo region.

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 land security and 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 land and forests to local people. In terms of the analysis, institutions do play a role in household choices, although not completely as expected. Better institutions are associated with a reduced probability of collecting fuel wood from private sources and multiple sources, while raising the probability of collecting fuel wood from open access forests and community forests. With respect to policy, the results are positive, in the sense that community forestry use is increased under stronger institutions. Unfortunately, the results are also negative, in the sense that the demand for open access forest resources also increases, 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. However, additional research is needed to provide better understanding of the impact of improved community forestry institutions on private source fuel wood collection.

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

[14] Note that distance to town is measured in terms of walking distance (in hours) from the household's residence to the nearest town.

certification is responsible for increased investment in the land's productivity, through better soil conservation and the 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, especially in terms of understanding the impact of certification on private forestry use.

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. 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. The probability of market purchase is increased when households are closer to town, suggesting that people will depend more on the market as communities become more accessible. 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 town – 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.

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Table 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	0.073	0.26
Market Source	0.086	0.28
Multiple Sources	0.041	0.20

Table 2. Descriptive Statistics by Fuel Wood Collection Source

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age hh head)	3.9183	3.8490	3.7369	3.8745	3.8373
	(0.0105)	(0.0309)	(0.0392)	(0.0340)	(0.0419)
Male hh head	0.8650	0.8190	0.8113	0.8105	0.8846
	(0.0127)	(0.0378)	(0.0543)	(0.0404)	(0.0447)
Educhh head	0.5014	0.4286	0.4151	0.3579	0.4808
	(0.0186)	(0.0485)	(0.0683)	(0.0494)	(0.0700)
ln(hh size)	1.8768	1.8238	1.6850	1.8169	1.9547
	(0.0136)	(0.0410)	(0.0598)	(0.0448)	(0.0422)
Credit Access	0.8512	0.9238	0.8868	0.8632	0.9038
	(0.0132)	(0.0260)	(0.0439)	(0.0354)	(0.0413)
New Stove	0.7934	0.8000	0.7925	0.6421	0.6346
	(0.0150)	(0.0392)	(0.0562)	(0.0494)	(0.0674)
Land Certificate	0.7755	0.8000	0.5849	0.5895	0.8462
	(0.0155)	(0.0392)	(0.0683)	(0.0507)	(0.0505)
East Gojam	0.6074	0.7810	0.7547	0.6000	0.7115
	(0.0181)	(0.0406)	(0.0597)	(0.0505)	(0.0634)
InstAvg>=3	0.3471	0.2381	0.4151	0.4737	0.4231
	(0.0177)	(0.0418)	(0.0683)	(0.0515)	(0.0692)
Institution A	2.5758	2.5714	3.2642	3.1895	2.5000
	(0.0597)	(0.1500)	(0.2089)	(0.1579)	(0.2338)
Institution B	3.8251	3.7524	4.1321	3.7895	4.0192
	(0.0499)	(0.1324)	(0.1661)	(0.1379)	(0.1912)
Institution C	2.7176	2.8095	2.8679	2.9474	2.6923
	(0.0553)	(0.1361)	(0.1925)	(0.1600)	(0.2065)
Institution D	2.5344	2.8000	3.0189	3.2000	2.6154
	(0.0594)	(0.1473)	(0.2262)	(0.1643)	(0.2365)
Inst Average	2.9132	2.9833	3.3208	3.2816	2.9567
	(0.0387)	(0.1026)	(0.1418)	(0.1221)	(0.1501)
ln(ha)	0.2556	0.2923	-0.2009	-0.0591	0.3062
	(0.0230)	(0.0677)	(0.0778)	(0.0618)	(0.0935)
ln(TLU)	1.2344	1.0735	0.2947	0.7610	1.0070
	(0.0377)	(0.1020)	(0.2148)	(0.1405)	(0.1501)
ln(dist to town)	0.0492	-0.0046	-0.1697	0.3707	0.1262
	(0.0334)	(0.0683)	(0.1510)	(0.0798)	(0.1134)
ln(dist to forest)	0.6191	0.5149	0.7922	0.8294	0.5664
	(0.0293)	(0.0587)	(0.1126)	(0.0633)	(0.0838)
Observations	726	105	53	95	52

Source: Data collected in Amhara Region of Ethiopia. Standard Errors in Parantheses.

Table 3. Land Certification Marginal Effects

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
Model I - Dummy for Institutional Average					
Land Certificate	0.0006	0.0273	-0.0008	-0.0542**	0.0271*
	(0.0376)	(0.0240)	(0.0111)	(0.0257)	(0.0139)
ln(hectares)	0.0577**	0.0066	-0.0260***	-0.0434***	0.0052
	(0.0260)	(0.0186)	(0.0083)	(0.0139)	(0.0121)
Model II - Institutional Average					
Land Certificate	-0.0119	0.0318	0.0003	-0.0498**	0.0295**
	(0.0370)	(0.0236)	(0.0107)	(0.0248)	(0.0136)
ln(hectares)	0.0561**	0.0066	-0.0259***	-0.0418***	0.0051
	(0.0259)	(0.0187)	(0.0081)	(0.0136)	(0.0122)
Model III - Institution Response A					
Land Certificate	-0.0136	0.0319	-0.0017	-0.0435*	0.0269**
	(0.0352)	(0.0226)	(0.0118)	(0.0228)	(0.0130)
ln(hectares)	0.0447*	0.0083	-0.0223***	-0.0363***	0.0056
	(0.0252)	(0.0182)	(0.0085)	(0.0131)	(0.0115)
Model IV - Institution Response D					
Land Certificate	-0.0178	0.0398*	-0.0053	-0.0420*	0.0254**
	(0.0357)	(0.0216)	(0.0123)	(0.0238)	(0.0125)
ln(hectares)	0.0669***	0.0044	-0.0282***	-0.0467***	0.0037
	(0.0255)	(0.0183)	(0.0085)	(0.0137)	(0.0110)
Model V - Institution Response A and D					
Land Certificate	-0.0176	0.0342	-0.0014	-0.0397*	0.0244*
	(0.0357)	(0.0230)	(0.0113)	(0.0228)	(0.0126)
ln(hectares)	0.0600**	0.0052	-0.0252***	-0.0428***	0.0028
	(0.0255)	(0.0187)	(0.0083)	(0.0130)	(0.0110)

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Table 4. Institutional Marginal Effects

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
Model I – Dummy for Institution Average					
Institute Average > 3	-0.0225	-0.0155	0.0176*	0.0294*	-0.0091
	(0.0274)	(0.0191)	(0.0097)	(0.0154)	(0.0127)
Model II – Institutional Average					
Institute Average	-0.0314**	0.0018	0.0093**	0.0190***	0.0013
	(0.0128)	(0.0092)	(0.0043)	(0.0069)	(0.0060)
Model III – Institution Response A					
A: Disagree	-0.0760*	0.0107	0.0034	0.0669*	-0.0050
	(0.0450)	(0.0280)	(0.0175)	(0.0352)	(0.0159)
A: Neutral	-0.2063***	0.0977*	0.0181	0.1026	-0.0120
	(0.0773)	(0.0577)	(0.0292)	(0.0650)	(0.0230)
A: Agree	-0.0744*	-0.0206	0.0365*	0.0800**	-0.0215
	(0.0412)	(0.0231)	(0.0198)	(0.0319)	(0.0131)
A: Strongly Agree	-0.1190***	-0.0148	0.0228	0.1008***	0.0102
	(0.0434)	(0.0247)	(0.0193)	(0.0349)	(0.0174)
Model IV – Institution Response D					
D: Disagree	-0.0882*	0.0412	-0.0057	0.0402	0.0124
	(0.0512)	(0.0384)	(0.0142)	(0.0353)	(0.0216)
D: Neutral	-0.1235**	0.1176**	0.0008	0.0423	-0.0372***
	(0.0584)	(0.0502)	(0.0174)	(0.0395)	(0.0117)
D: Agree	-0.1030**	0.0506	0.0054	0.0517*	-0.0047
	(0.0427)	(0.0323)	(0.0140)	(0.0295)	(0.0149)
D: Strongly Agree	-0.1521***	0.0167	0.0191	0.1089***	0.0075
	(0.0441)	(0.0296)	(0.0167)	(0.0351)	(0.0162)
Model V – Institution Response A and D					
A: Disagree	-0.0304	-0.0102	-0.0002	0.0471	-0.0062
	(0.0452)	(0.0270)	(0.0170)	(0.0334)	(0.0161)
A: Neutral	-0.1530**	0.0575	0.0181	0.0832	-0.0058
	(0.0777)	(0.0517)	(0.0293)	(0.0611)	(0.0257)
A: Agree	-0.0360	-0.0382*	0.0305	0.0666**	-0.0229*
	(0.0427)	(0.0227)	(0.0199)	(0.0319)	(0.0131)
A: Strongly Agree	-0.0575	-0.0219	0.0138	0.0558*	0.0098
	(0.0443)	(0.0260)	(0.0178)	(0.0316)	(0.0187)
D: Disagree	-0.0771	0.0424	-0.0043	0.0216	0.0173
	(0.0530)	(0.0417)	(0.0144)	(0.0303)	(0.0249)
D: Neutral	-0.0968	0.1209**	-0.0039	0.0146	-0.0348***
	(0.0601)	(0.0549)	(0.0153)	(0.0310)	(0.0129)
D: Agree	-0.0920**	0.0714*	-0.0011	0.0198	0.0019
	(0.0455)	(0.0382)	(0.0126)	(0.0243)	(0.0173)
D: Strongly Agree	-0.1186**	0.0313	0.0163	0.0650**	0.0061
	(0.0468)	(0.0348)	(0.0171)	(0.0319)	(0.0176)

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Table 5. Other Marginal Effects (Model I)

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age of hh head)	0.1605***	-0.0501	-0.0435***	-0.0236	-0.0432**
	(0.0475)	(0.0339)	(0.0156)	(0.0242)	(0.0206)
Male	-0.0054	-0.0150	0.0058	0.0067	0.0079
	(0.0399)	(0.0303)	(0.0113)	(0.0184)	(0.0166)
Education	0.0845***	-0.0262	-0.0100	-0.0368**	-0.0114
	(0.0277)	(0.0200)	(0.0095)	(0.0150)	(0.0119)
ln(hh size)	-0.0404	-0.0217	-0.0146	0.0249	0.0518***
	(0.0399)	(0.0279)	(0.0120)	(0.0210)	(0.0194)
Credit Access	-0.0737**	0.0602***	0.0103	-0.0064	0.0096
	(0.0345)	(0.0203)	(0.0111)	(0.0218)	(0.0158)
New Cook Stove	0.1003***	0.0030	-0.0010	-0.0607***	-0.0416**
	(0.0352)	(0.0230)	(0.0112)	(0.0223)	(0.0187)
East Gojam	-0.1192***	0.0744***	0.0289***	-0.0075	0.0235**
	(0.0292)	(0.0200)	(0.0101)	(0.0169)	(0.0119)
ln(TLU)	0.0506***	-0.0079	-0.0126***	-0.0152**	-0.0150***
	(0.0134)	(0.0095)	(0.0037)	(0.0063)	(0.0052)
ln(dist to town)	-0.0142	-0.0185*	-0.0119**	0.0401***	0.0045
	(0.0162)	(0.0109)	(0.0047)	(0.0104)	(0.0070)
ln(dist to forest)	-0.0139	0.0017	0.0089	0.0036	-0.0003
	(0.0208)	(0.0155)	(0.0065)	(0.0110)	(0.0088)

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Appendix Table A1: Test of Mean Differences via One-way ANOVA

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Dummy for Education	Between Groups	4.129	4	1.032	4.166	0.002
	Within Groups	381.595	1540	0.248		
	Total	385.724	1544			
size of land	Between Groups	56.432	4	14.108	16.989	.000
	Within Groups	1278.836	1540	0.83		
	Total	1335.268	1544			
Numberof livestock	Between Groups	619.457	4	154.864	17.773	.000
	Within Groups	13418.801	1540	8.714		
	Total	14038.259	1544			
Dummy for certificate	Between Groups	4.834	4	1.209	7.568	.000
	Within Groups	245.942	1540	0.16		
	Total	250.777	1544			
Dummy for region	Between Groups	13.96	4	3.49	14.456	.000
	Within Groups	371.801	1540	0.241		
	Total	385.761	1544			
Distance of forest	Between Groups	49.575	4	12.394	2.739	0.027
	Within Groups	6969.413	1540	4.526		
	Total	7018.988	1544			
A dummy for Institutions	Between Groups	10.134	4	2.533	10.393	.000
	Within Groups	375.39	1540	0.244		
	Total	385.524	1544			

Appendix Table B1.
Marginal Effects Estimates – Model I

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age hh head)	0.1696***	-0.0591*	-0.0397**	-0.0246	-0.0463**
	(0.0490)	(0.0342)	(0.0157)	(0.0263)	(0.0224)
Male hh head	0.0068	-0.0218	0.0069	-0.0026	0.0107
	(0.0419)	(0.0319)	(0.0113)	(0.0217)	(0.0175)
Educ of hh head	0.0926***	-0.0262	-0.0114	-0.0426***	-0.0124
	(0.0284)	(0.0201)	(0.0096)	(0.0161)	(0.0130)
ln(hh size)	-0.0474	-0.0208	-0.0124	0.0307	0.0500**
	(0.0409)	(0.0281)	(0.0122)	(0.0225)	(0.0208)
Credit Access	-0.0823**	0.0557***	0.0117	0.0043	0.0106
	(0.0351)	(0.0214)	(0.0105)	(0.0215)	(0.0176)
New Stove	0.1026***	0.0038	0.0005	-0.0630***	-0.0440**
	(0.0353)	(0.0228)	(0.0109)	(0.0229)	(0.0197)
Land Certificate	0.0006	0.0273	-0.0008	-0.0542**	0.0271*
	(0.0376)	(0.0240)	(0.0111)	(0.0257)	(0.0139)
East Gojam	-0.1182***	0.0803***	0.0306***	-0.0142	0.0215*
	(0.0298)	(0.0198)	(0.0101)	(0.0182)	(0.0131)
ln(ha)	0.0577**	0.0066	-0.0260***	-0.0434***	0.0052
	(0.0260)	(0.0186)	(0.0083)	(0.0139)	(0.0121)
ln(TLU)	0.0485***	-0.0078	-0.0113***	-0.0138**	-0.0157***
	(0.0135)	(0.0096)	(0.0036)	(0.0067)	(0.0056)
ln(dist to town)	-0.0090	-0.0181	-0.0132***	0.0365***	0.0039
	(0.0166)	(0.0111)	(0.0046)	(0.0112)	(0.0077)
ln(dist to forest)	-0.0101	-0.0037	0.0106	0.0014	0.0018
	(0.0211)	(0.0153)	(0.0065)	(0.0119)	(0.0096)
InstAvg>=3	-0.0225	-0.0155	0.0176*	0.0294*	-0.0091
	(0.0274)	(0.0191)	(0.0097)	(0.0154)	(0.0127)
Observations	1,031	1,031	1,031	1,031	1,031

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Appendix Table B2.
Marginal Effects Estimates – Model II

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age hh head)	0.1703***	-0.0586*	-0.0399**	-0.0261	-0.0458**
	(0.0490)	(0.0344)	(0.0155)	(0.0257)	(0.0226)
Male hh head	0.0054	-0.0204	0.0064	-0.0031	0.0117
	(0.0416)	(0.0317)	(0.0112)	(0.0213)	(0.0173)
Educ of hh head	0.0878***	-0.0253	-0.0109	-0.0399**	-0.0116
	(0.0285)	(0.0202)	(0.0094)	(0.0159)	(0.0131)
ln(hh size)	-0.0475	-0.0209	-0.0120	0.0305	0.0499**
	(0.0407)	(0.0281)	(0.0121)	(0.0221)	(0.0208)
Credit Access	-0.0755**	0.0550**	0.0107	0.0001	0.0097
	(0.0358)	(0.0217)	(0.0107)	(0.0220)	(0.0181)
New Stove	0.1011***	0.0033	0.0009	-0.0609***	-0.0445**
	(0.0353)	(0.0230)	(0.0107)	(0.0225)	(0.0198)
Land Certificate	-0.0119	0.0318	0.0003	-0.0498**	0.0295**
	(0.0370)	(0.0236)	(0.0107)	(0.0248)	(0.0136)
East Gojam	-0.1230***	0.0815***	0.0313***	-0.0122	0.0224*
	(0.0298)	(0.0199)	(0.0100)	(0.0178)	(0.0131)
ln(ha)	0.0561**	0.0066	-0.0259***	-0.0418***	0.0051
	(0.0259)	(0.0187)	(0.0081)	(0.0136)	(0.0122)
ln(TLU)	0.0502***	-0.0077	-0.0118***	-0.0149**	-0.0157***
	(0.0136)	(0.0096)	(0.0036)	(0.0066)	(0.0056)
ln(dist to town)	-0.0102	-0.0182	-0.0129***	0.0371***	0.0042
	(0.0166)	(0.0111)	(0.0046)	(0.0110)	(0.0078)
ln(dist to forest)	-0.0136	-0.0021	0.0104	0.0027	0.0026
	(0.0211)	(0.0153)	(0.0064)	(0.0116)	(0.0097)
Inst. Average	-0.0314**	0.0018	0.0093**	0.0190***	0.0013
	(0.0128)	(0.0092)	(0.0043)	(0.0069)	(0.0060)
Observations	1,031	1,031	1,031	1,031	1,031

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Appendix Table B3.
Marginal Effects Estimates – Model III

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age hh head)	0.1599***	-0.0508	-0.0450***	-0.0217	-0.0423**
	(0.0472)	(0.0332)	(0.0161)	(0.0241)	(0.0214)
Male hh head	0.0079	-0.0191	0.0036	-0.0005	0.0080
	(0.0406)	(0.0304)	(0.0125)	(0.0197)	(0.0175)
Educ of hh head	0.0764***	-0.0256	-0.0078	-0.0329**	-0.0101
	(0.0274)	(0.0195)	(0.0098)	(0.0148)	(0.0123)
ln(hh size)	-0.0299	-0.0216	-0.0158	0.0167	0.0505**
	(0.0397)	(0.0276)	(0.0124)	(0.0207)	(0.0199)
Credit Access	-0.0680*	0.0567***	0.0042	-0.0037	0.0109
	(0.0351)	(0.0205)	(0.0131)	(0.0215)	(0.0165)
New Stove	0.1022***	0.0067	-0.0040	-0.0627***	-0.0422**
	(0.0347)	(0.0220)	(0.0121)	(0.0222)	(0.0189)
Land Certificate	-0.0136	0.0319	-0.0017	-0.0435*	0.0269**
	(0.0352)	(0.0226)	(0.0118)	(0.0228)	(0.0130)
East Gojam	-0.1220***	0.0766***	0.0317***	-0.0103	0.0240*
	(0.0290)	(0.0196)	(0.0105)	(0.0169)	(0.0124)
ln(ha)	0.0447*	0.0083	-0.0223***	-0.0363***	0.0056
	(0.0252)	(0.0182)	(0.0085)	(0.0131)	(0.0115)
ln(TLU)	0.0499***	-0.0074	-0.0135***	-0.0138**	-0.0153***
	(0.0132)	(0.0094)	(0.0038)	(0.0063)	(0.0054)
ln(dist to town)	-0.0150	-0.0168	-0.0134***	0.0404***	0.0049
	(0.0160)	(0.0107)	(0.0048)	(0.0104)	(0.0074)
ln(dist to forest)	-0.0091	-0.0011	0.0058	0.0038	0.0006
	(0.0203)	(0.0149)	(0.0067)	(0.0108)	(0.0092)
A: Disagree	-0.0760*	0.0107	0.0034	0.0669*	-0.0050
	(0.0450)	(0.0280)	(0.0175)	(0.0352)	(0.0159)
A: Neutral	-0.2063***	0.0977*	0.0181	0.1026	-0.0120
	(0.0773)	(0.0577)	(0.0292)	(0.0650)	(0.0230)
A: Agree	-0.0744*	-0.0206	0.0365*	0.0800**	-0.0215
	(0.0412)	(0.0231)	(0.0198)	(0.0319)	(0.0131)
A: Strongly Agree	-0.1190***	-0.0148	0.0228	0.1008***	0.0102
	(0.0434)	(0.0247)	(0.0193)	(0.0349)	(0.0174)
Observations	1,079	1,079	1,079	1,079	1,079

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Appendix Table B4.
Marginal Effects Estimates – Model IV

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age hh head)	0.1637***	-0.0492	-0.0493***	-0.0232	-0.0420**
	(0.0478)	(0.0333)	(0.0162)	(0.0257)	(0.0206)
Male hh head	0.0009	-0.0212	0.0056	0.0042	0.0105
	(0.0405)	(0.0308)	(0.0122)	(0.0199)	(0.0158)
Educ of hh head	0.0872***	-0.0230	-0.0117	-0.0416***	-0.0108
	(0.0279)	(0.0195)	(0.0099)	(0.0159)	(0.0119)
ln(hh size)	-0.0483	-0.0200	-0.0093	0.0286	0.0490**
	(0.0399)	(0.0271)	(0.0129)	(0.0221)	(0.0192)
Credit Access	-0.0739**	0.0568***	0.0141	-0.0053	0.0082
	(0.0348)	(0.0204)	(0.0107)	(0.0224)	(0.0165)
New Stove	0.0936***	0.0018	0.0008	-0.0560**	-0.0402**
	(0.0348)	(0.0227)	(0.0113)	(0.0221)	(0.0184)
Land Certificate	-0.0178	0.0398*	-0.0053	-0.0420*	0.0254**
	(0.0357)	(0.0216)	(0.0123)	(0.0238)	(0.0125)
East Gojam	-0.1230***	0.0796***	0.0300***	-0.0092	0.0226*
	(0.0295)	(0.0196)	(0.0104)	(0.0178)	(0.0120)
ln(ha)	0.0669***	0.0044	-0.0282***	-0.0467***	0.0037
	(0.0255)	(0.0183)	(0.0085)	(0.0137)	(0.0110)
ln(TLU)	0.0508***	-0.0066	-0.0133***	-0.0161**	-0.0148***
	(0.0134)	(0.0094)	(0.0038)	(0.0067)	(0.0053)
ln(dist to town)	-0.0131	-0.0163	-0.0137***	0.0374***	0.0057
	(0.0162)	(0.0108)	(0.0048)	(0.0108)	(0.0071)
ln(dist to forest)	-0.0138	0.0024	0.0073	0.0036	0.0006
	(0.0208)	(0.0149)	(0.0068)	(0.0118)	(0.0088)
D: Disagree	-0.0882*	0.0412	-0.0057	0.0402	0.0124
	(0.0512)	(0.0384)	(0.0142)	(0.0353)	(0.0216)
D: Neutral	-0.1235**	0.1176**	0.0008	0.0423	-0.0372***
	(0.0584)	(0.0502)	(0.0174)	(0.0395)	(0.0117)
D: Agree	-0.1030**	0.0506	0.0054	0.0517*	-0.0047
	(0.0427)	(0.0323)	(0.0140)	(0.0295)	(0.0149)
D: Strongly Agree	-0.1521***	0.0167	0.0191	0.1089***	0.0075
	(0.0441)	(0.0296)	(0.0167)	(0.0351)	(0.0162)
Observations	1,057	1,057	1,057	1,057	1,057

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.

Appendix Table B5.
Marginal Effects Estimates – Model V

VARIABLES	Private	Community	Market	Open Access	Multiple Sources
ln(age hh head)	0.1605***	-0.0501	-0.0435***	-0.0236	-0.0432**
	(0.0475)	(0.0339)	(0.0156)	(0.0242)	(0.0206)
Male hh head	-0.0054	-0.0150	0.0058	0.0067	0.0079
	(0.0399)	(0.0303)	(0.0113)	(0.0184)	(0.0166)
Educ of hh head	0.0845***	-0.0262	-0.0100	-0.0368**	-0.0114
	(0.0277)	(0.0200)	(0.0095)	(0.0150)	(0.0119)
ln(hh size)	-0.0404	-0.0217	-0.0146	0.0249	0.0518***
	(0.0399)	(0.0279)	(0.0120)	(0.0210)	(0.0194)
Credit Access	-0.0737**	0.0602***	0.0103	-0.0064	0.0096
	(0.0345)	(0.0203)	(0.0111)	(0.0218)	(0.0158)
New Stove	0.1003***	0.0030	-0.0010	-0.0607***	-0.0416**
	(0.0352)	(0.0230)	(0.0112)	(0.0223)	(0.0187)
Land Certificate	-0.0176	0.0342	-0.0014	-0.0397*	0.0244*
	(0.0357)	(0.0230)	(0.0113)	(0.0228)	(0.0126)
East Gojam	-0.1192***	0.0744***	0.0289***	-0.0075	0.0235**
	(0.0292)	(0.0200)	(0.0101)	(0.0169)	(0.0119)
ln(ha)	0.0600**	0.0052	-0.0252***	-0.0428***	0.0028
	(0.0255)	(0.0187)	(0.0083)	(0.0130)	(0.0110)
ln(TLU)	0.0506***	-0.0079	-0.0126***	-0.0152**	-0.0150***
	(0.0134)	(0.0095)	(0.0037)	(0.0063)	(0.0052)
ln(dist to town)	-0.0142	-0.0185*	-0.0119**	0.0401***	0.0045
	(0.0162)	(0.0109)	(0.0047)	(0.0104)	(0.0070)
ln(dist to forest)	-0.0139	0.0017	0.0089	0.0036	-0.0003
	(0.0208)	(0.0155)	(0.0065)	(0.0110)	(0.0088)
A: Disagree	-0.0304	-0.0102	-0.0002	0.0471	-0.0062
	(0.0452)	(0.0270)	(0.0170)	(0.0334)	(0.0161)
A: Neutral	-0.1530**	0.0575	0.0181	0.0832	-0.0058
	(0.0777)	(0.0517)	(0.0293)	(0.0611)	(0.0257)
A: Agree	-0.0360	-0.0382*	0.0305	0.0666**	-0.0229*
	(0.0427)	(0.0227)	(0.0199)	(0.0319)	(0.0131)
A: Strongly Agree	-0.0575	-0.0219	0.0138	0.0558*	0.0098
	(0.0443)	(0.0260)	(0.0178)	(0.0316)	(0.0187)
D: Disagree	-0.0771	0.0424	-0.0043	0.0216	0.0173
	(0.0530)	(0.0417)	(0.0144)	(0.0303)	(0.0249)
D: Neutral	-0.0968	0.1209**	-0.0039	0.0146	-0.0348***
	(0.0601)	(0.0549)	(0.0153)	(0.0310)	(0.0129)
D: Agree	-0.0920**	0.0714*	-0.0011	0.0198	0.0019
	(0.0455)	(0.0382)	(0.0126)	(0.0243)	(0.0173)
D: Strongly Agree	-0.1186**	0.0313	0.0163	0.0650**	0.0061
	(0.0468)	(0.0348)	(0.0171)	(0.0319)	(0.0176)
Observations	1,041	1,041	1,041	1,041	1,041

Source: Marginal Effects from Multinomial Logit Estimates. Standard Errors in Parantheses.
*** Significant at 0.001, ** Significant at 0.01, * Significant at 0.05.