Socioeconomic factors determining household level tree species abundance and composition in Gondar district, Ethiopia

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Declaration

I, the undersigned, declare that this thesis is an outcome of my own work and has not been submitted for the award of any degree in any university in Norway or abroad and all the materials used in the thesis are duly acknowledged.

Maru Shete Bekele

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Norway

Dedication

Dedicated to my daughter: Naomi Maru Shete

Acknowledgement

My sincere acknowledgement goes to my supervisor, Fred Midtgaard (Dr. Scient. and Associate prof.), for his technical guidance in the thesis work and moral support while I had a personal problem. I am also indebted to the Department of Ecology and Natural Resource Management (INA) for covering my expenses for the field work and for offering me a place of study in the MSc program. Tusen Takk!!!

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Lastly, I am thankful for my lovely daughter, Naomi Maru, who cheers me up and kept me inspired during all those days of my loneliness. I love you Naomi, and you have a special place in my heart.

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Abstract

The study investigated if there is variation in the frequency of tree species maintained at household level, and the socioeconomic factors that can explain its variation. Data were collected from 156 randomly selected households in 2009 in Ambober village of Gondar district, Ethiopia. Farm visits and recording, observation, group discussion and interview were the methods used to collect the data. Data were analyzed using mean, independent samples test, one way analysis of variance, and multiple regression techniques. The results showed that there was significant variation in tree species abundance with fast growing tree species like Ecucalyptus camaldulensis being the most common. The ordinary least square estimation results indicated that family size, income, and household's head age contributed positively towards household level tree species abundance. While farm size, tropical livestock unit, walking distance affected the variation in tree species abundance negatively, sex of household head, location dummy, land tenure and years of land ownership turned out to be insignificant. On the other hand, tropical livestock unit, family size, income, household's head age, tenure insecurity, and walking distance positively affected household level tree species composition. Introduction of multi-purpose tree species that have animal feed values and that can address the fuel wood demand of farm households is believed to enhance household level tree species abundance.

Key words: Tree species, composition, abundance, OLS, Ambober village, Ethiopia

CHAPTER ONE

INTRODUCTION

1.1 Background

Ever since man began with agriculture, the relationship between people and the environment has been critical. Man, as an ecological factor and manipulator of the environment, altered the ecological processes and disrupted the environment. Agriculture as a managed-ecosystem (agro-ecosystems) began some 12,000 years ago whereby humans manipulate the various components of the ecosystem to increase the carrying capacity of the environment (Thrupp, 2000).

Ethiopia is endowed with heterogeneous environmental conditions (nine vegetation based ecosystems) and diverse cultural history (over 72 ethnic groups with distinct culture). The major ecosystems found in Ethiopia are the afroalpine and sub-afroalpine ecosystem, the dry evergreen montane forest and scrub ecosystem, the montane moist forest ecosystem, the acacia-commiphora ecosystem, the combretum-terminalia ecosystem, the lowland tropical forest ecosystem, the desert and semi-desert ecosystem, the wetland ecosystem and the aquatic ecosystem. Due to such variability, genetic resources of the country exhibit an enormous diversity. The Ethiopian flora is estimated to harbor more than 6500 to 7000 species of higher plants of which 12% are known to be endemic (Teketay, 2001). There are over 300 tree species, but the exact number of non- flowering species is still unknown.

1.2 Problem statement

Including savanna woodlands, forest cover in Ethiopia were estimated to constitute 66% of the total land mass before human settlement took place (Yirdaw, 1996). Over the last 3000 years there has been progressive deforestation, which has accelerated tremendously during the last century. Rapid population growth (3% per year), extensive forest clearing for cultivation, over-grazing, movement of political centers, and exploitation of forests for fuel wood and construction materials without replanting has reduced the forest cover of the country to 16% in the 1950s and to 3.1% in 1982 (EFAP, 1994). The estimated forest resource of Ethiopia covered 27.5 million hectares of land in 1992 (MNRCDEP, 1994 cited in Teketay, 2001). Further estimates of the distribution of forest and woodland areas made on the basis of information from LANDSAT imagery (1979) revealed that Ethiopian forest cover has declined to 2.7% of the total land surface with an estimated annual loss of 150,000-200,000 hectares (Kuru, 1990; EFAP, 1994). The problem is particularly severe in the northern and central highlands where ecological degradation resulting from deforestation, accelerated soil erosion, and depletion of organic matter and nutrients significantly has changed the micro environment over the past decades (Kefeni, 1990; Hurni, 1990).

The attention given to the conservation and sustainable use of forest resources in Ethiopia has been inadequate. While conservation of agricultural biodiversity is given high priority, that of forest biodiversity is under medium priority in the country. Absence of a recent forest policy and a low level of enforcement of the existing forest proclamation have also contributed to the erosion of forest resources. Sound policies on land use and utilization of natural resources have not been formulated and implemented. The lack of adequate knowledge of the genetic diversity of most tree species as well as the insufficient information on their distribution and demographic status are among the major constraints to conservation (Mekonnen *et al.*, 2006).

With high level of genetic erosion, the likely outcome for some tree species to disappear is also high. Teketay (2001) presented poverty, high population growth rate, low economic growth rate, and markets as mutually reinforcing and interacting factors for the accelerated deforestation problem in the country. Nevertheless, such presentations are too general and do not reveal local level realities and the exact agents of the problem.

With the perspective of getting local level and in depth understanding about the status of tree species that are under use by farm households and their associated socioeconomic factors governing them, this study is designed to be conducted in Ambober village of Gondar district, northwestern Ethiopia.

1.3 Objectives and research questions

The study has the general objective of identifying socioeconomic variables that determine trees species abundance and composition at household level in Ambober village. The research will specifically aim at answering the following questions:

1. What socioeconomic variables affect abundance and composition of trees species maintained at household level?
2. What tree species are more abundant at household level?
3. What are the dominant growing areas for the different types of tree species maintained at household level?
4. Is there significant variation in tree species abundance and composition between Ambober and Woyniye kebeles[1]?

1.4 Scope of the study

The scope of this study is limited to analyzing the socioeconomic factors that determine number of trees and tree species maintained by households. Besides socioeconomic factors, it is clear that biophysical factors are also important determinant factors. But the latter case is beyond the scope of the study. In addition, time and money is always a constraint in research works. Hence, the focus of the study is only in one village of Gondar district, north western Ethiopia.

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[1] *Kebele* is the term used in Ethiopia to designate the lowest administrative unit.

CHAPTER TWO

LITERATURE REVIEW

2.1 Forest biodiversity and conservation efforts

Tropical, temperate and boreal forests offer diverse set of habitats for plants, animals and micro-organisms. Forests store 46% of the world's terrestrial carbon. It covers only 6% of the planet but harbor about 90% of the globes terrestrial biodiversity. In terms of biodiversity, tropical forests are the richest terrestrial ecosystems (Toit *et al.*, 2004). The biodiversity could be at different levels on the genetic, species and ecosystem level. About 1.6 billion people in the world depend on forests for fuel wood, medicine and income. Forests also serve as important sources of raw materials for various industries. Nevertheless, forest resources are being lost at an alarming rate contributing about 20% of the world's greenhouse gas emission, which puts a threat to biodiversity (World Bank, 2008; Bawa and Seidler, 1996).

Nature reserves are widely used in the world to deal with loss of terrestrial biodiversity (Toit *et al.*, 2004). The fact that most terrestrial biodiversity are found in the tropics where institutions are weak (Barrett *et al.*, 2001), corruption is common (McCarthy, 2002), financial capital and technical knowledge is lacking and where human interference are unsustainable (Toit *et al.*, 2004), makes putting theory of nature reserves into practice very challenging. Besides, nature reserves alone cannot curb the problem of biodiversity loss unless the remaining unprotected areas are put under sustainable use. If local communities are empowered through participating them in all the stakes that affect their environment, empirical findings revealed that they can use their indigenous knowledge to manage natural resource under sustainable use (Toit et al., 2004; Ayoo, 2007). Ecologists claim that state run conservation schemes are often not successful, especially in Africa (Salafsky *et al*., 2001), and advocate active involvement of resource users through Community Based Natural Resource Management (CBNRM) approach. Well managed CBNRM helps to save loss of biological diversity, reduces resource use conflicts, promote sustainable resource use and economic benefits (Kellert *et al*., 2000; Adams and Hulme, 2001; Ayoo, 2007). However, experiences from some countries revealed that CBNRM was not successful because of lack of clear property rights for community members, lack of adequate participation from community stakeholders, lack of adequate funds to reinvest on natural resource management, and because design of CBNRM is donor driven (Salafsky *et al*., 2001; Ayoo, 2007; Inamdar *et al*., 1999).

2.2 Threats to forest biodiversity

Conservation biologists claim that natural and anthropogenic factors alter species richness and ecosystem properties. Any form of disturbance affects ecosystem stability and hamper the succession process (Kumar and

Ram, 2005). Deforestation, introduction of invasive alien species, pollution, urbanization and industrialization, and human induced climate change are among the anthropogenic factors mentioned as threat to forest biodiversity (Gitay *et al*., 2002). Similarly, World Bank (2008) presented institutional and economic factors as the main causes of habitat and biodiversity losses.

Mechanized commercial logging operations carried out in the tropics not only contributed to significant loss of forest biomass but also alter distribution and abundance of plant and animal species (Bawa and Seidler, 1996). Although there is local increase in species diversity, logged forests generally tend to become increasingly homogeneous on a regional scale. Logging contributes to loss of habitat, and decrease geographic range of species. Those species that are adapted to narrow geographic range decline due to loss of habitat/shrinking of geographic range (Frumhoff, 1995). Others (Ganzhorn *et al.*, 1990; Primack and Lee, 1991) revealed the availability of evidence for decline of larger commercial species but increase in abundance of small stemmed species.

Human disturbance decreases the dominance of single tree species but increase plant diversity of different succession status (Pomeroy, 1996). Nevertheless, mean tree density showed decreasing trend from high to moderate disturbances (Kumar and Ram, 2005). Introduction of alien tree species in the tropics is another problem affecting forest biodiversity. For instance, *Prosopis juliflora* was deliberately introduced from Central America to Ethiopia as multipurpose tree. The species impairs growth of grasses, and has reduced the total biodiversity of the area by disturbing ecosystem functions (Berhanu and Tesfaye, 2004). Mangrove forests are being cleared in the world for urban development that put a threat on biodiversity (World Bank, 2008). It is also noted that human induced climate change and concentration of green house gases in the atmosphere exerted pressure on forest biodiversity through influencing length of growing seasons, distribution of species, frequency of disease and pest outbreaks, population size, etc (Gitay *et al*., 2002).

Deforestation creates habitat fragmentation that results in increase in number of patches, decrease in patch size, and increase in isolation of patches (McGarigal *et al*., 2002; Boulinier *et al.,* 2001). This often leads to habitat loss (Fahrig, 2003). Species richness, population abundance and distribution, and genetic diversity are some of the important aspects of forest biodiversity that are negatively affected due to habitat loss (see Steffan-Dewenter *et al.,* 2002; Guthery *et al.,* 2001; Gibbs, 2001).

2.3 Theories of forest cover changes

Forest transition theory: A temporal analysis

Forest transition theory describes that a forested region goes through a time path of deforestation before the forest cover eventually stabilizes and starts to increase. It was Alexander Mather who used the term ‘forest transition’ in his empirical work on historical changes in Scottish landscapes (Mather, 1990). According to Mather, a prolonged decline of forest cover due to urbanization and industrialization is followed by a partial recovery through reforestation (Mather, 1992). Angelsen (2007) also presented four distinct stages where forest region passes through. At the initial stage there is high forest cover and low deforestation rate followed by accelerated deforestation rate. Then, deforestation rate slows down and forest cover stabilizes. Finally, a period of reforestation commences. In his most recent article, Mather (2007) used forest transition theory to explain the turnaround from deforestation to reforestation in China, India and Vietnam. Abandonment of less fertile land for forests to reoccupy, cultural factors, effort of professional foresters to improve landscapes by planting trees, and shift from wood to coal as energy source are some of the historical explanations given for the onset of forest transitions (Mather, 2001; Mather, 2004).

The Von Thunen Model: A spatial analysis

The Von Thunen land use model describes the spatial determinants of the rent of different land uses. In his seminal work of 'The Isolated State' in 1826, John Von Thunen presented a spatial model of different land uses as determined by distance from a commercial center (O'Kelly and Bryan, 1996). The model argued that deforestation is caused by any changes that increase the land rent value of agriculture to forest use. Angelsen (2007) presented five alternative land uses with different land rent values. Near the city center, intensive agriculture is the most profitable activity followed by extensive agricultural activities. Then, the land is used for managed forests, open access forests and old growth forests as in the order presented when the distance from the central market increases. The extensive agriculture marks the forest-non-forest border, and the open access forest demarcates where logging is practiced. Although the model failed to explain what factors increase land rent value, Angelsen and Kaimowitz (1999) argued that factors such as road infrastructure, agricultural subsidies, access to cheap agricultural credit, technological progress, and market demand for agricultural products increase the land rent value for agricultural use around the center and encourages agricultural frontier.

2.4 Socioeconomic factors for loss of trees in the tropics

Montagnini and Jordan (2006) started by presenting the rate of deforestation in the tropics between 1990 and 1997. According to the authors, 2.5 million hectares of land per annum in Latin America, 0.85 million hectares per annum in Africa and 2.5 hectares per annum in Southeast Asia are deforested between 1990 and 1997. They further described the causes of tropical deforestation as infrastructure development (road networks, markets, mining and oil exploration), agricultural expansion (permanent and shifting cultivation, ranching), wood extraction (logging, fuel wood and charcoal production), and economic shocks and misguided policies, tenure insecurity, cultural factors (household and public behavior with little concern to forests), technological factors, economic factors (commercialization, price increase), and demographic factors (fertility, migration and density) as causes of tropical deforestation.

Geist and Lambin (2002) analyzed 152 case studies (55 from Asia, 78 from Latin America and 19 from Africa) that examined the factors of deforestation in the tropics between 1880 and 1996. They identified proximate and underlying causes of deforestation. Their findings revealed that 96% of the case studies presented agricultural expansion (shifting cultivation, conversion for permanent cultivation, cattle ranching and colonizing migrants) as cause of deforestation. Commercial logging in Asia and tree cutting for fuel wood and poles for domestic use in Africa, and infrastructure expansion (road development) in Latin America were the second and third dominant factor raised by the case studies. They further revealed that 81% of the case studies mentioned economics factors as factors of tropical deforestation followed 78% of the case studies mentioning national policies (land tenure, subsidies and infrastructure development) as second most important factor of deforestation. Technological, cultural and demographic factors are mentioned to be the other important factors explained by 70%, 66% and 61% of the case studies respectively. In an earlier study, Deacon (1994) used data from 120 countries to see the relationship among population growth income and property rights with deforestation employing regression method. The findings indicated that with population growth peasants that migrated to forested areas seeking land for subsistence farming has increased. Further, population growth also increased fuel wood collection that further aggravated rate of deforestation.

Kaimowitz and Angelsen (1998) mentioned the difficulty of establishing clear casual relationship between deforestation and underlying causes of deforestation when data from multiple countries for various years are not available. However, they employed regression tools using available data to present the underlying factors of tropical deforestation. According to them, population density increased rate of deforestation through influencing the demand of rural families for agricultural land, forest and forest products. In addition, changes in government policies (agricultural subsidies, road construction, colonization policies, gasoline prices and tax policies) make forested areas more economically attractive that further exacerbated deforestation. Economic growth or increased income may have a relieving effect in the short run by making available off farm employment opportunities but may re-enforce deforestation in the long-run by increasing the demand for agricultural and forest products.

A study in Ethiopia based on data from field observations, satellite image, maps, interviews, and literature studies revealed that forest cover has declined from 40% at the turn of the 19th century to less than 3% in the year 2000 (Dessie and Christiansson, 2008). Wakijira (2007) analyzed the land cover changes in southern Ethiopia from satellite image data from 1973 to 2005 and incorporated the qualitative reaction of villagers for the changes. Both studies (Wakijira, 2007; Dessie and Christiansson, 2008) indicated that improvements in transportation service, population growth, tenure insecurity, sociopolitical changes, were found to be factors of forest loss. In

Kenya, deforestation through logging, charcoal burning and firewood collection and overgrazing and expansion of cultivation towards forest areas has led the decrease of forest covers to less than 2% in the Mau catchment (Kenya Working Group, 2006). In Tanzania researchers (MNRT, 2001) claim that the high deforestation rates in the country is due to proximate factors such as settlement and agricultural expansion, charcoal and fuel wood production, overgrazing, uncontrolled fires, shifting cultivation and illegal logging. Kaoneka and Solberg (1997) also mentioned high population growth, poverty, market and policy failures, absence of proper definition of property rights and security of tenure as underlying factors for the forest loss in Tanzania.

According to Barbier *et al*. (1991), logging and fire contributed to loss of about 150,000ha/year forests in 1980s in Indonesia and about 500,000 ha/year forest land was converted into agricultural land in 1990s. Such huge loss of forest was aggravated due to misguided policies and population increase that are engaged in shifting cultivation and conversion of forest lands into agricultural lands.

The *Ribeira* valley region of Amazon rainforest has been considered as one of the most important conservation priorities by IUCN. Alves and Hogan (2009) used a mixture of data sources from household surveys, land cover changes data and GIS so as to identify the major drivers of deforestation in this region. They found that population size, growth and density, years of schooling of household heads, income of household head, and access to markets and infrastructures to have a positive correlation to rate of deforestation. Others argued that government policies related to agricultural credit, subsidies and interest rates, population growth, misguided policies that encouraged deforestation as a means to claim land title (Fearnside 1993), improved transportation for soybean cultivation (Fearnside 2001), and logging roads and fire (Fearnside 2005) are important ultimate factors of deforestation in the Amazonian rainforest. On the other hand, percentage of heads of households earning less than one dollar a day (poor), topography and availability of conservation units to have negative correlation to rate of deforestation.

CHAPTER THREE
MATERIAL AND METHODS

3.1 Study area

The study area, Ambober village, is found in Gondar district of northwestern Ethiopia. It is located north of Lake Tana at latitude and longitude of 12 12°36′N 37°28′E12.6°N 37.467°E with an elevation of about 2133 meters above sea level (CSA, 2004). The area is a mixed farming system where crop-livestock interact in making the livelihood for the households. The area is one of the living places for Flasha Mur (Ethiopian Jews) before many of them rejoined Israel through the Israel re-union program. The settlement history of the location attracts attention to study tree species diversity since forest resources are more dynamic with settlement history. Ambober village is further administratively classified into two kebeles called Woyniye and Ambober and the data collection covered both of them.

3.2 Variables and data collection method

The study followed a cross sectional study design and households[2] are the unit of analysis. A random sample of 156 households was taken using the tax payers list as a sampling frame. The household survey was conducted in

[2] Household: constitutes of a person or group of persons, irrespective of weather related or not who normally live together in the same housing unit or group of housing units and who have common cooking arrangements (CSA, 2004).

summer 2009 to collect variables such as type and number of tree species maintained at household level at different growing areas (homestead, woodlots, scattered on the farm, live fences), years of land ownership/settlement, age of household head, landholding size, livestock type and number, sex of household head, income, feeling of tenure security, walking distance from home to main road, sex of head, etc. Focus group discussion was carried out to identify the common growing areas for the tree species maintained by farm households. Livestock holding per household is aggregated into a single unit based on Tropical Livestock Unit (TLU)[3] (see Annex 1 for conversion factors). Farm visits and recording, focus group discussion and structured questionnaire were the techniques used to collect the research variables.

Land in Ethiopia is owned by the government. Farmers have usufruct right and can exclude others from using it. But, they cannot sell their lands in anyway, except leasing it out on a short term basis. In this study, the tree species recording is made in all the lands that are privately managed and used by the households (home compound, and farmlands). Four sets of dependent variables are generated for running the OLS regression analysis. The dependent variables are presented below

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[3] TLU is used to describe livestock numbers of various species as a single aggregate figure so as to expresses the total amount of livestock holding by households. It is based on an equivalence scale of animal's average biomass consumption (Babu and Sanyal, 2009 and EADD, 2009).

1. **Total number of tree count**: this variable represents the total number of trees maintained by the household in the different growing areas. The variable is generated by counting the trees found under the ownership of households during the household survey. It is used as indicator for tree species abundance.
2. **Number of tree count per hectare**: represents the total number of trees maintained by the household adjusted for the size of land owned. It is used as indicator for tree species abundance per hectare of land owned.
3. **Tree species count**: represents the frequency of tree species maintained by the household in the different growing areas. One tree species is counted only once even though the household maintained more than one tree of same species. It is used as indicator for household level tree species composition.
4. **Tree species count per hectare**: the variable under No. 3 adjusted for the size of land owned by the household.

3.3 Hypothesis

Based on theory and past research findings, the following research hypotheses are formulated. The variables are grouped into three as:

Hypothesis one: Household characteristics variables

- Age of household head and being male headedness of household head are expected to contribute positively to the number of tree species maintained by households.
- Family size: high family size is expected to have a positive/negative effect on the number of tree species maintained by the household
- Feeling of tenure security: those farm households that have feeling of tenure security are expected to maintain more tree species than their counterparts.
- Number of years of land ownership: long year of land ownership is expected to build household's confidence on tenure security. Hence expected to have positive influence on the dependent variable.

Hypothesis two: Location variables

- Walking distance: households located far from the main road are expected to maintain more tree species than those located near to road facilities
- Village dummy: households located in Ambober kebele are expected to maintain less tree species than those located in Woynyie kebele.

Hypothesis three: Economic factors

- Farm land and annual income: farm households with higher income and large ownership of farm land are expected to maintain more tree species than their counterparts

Table 1: Variables and their expected signs

Variable	Measurement	Expected sign
Annual income	Ethiopian Birr (ETB)[4]	Positive
Livestock	Tropical Livestock Unit (TLU)	Positive/negative
Age of household head	Years	Positive
Farm size	Hectares	Positive
Family size	Number	Positive/negative
Years of land ownership	Years	Positive
Sex of household head	Dummy; 0 if the head is female and 1 if otherwise	Positive
Tenure security	Dummy; 0 represents insecurity and 1 if otherwise	Positive
Village dummy	Dummy; 0 if located in Woynyie kebele and 1 if located in Ambober kebele	Negative
Walking distance	Hours	Positive

[4] One USD is equivalent to 13.45 ETB

3.4 Data analysis

The data were subjected to different statistical analysis such as regression through Ordinary Least Square Estimation (OLS), one way analysis of variance (ANOVA), independent t-test, mean and frequency. The relative abundance of tree species maintained by households in the different growing areas such as live fences, homestead, woodlots and scattered on the farm were done through one way analysis of variance. The study employed independent t-test to see if there exists variation in tree species abundance and composition between the two kebeles included in the survey. Multiple regression analysis through the OLS estimation technique was done to identify the socioeconomic factors that determine the number of tree species maintained by households. For all the analysis, SPSS was used.

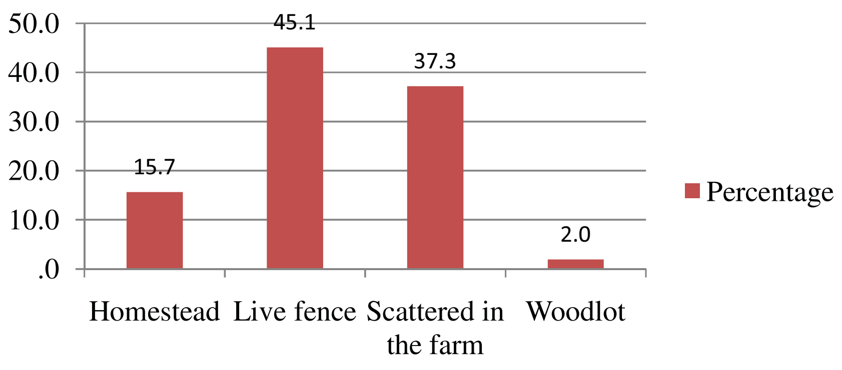
CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Descriptive statistics

In the study area as many as 51 tree species were recorded. On average, households maintained as many as 99 trees in the lands that they privately manage, which is lower than the amount of trees recorded per household (150 trees) in a study by Mekonnen (2009) in north western Ethiopia. Tree species abundance showed very high variability (about 157 trees) with the maximum reaching up to 772 trees per household. In terms of the number of tree species composition that farm households grew, the study revealed that they maintained about 6 tree species (Table 2).

Figure 1: The dominant growing areas (n=51 tree species)



As presented in Figure 1, about 45% of the tree species recorded in the survey dominantly found to grow as live fences surrounding the home compound. My study also revealed that agroforestry plays important role in which about 37% of the tree species recorded are found scattered in the farms. The significance of forest scarcity path that leads to adoption of agroforestry system in ecosystem services compared to monoculture is well documented in the literature (Harvey *et al.*, 2006; Jose, 2009). For woodlots, farm households maintain only *Eucalyptus* species (see Annex 2 for details). A study by Price and Campbell (1998) about household tree holding in Zimbabwe indicated that tree holding in rural households concentrate in homestead areas than adjacent fields.

Average land holding size in the study area was 1.2 hectares, which is better than the national landholding average of 1.026 (FDRE, 2002) and about 1 hectare in north western Ethiopia (Mekonnen, 2009). Land tenure in Ethiopia is government owned. It is often mentioned in the literature that farmers with the expectation of insecure property rights often discouraged to think about long term investments like tree planting (Besley, 1995). In this study, the variable is captured by directly asking their feeling of tenure security and by recording the number of years that farm households own their farmlands with the view that the longer period they own their lands the more they feel secured and *vice versa*. The mean number of years that farmers own their lands is about 21 years (Table 2). In a disaggregated analysis, households in Ambober and Woyniye kebele owned their lands for about 19 and 22 years respectively, and the mean year difference is statistically significant at P<0.05 level (mean difference = -3.15 and t value =-2.058).

Table 2: Descriptive statistics of variables

Variable	Mean/Frequency	Std. deviation
Total tree count	99.01	156.67
Total tree count per hectare	102.22	157.29
Tree species count	5.73	5.61
Tree species per hectare	7.57	12.19
Annual income (in *ETB*)	2244.99	1340.19
Livestock (TLU)	2.43	2.53
Age of household head	46.31	14.80
Farm size in hectares	1.18	0.87
Family size	5.02	2.141
Years of land ownership	20.54	9.576
Sex of household head	0.74	NA
Feeling of tenure security	0.44	NA
Village dummy	0.62	NA
Walking hours to main road	1.99	NA

NA denotes Std. deviation is "Not Applicable" for qualitative variables.

4.2 Relative abundance of tree species in Ambober village

The result of the ANOVA test indicated that the null hypothesis that there is no difference in the mean tree species maintained at household level in Ambober village is rejected at P<0.01. As presented on Table 3, *Eucalyptus camaldulensis* ranked to be the first tree species in terms of its abundance with a mean tree count of about 42 trees per household. With an ever increasing population (average family size in the study area is five), the demand for trees for construction poles, farm implements, fuel wood collection and charcoal production increases.

Previous findings by Jagger and Pender (2003) stated that households often plant fast growing tree species like *Eucalyptus camaldulensis*, which is profitable with over 20% rate of return to investment. Mekonnen (2009) also pointed out that Eucalyptus is the most important tree species as perceived by households in northwestern Ethiopia. Except only for very few tree species, the mean abundance level of many of the trees species recorded at household level in this study is close to none. From the indigenous tree species that are under sever threat (see Tegbe *et al*., 2006), *Ficus thonningii, Croton macrostachys, Cordia africana, and Acacia abyssinica* are found in some frequencies in Ambober village. Mekonnen *et al*. (2006) contended that farmers in Ethiopia establish woodlots of fast growing Eucalyptus tree species to meet their various demands. Their studies also indicated that indigenous tree species like *Cordia africana and Acacia abyssinica* showed slow growth rates.

Table 3: Relative abundance of tree species at household level in Ambober village

Tree Species	Mean	Std. deviation
Eucalyptus camaldulensis	42.37	102.432
Rahminus prinoides	16.63	40.259
Euphorbia tirucallii	6.05	18.000
Senna dydmobotria	5.24	12.499
Ficus thonningii	4.20	9.237
Croton macrostachys	3.06	5.356
Calpurnia aurea	2.79	6.888
Cordia africana	2.53	4.726
Dodonea anguistifolia	2.13	8.725
Albizia schimperiana	1.63	3.914
Acacia abyssinica	1.45	2.922
Olea europea	1.33	2.565
Rumex nervosa	1.21	6.753
Vernonia amygdalina	1.14	5.107
Coffee arabica	0.73	6.094
Arundo donax	0.67	6.133
Carisa edulis	0.55	1.997
Prunus persica	0.54	1.603
Phytolacca dodecandra	0.50	1.486
Rosa abyssinica	0.45	1.567
Pterollobium stellatum	0.37	1.789
Euclea schimperian	0.36	1.900
Euphorbia abyssinica	0.33	2.115
Rhus vulgaris	0.28	1.408
Rhus glutinosa	0.26	1.409
Grewia feruginea	0.18	0.740
Caparis tomentosa	0.17	1.089
Acacia seyal	0.17	1.063
Abutilon figuranium	0.12	0.894
Ficus sur	0.11	0.542
Combretum molle	0.11	0.676
Musa acuminate	0.10	1.246
Otostegia schimperi	0.09	0.781
Stereospurmum kuntianum	0.08	0.391
Racinus communius	0.07	0.828
Syzium guineense	0.06	0.603
Mangifera indica	0.06	0.556
Bersama abyssinica	0.06	0.338
Acockantra schimperi	0.05	0.446
Budleya polytchys	0.03	0.218
Dombeya torrid	0.03	0.262
Gardenia volkensi	0.03	0.218
Maytenus undata	0.03	0.262
Opuntia ficus indica	0.03	0.415
Milletia feruginea	0.01	0.166
Myrsince salicifolia	0.01	0.117
Celtis africana	0.01	0.166
Citrus aurantifolia	0.01	0.083
Dovyalis abyssinica	0.01	0.117
Eckebergia capensis	0.01	0.117
Zizipus spinachristi	0.01	0.083
Relative abundance:	**Mean Square value = 5405.783**	**F value = 22.328***

**Significant at P<0.01*

4.3 Determinants of tree species abundance and composition in Ambober village

4.3.1 Socioeconomic factors for tree species abundance

Multiple regression estimation result indicated that the model explained 49% of the variation in the number of trees maintained at household level. When the dependent variable is adjusted for the size of land owned (number of trees per hectare) and fitted for same explanatory variables, the prediction power slightly declined to 45%. In both of the models, all the variables jointly explained the variation in tree count per household (F values for both of the models are significant at $P<0.001$). Variables such as family size, livestock ownership, annual income, and distance to main road were consistently and significantly predicted by both of the models. Nevertheless, farm size and age of household head were significant in the regression model when the dependent variable is adjusted for size of land owned but not in the first model. A brief account of the variables is presented below.

Population growth and density is documented to be one of the factors contributing to tropical forest loss (Montagnini and Jordan, 2006; Geist and Lambin, 2002; Dessie and Christiansson, 2008; Wakijira, 2007; Teketay, 2001). Theoretically, there are arguments presented for and against population growth on natural resource management. Boserup (1965) argued in favor of population growth towards its role in natural resource management saying that population growth leads to intensification and better resource management including forest conservation. On the other, Malthus population theory argued that with increasing family size, households degrade natural resources through cutting of trees for construction, fuel wood and charcoal production, mining of soils without adequate enrichment of its fertility status etc (Ashraf and Galor, 2008). Results from this study supported the argument presented by Boserup (Ibid). It indicated that an increase in family size contributed positively towards maintaining trees at household level. The variable was significant at $P<0.01$ (in both of the regression models), and as family size increases by one person, the availability of trees in the household increased by 9 trees. Planting, cutting and delivering of trees to nearby markets require labor force. Those households with higher family size have better labor supply, and hence it contributed positively towards tree availability. Others also discussed that labor availability to be a positive factor in determining amount of tree planting in Ethiopia (Gebreegziabher *et al*., 2010; Mekonnen, 2009; Holden *et al.*, 2003).

Open grazing is mentioned in the literature as a threat to natural resources including trees, especially when property rights are open access. Nevertheless, livestock ownership can also promote tree plantation and conservation of species that have forage values. In the study area, households own a mean TLU value of 2.43. The variable is found to have a negative influence on the amount of trees maintained at household level. A one unit increase in the number of tropical livestock unit decreased the frequency of trees maintained by farm households by four trees at P<0.001. In the second regression model, the variables decreased the frequency of trees maintained per hectare by two trees at P<0.05. Gebreegziabher *et al*. (2010) employed logistic regression to analyze household level data collected in northern Ethiopia. They found that as the number of livestock managed in the household increased, the propensity to plant trees and the amount of trees planted decreased.

The other important variable that presumed to contribute to tropical forest loss is lack of adequate income. Theoretically environmental Kuznets curve depicts that there is a negative relationship between income and forests at low level of economic growth but as economic growth accelerates, income contributes positively to improve conservation efforts (Stern, 2003). Cropper and Griffiths (1994), Jepma (1995) and Rock (1996) claimed to support their empirical findings with environmental Kuznets curve for deforestation. Poverty or low level of income increases dependence on natural resource through fuel wood collection, and charcoal production that contributed to loss of tropical forest resources. Empirical findings revealed that in countries where there are high wage rates for off-farm employment activities, dependence on forest income through collecting fuel wood and charcoal production decrease substantially (Bluffstone, 1995; Pichon, 1997). Others discussed that due to high levels of poverty in many developing countries, there is a vicious circle of "poverty-environmental degradation-poverty" trap (Shibru and Kifle, 1998; Sherbinin *et al*., 2010).

Table 4: OLS estimation for household level tree species abundance

Variables	Model 1 Total number of trees in a household	Model 2 Number of trees in a household per hectare
Family size	9.47 (1.88)***	9.635(1.853)***
Farm size in hectares	20.83 (1.39)	-91.3 (-5.89)*
Age of household head	1.14 (1.21)	2.725 (2.8)*
Livestock	-18.78 (3.97)*	-10.39 (2.12)**
Annual income	0.19 (0.16)**	0.27 (3.38)*
Walking hours to main road	-67.76 (-5.61)*	-65.23 (-5.21)*
Years of land ownership	0.26 (0.17)	1.49 (0.94)
Sex of head	-28.35 (-1.17)	7.068 (0.28)
Location dummy	-22.96 (-0.96)	9.74 (0.39)
Tenure security	1.00 (0.047)	-10.57 (-0.47)
Constant	48.78 (0.88)	41.54 (0.73)
Joint Significance (F-test)	196291.61 (15.36)*	186062 (13.58)*
Adjusted R^2	0.49	0.46

*Figures in parenthesis are corresponding t-values for the coefficients and the astrix marks indicate their level of significance where *=P<0.01, **=P<0.05 and ***=P<0.1*

In this study, annual income of households showed to have positive effect on the number of trees maintained, which was significant at P<0.05 in the first model and significant at P<0.001 in the second model. An increase of annual income by 100 Ethiopian Birr increased the frequency of trees maintained in the household by about 20 trees. Gebreegziabher *et al*. (2010) and Mekonnen (1998) also found similar result for the income variable on the amount of tree planting by households.

Road infrastructure is generally discussed to increase accessibility of forests, which were previously inaccessible, and hence increases rate of deforestation (see Angelsen and Kaimowitz, 1999; Kaimowitz and Angelsen, 1998; Geist and Lambin, 2002; Alyes and Hogan, 2009). Such cases are especially holds true in areas of virgin forest areas where commercial logging is point of interest. In a related argument, Angelsen (2007) presented the Von Thunen model of land use with five alternative land uses. The model justified that land is allocated to the use that gives the highest land rent value. Road and market development are some of the factors the increase the rent value of land. Managed forests/woodlots come next to agricultural lands in terms of its rent value and in some situations, before extensive agriculture.

In this study, a variable that captures the distance of the household to main road facility was included. The variable turned out to have a negative effect on the frequency of trees maintained by farm households at $P<0.001$ (in both models), supporting the basic land use model of Von Thunen. A one hour increase in the time to reach to main road decreased household level tree abundance by about 5 trees (Table 4), but increased household level tree species composition by about 2 trees (Table 5). Those households that are located near main road facilities have the motivation to keep more

Eucalyptus as it will be easy to take to nearby markets as fuel wood and construction material. Hence, the tendency to shift to monoculture increases if the household is located near to main road facility but it decreases if located far away.

Age of household head and size of farm land owned turned out to be significant in the second regression model when the number of trees counted in the household was adjusted for area of farm land owned. As age of household head increased by one year, the frequency of trees maintained per hectare in a household also increased by 3 trees at $P<0.001$. Age is often taken to be a sign of accumulated farming experience that gives a better chance for households to realize the benefit of keeping more trees. Ostuka (1997) in Indonesia and Gebreegziabher *et al.* (2010) in Ethiopia found that households that are headed by older ones planted more trees on their plots than those headed by younger ones.

The finding with regards to farm size revealed that those farm households with relatively small plots of lands maintained more trees compared to those farm households that owned a relatively large size of land. The finding further strengthened Boserup's argument presented in the previous section where with increasing family size, farm land becomes increasingly small which further leads to intensification and better resource management. As farm land owned increased by one hectare, the frequency of trees maintained per hectare in a household decreased by 6 trees at $P<0.001$. Ostuka (1997) also found a negative relationship between plot size and tree planting in Indonesia analyzing household level data through logit model. However, Gebreegziabher *et al*. (2010) found that households with larger plots of land planted more trees than those with smaller plots of lands in north Ethiopia.

4.3.2 Socioeconomic factors for tree species composition

Again the socioeconomic factors that determine the frequency of tree species maintained at household level were predicted through two alternative models. The first model was predicted using frequency of tree species as dependent variable along with lists of explanatory variables. The model predicted 56% of the variations in the dependent variable. In the second model, frequency of tree species adjusted for size of farm land owned was used as a dependent variable along with same explanatory variables as in the first model. The second model predicted 27% of the variation in the dependent variable. In both of the models, the joint significance of the explanatory variables in predicting the variations in the dependent variables were significant at $P<0.001$ (see Table 5).

Variables such as family size, age of household head, number of livestock unit, annual income, distance to main road and tenure security significantly explained the variation in frequency of tree species maintained in the household. Except the variables "distance to main road" and "tenure security", all the other variables were significant at $P<0.05$ level. But it is important to note that although these variables happened to explain variations in frequency of tree species maintained in a household, their marginal effects seem to be very minimal with a rate of change of frequency of tree species by less than one unit (Table 5, Model 1).

The impact of distance to main road on frequency of tree species maintained by households was significant at P<0.001 with a positive sign. A one hour increase in the walking distance to main road facility increased household level tree species composition by 2 trees. It is quite logical that those farm households that are located near to main road facility will go for monoculture plantation of *Eucalyptus camaldulensis* for reason of better market value as fuel wood and construction poles (see results from Table 4).

In the same Table 5, feeling of tenure security was also found to increase frequency of tree species maintained by households at P<0.01. Those households that feel tenure security maintained four more tree species than those who feel insecurity. Land tenure is often conceptualized as the social institutions and relations that govern access to and ownership of land and its associated natural resources. It could be statutory or customary, and defines who can use what and for what purpose (Maxwell and Wiebe, 1998). Previous research finding also documented the negative impact of tenure insecurity on natural resource management like tree planting (see Gebreegziabher *et al*., 2010; Suyanto *et al*., 2005; Mekonnen, 2009). Mekonnen (Ibid) further explained that the variable doesn't have impact on the amount of trees to plant. Angelsen and Kaimowitz (1999) are pessimistic on the reliability of data on the variable but their simulation and empirical studies showed an increase in rate of deforestation with tenure insecurity.

Table 5: OLS estimation for household level trees species composition

Variables	Model 1	Model 2
	Frequency of tree species in a household	**Frequency of tree species per hectare**
Family size	0.39 (2.36)**	0.090 (0.19)
Farm size in hectares	0.31 (0.63)	-6.52 (-4.69)*
Age of household head	0.065 (2.09)**	0.094 (1.07)
Livestock	0.38 (2.47)**	0.54 (1.24)
Annual income of household	0.001 (2.53)**	0.001 (1.73)***
Walking hours to main road	2.0 (5.0)*	3.52 (3.14)*
Years of land ownership	-0.49 (-0.97)	-0.127 (-0.89)
Sex of head	0.30 (0.37)	1.91 (0.84)
Location dummy	-0.41 (-0.52)	4.13 (1.85)**
Tenure security	3.89 (5.53)*	0.86 (0.43)
Constant	1.33 (0.73)	11.69 (2.28)**
Joint Significance (F-test)	278.11 (19.89)*	725.30 (6.56)*
Adjusted R^2	0.56	0.27

*Figures in parenthesis are corresponding t-values for the coefficients with their level of significance where *=P<0.01, **=P<0.05 and ***=P<0.1*

When size of land ownership is taken as adjustment factor, variables such as farm size, income, distance to main road, and location dummy explained the variation in frequency of tree species maintained per hectare (Table 5, Model 2). The results indicated that those farm households with smaller plots of land maintained about 7 tree species per hectare than those who own bigger plots of land. The variable is significant at P<0.01 with a negative impact of frequency of tree species per hectare. Distance to main road is again a variable that has a positive effect (P<0.01) in terms of maintaining more tree species per hectare with a marginal effect of about 4 tree species per hectare.

Again those farm households that are found in Woynyie kebele kept more tree species than those that are found in Ambober kebele. The village dummy variable is significant at P<0.05 level with a marginal effect of 4 tree species per hectare. Although it is significant (P<0.05), the marginal effect of annual income in influencing the frequency of tree species maintained per hectare is very small. Annual income and walking distance to main road are the variables that consistently predicted variations in the dependent variables in all of the models (Table 4 and Table 5).

Although livestock holding negatively affected household level tree species abundance, in terms of tree species composition, it is found to have a positive effect at P<0.05. Households that keep large livestock holdings planted diverse tree species that have animal feed value compared to those that keep small livestock holding. Given the dwindling land size that limited the opportunity of hay production, it is quite logical for farmers to keep diverse tree species of forage value (Table 5). A related study conducted in Gondar district revealed that farmers in the area planted multipurpose tree species like *F. thonningii* as live fences to use it as source of animal feed (84.5%

of them use it as fodder), fuel wood (86.7% of them use it as source of energy), and shade and wind break (Tegegne, 2007).

4.3.3 Variation in tree species abundance and composition between sub-villages

An independent t-test was run to see if there are variations in terms of tree species abundance and composition between the two kebeles in Ambober village (Table 6). While the result presented in table 6 indicated that there is no variation in terms of trees species abundance between the two sub-villages (kebeles*)*, the result showed that there is significant variation ($P<0.001$) in terms of tree species composition. Mean values for tree species count in Woynyie kebele was about 7 trees, which is slightly higher than that of Ambober kebele of about 5 tree species. Ambober kebele was a home place for the Israel Jews who lived in Ethiopia before they moved to Israeli in the re-union scheme that started in 1993. New inhabitants took over the lands from nearby villages, which lead to loss of some important tree species. The result from this study supported the forest transition theory where at early stage of urbanization there are subsequent deforestation activities (Mather, 1990).

Table 6: Test of equality of mean tree species abundance and composition between Ambober and Woynyie kebele

Indices	Mean values for Ambober kebele	Mean values for Woynyie kebele	Mean Difference
Tree species abundance /ha	104.05	101.08	2.973 (0.112)
Tree species composition/ ha	6.57	8.19	-1.626 (-0.93)
Tree species composition (Overall in the household)	4.52	6.49	-1.973(-2.315)**
Tree species abundance (Overall in the household)	76.67	112.97	-36.302 (-1.564)

*Figures in parenthesis are t-values for the mean differences and its associated level of significance where **=P<0.05*

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Summary and conclusion

Previous empirical studies documented the importance of proximate and underlying socioeconomic factors in determining loss of tropical forest. In this study, I have found sufficient evidence supporting the claim that socioeconomic variables are worth considering in determining household level tree species composition and abundance.

Natural resources are sources of livelihood for poor rural households. *Eucalyptus* was the dominant tree species maintained by the majority of households for reason of income generation. It is dominantly grown as woodlots. Households maintained about 37% of the tree species in their farms, which indicates the place of farm forestry in the area. Socioeconomic factors such as annual income, family size, and age of household head have positive effect on household level tree species abundance. Whereas, livestock holding, relative size of farm land and distance to main road negatively affected household level tree abundance in the study area. On the other hand, annual income, family size, livestock holding, tenure security, age of head, being located in Woyinye kebele (village dummy), and distance to main road positively determined household level tree species composition while relative size of land ownership negatively affected holding of tree species composition.

In conclusion, it is worth noting that government and non-government organizations engaged in promoting tree planting and conservation address the correlates of household level tree species abundance and composition. Based on the findings, the following recommendations can be forwarded.

5.2 Recommendation

Livestock holding has decreased the abundance of tree species but promoted holding of different tree species (tree species composition) that have animal feed value. Future interventions should capitalize this opportunity by introducing different tree species that have more than feed values (multi-purpose tree species). Those households that have large families planted more trees (mainly *Eucalyptus*) for earning income. In the long run, this might lead to a monoculture situation where farmers replace other tree species with that of eucalyptus. This is a threat in terms of maintaining diversity of tree species. Hence, alternative income sources have to be sought while at the same time trying to manage family size by introducing family planning techniques.

It was evident that income has an overall positive impact both in tree species abundance and composition. Poverty reducing interventions should be targeted towards creating employment opportunities. In addition, although changing the land ownership policy of the country from government ownership to private ownership is a political issue in the country, the evidence from this study showed that those households that have feeling of tenure security did well in terms of tree species composition. At minimum, long term land ownership certification should be done to increase land tenure security feeling of households. Road infrastructure induced plantation of eucalyptus tree species. Although households have the right to have road development, it is of great concern that this might lead conversion of other tree species into eucalyptus monoculture. Degraded hills that are under government ownership better be allocated for such plantation, and concerned institutions should work on this.

5.3 Limitation and future research areas

Tree species abundance and composition would be better studied if one has data for multiple years so as to track the trajectory of change. This study is purely based on a cross sectional household survey and it was hardly possible to account for historical and policy changes. So, future research is needed incorporating some policy variables with multiple year data. In addition, this study did not analyze the socioeconomic determinants of tree species abundance and composition independently for each tree species. Farmers prefer to maintain some tree species over the other due to the attributes of the tree species. Hence, future research should analyze the socioeconomic determinants species by species.

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Annex 1: Tropical Livestock Unit Conversion Factors

Type of livestock	TLU value
Camel	1.0
Cattle	0.8
Goat	0.1
Sheep	0.1
Pigs	0.2
Chicken	0.01

Adapted from Babu and Sanyal (2009) and EADD (2009)

Annex 2: Dominant growing areas for tree species in use by households

Tree species	Dominant growing area
Citrus aurantifolia	Homestead
Coffee arabica	Homestead
Mangifera indica	Homestead
Musa acuminate	Homestead
Prunus persica	Homestead
Racinus communius	Homestead
Rahminus prinoides	Homestead
Vernonia amygdalina	Homestead
Abutilon figuranium	live fence
Acockantra schimperi	live fence
Arundo donax	live fence
Bersama abyssinica	live fence
Calpurnia aurea	live fence
Caparis tomentosa	live fence
Carisa edulis	live fence
Dodonea anguistifolia	live fence
Dovyalis abyssinica	live fence
Euclea schimperian	live fence
Euphorbia abyssinica	live fence
Euphorbia tirucallii	live fence
Ficus thonningii	live fence
Maytenus undata	live fence
Myrsince salicifolia	live fence
Opuntia ficus indica	live fence
Phytolacca dodecandra	live fence
Pterollobium stellatum	live fence
Rhus glutinosa	live fence
Rhus vulgaris	live fence
Rosa abyssinica	live fence
Rumex nervosa	live fence
Senna dydmobotria	live fence
Acacia abyssinica	scattered inside farm
Acacia seyal	scattered inside farm
Albizia schimperiana	scattered inside farm
Budleya polytchys	scattered inside farm
Celtis africana	scattered inside farm
Combretum molle	scattered inside farm
Cordia africana	scattered inside farm
Croton macrostachys	scattered inside farm
Dombeya torrid	scattered inside farm
Eckebergia capensis	scattered inside farm
Ficus sur	scattered inside farm
Gardenia volkensi	scattered inside farm
Grewia feruginea	scattered inside farm
Milletia feruginea	scattered inside farm
Olea europea	scattered inside farm
Otostegia schimperi	scattered inside farm
Stereospurmum kuntianum	scattered inside farm
Syzium guineense	scattered inside farm
Zizipus spinachristi	scattered inside farm
Ecucalyptus camaldulensis	Woodlots