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RESEARCH PAPER

Tree Planting by Smallholder Farmers in the Upper Catchment of Lake Tana Watershed, Northwest Ethiopia

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Abstract Tree growing by smallholder farmers is an emerging livelihood strategy in Lake Tana catchment. The objectives of this study were to (1) identify the most important tree species grown, (2) investigate the drivers of the existing pattern, and (3) identify determinants of the number and diversity of tree species and their spatial patterns. Survey data were collected from 200 households. Multiple linear regression was employed to identify the determinants of tree growing behaviour of households and spatial variables affecting the abundance of tree species. *Eucalyptus globulus*, *Acacia decurrens* and *E. camaldulensis* dominate woodlots. Only a fraction of the forest production is used by the households, the rest being sold as poles or charcoal. Location in relation to market centres, number of livestock owned, landholding size and age of household head were found to positively affected the number of tree species and trees grown. Gender affected the species and spatial pattern of trees. Woodlots, farm boundaries and homesteads were found to be important tree growing niches. These results substantiate the proposition that farmers assign their parcels of land to uses that increase the rent value of the land, and this value is affected by access to roads. Woodlots are on the increase at the cost of productive agricultural land. Provision of a tree planting extension service may increase participation of farmers in tree planting, and a management-oriented tree planting extension service may give desirable results.

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Introduction

The Ethiopian highlands contribute the majority of the water in the Nile drainage basin. However, these highlands are highly degraded due to a long history of intensive land use and deforestation (Hurni 1983, 1988; Bekele 2003; Hurni et al. 2005). These areas of the country have suffered from biomass deficit, and therefore State-initiated tree plantating was commenced near the end of the nineteenth century (Bekele 2003; Kassa et al. 2011). Currently, trees are planted by smallholder farmers either for biomass or as a major source of income.

In parts of Africa, Asia and Latin America, tree growing of smallholder farmers has been constrained by a wide range of factors, which vary kaleidoscopically according to owners' characteristics, suitability of tree species for various purposes and the environment in which they are grown, as well as market drivers and policy variables (Arnold 1997; Beach et al. 2005; He et al. 2007; Zhang and Aboagye 2007; McGinty et al. 2008; Viswanathan and Shivakoti 2008). The importance of resource endowments of households in terms of farm land, available labour and livestock owned were reported to affect smallholder tree planting by Adesina and Chianu (2002) and Pattanayak et al. (2003). These factors and their interaction and the trade-off with the allocation of scarce resources were also reported to affect tree planting by Salam et al. (2000). The importance of government incentives in promoting tree planting was also reported by Nibbering (1999) from Indonesia, and by Harrison et al. (2008) in South-east and East Asia. However, Dewees (1993) reported that government-initiated tree planting incentives did not increase the rate of tree plantations in Malawi because management of incentives increased the difficulty of implementing the initiative. In the Philippines, Emtage and Suh (2004) reported the importance of household demand and consumption of wood for timber and fuel being the most important factors driving households' decisions to plant trees.

The decision to grow trees by smallholder farmers is also affected by market incentives, including availability of markets for outputs and as a source of inputs, and prices of both (Arnold 1997; Warner 1997; Arnold et al. 2006). On the other hand, Patel et al. (1995) reported that the decision of households to grow trees, whether this is profitable or not, may be influenced by differences in factor costs, factor endowments and functioning of factor markets. Markets and policy variables affect household tree planting because they are important in shaping risk perception and risk forecast and speculation of the decision-maker (Murray and Bannister 2004). Where farmers perceive uncertainties in land and tree tenure, and are too poor to enjoy long-term benefit, they do not show interest in investing in long-rotation forestry (Bannister and Nair 2003). These factors at the farm level affect the spatial pattern, timing of planting and management of trees (Nawir et al. 2007).

In Ethiopia, tree growing practices by smallholder farmers and their characterization have been described by Abebe et al. (2010), who noted that tree growing in the form of Agroforestry is an indigenous practice in much of southern Ethiopia. Especially, the importance of factors such as landholding size, family size, gender of head of household, education of household head, and livestock holding in constraining and shaping the decision of households to plant trees has been reported for the southern highlands (Ayele 2008), central highlands (Mekonnen et al. 2006, 2009; Duguma and Hager 2010) and northern highlands (Mekonnen 2009; Gebreegziabher et al. 2010). These studies also indicate the importance of resource endowments in influencing household tree planting behaviour. For example, Gebreegziabher et al. (2010) pointed out that households that have more male labour, higher overall income, with a higher proportion of off-farm income, are the most likely to plant trees in northern Ethiopia.

While tree planting has been among the measures to diversify livelihoods, create alternative income, and increase biomass supply, a greater proportion of the farmers are converting their crop and grazing land into forest land for higher financial returns in the Lake Tana Watershed (Matthies and Karimov 2014). The warm and humid climate and the moderately deep soils of the watershed are suitable for fast growing trees and shrubs, including the shrub *Catha edulis* (Vahl) Forssk. ex Endl., which contain an amphetamine-like stimulant. Conversion of productive agricultural and grazing land to woodlots may pose a long-term sustainability challenge in terms of land allocation to alternative uses including food production. Further, there is little information available as a basis for sound policy advice that will help boost participation of smallholder farmers in tree planting and enhance the contribution of trees to improve rural livelihoods. Therefore, the objectives of this study were to identify the most important tree species grown by smallholder farmers and investigate factors that affect farmers' decisions to grow trees in the Amhara region of Ethiopia. The hypothesis for this study is thus household characteristics of smallholder farmers such as resource endowments, gender and age, and the spatial location of farms explain the species composition, diversity and abundance of trees.

The Study Area

The study was conducted in villages located in the upper catchment of Lake Tana, the largest lake in Ethiopia. Specifically, the study was carried at Gonder Zuria (hereafter referred to as GZ) and Libo Kemkem (LK) districts. The lake catchment region is also the nearest market for wood products for major cities in the region. The farming system is to grow mixed crops and raise livestock but trees also form a valuable component of household livelihood. The average mean monthly maximum and minimum temperature between 13 and 27 °C, and the mean annual rainfall is 1085 mm, being highest from June to September.

Research Method

The research method comprised a landholder survey, focus group discussions, direct observation and village walks. A questionnaire was developed and a reconnaissance survey of the landscape and households was carried out before sample selection.

The two districts were selected purposively, and one village was selected purposely from each district, from each of which 100 households were selected randomly. The sample households were interviewed with a semi-structured questionnaire to collect data on variables expected to affect the decision of households to grow trees and on variables that affect their preferences for tree species. The variables included age and gender of the household head, landholding size, number of cattle owned, family size and age structure, and years experience managing the land. The numbers of cattle owned were rescaled into Tropical Livestock Units (TLUs) based on body weight of the animals. The tropical livestock unit is commonly taken to be an animal of 250 kg liveweight.

Focus group discussions facilitated by researchers, and transect walks and repeated farm visits, were used to collect tree-related data. From the six focus group discussions, an exhaustive list of the tree species grown by the smallholder farmers and the purpose of growing them were recorded, followed by ranking of the tree species based on their level of importance. During farm visits, every tree species observed on a farm or communicated by any member of the household about its presence, including presence in particular tree growing niches, was recorded. A tree growing niche on a farm refers to the location of a tree on the farm and its establishment pattern at the location. The niches that were distinguished were trees in the homestead area, mixed and scattered on cropland, on boundaries of the farm, and in woodlots.

For this study, only those tree species which were planted by the households were included in the sample, i.e. remnant native trees were not recorded. The number of mature individual trees growing on the farm and their number and frequency on the farm were considered as dependent variables. The total number of *trees* and *tree species* per household were regressed with and without adjusting for farm size. The survey was carried out from January to August 2009, December 2009 to October 2010 and September to October 2012. Most of the survey was carried out during the first round. The subsequent sessions were deemed important to replace those sampled households which were rejected as incomplete survey responses or outliers.

Household data were rectified for possible outliers. Those previous observations which were found to be outliers were removed from the analyses, the data from 135 households being used for further analysis. Total number of trees and the number of tree species among households and tree growing niches were tested for differences using one-way ANOVA. Independent sample t-tests were employed to test for differences in the number of trees and number of tree species grown between male-headed and female-headed households, and also differences between GZ and LK locations. Ordinary least square multiple regression was performed to identify household socio-economic characteristics that affect household tree growing behaviour, and diversity and density of trees grown by particular households. The explanatory variables included in the analysis were village, gender and age of the household head, number of years that the household resided in the present landholding, family size, area of landholding in hectares, and number of livestock units (in TLU). The dependent variables used in the analyses were diversity statistics of trees grown by the household as measured by the absolute density of trees and number of on-farm tree species with and without adjusting for farm size. All the analyses were performed using SPSS.

Results

A total of 25 tree species were grown by farmers. The average number of tree species grown per household was 5.9, and the average number of trees per household was 98.2. The average landholding size was found to be 0.56 ha, scattered on separate parcels with average distance of 2.1 km between plots (Table 1).

Tree species grown varied depending on planting niche, village and gender of household head. The most widely planted tree species were *Eucalyptus globulus* Labill., *E. camaldulensis* Dehnh., *Rhaminus prinoides* L'Her., *Acacia decurrens* Willd., *Ficus thoninngii* Blume, *Albizia schimperiana* Oliv., *Cordia africana* Lam. and *Croton macrostachyus* Hochst. ex Del. (Table 2). In GZ district, *E. globulus* and *E. camaldulensis* accounted for more than 90 % of the total number of trees, followed by *F. thonningii* (3 %) and *R. prinoides* (2.3 %). In LK, *E. globulus*, *A. decurrens* and *E. camaldulensis* accounted for more than 50 % of the total number of trees, followed by *R. prinoides* (19 %), *C. macrostachyus* (4 %), *Euphorbia tirucalli* L. (4 %) and *F. thonningii* (3 %) (Table 2).

Significance differences were found in the number of tree species and trees among tree growing niches ($F = 9.10$, $P < 0.001$). The highest numbers of trees were recorded in woodlots followed by inside farms, along farm boundaries and in homestead areas. The highest and lowest numbers of tree species were recorded in homesteads and woodlots, respectively. The most-abundant tree species scattered inside the farms were *R. prinoides*, *A. schimperiana*, *C. macrostachyus*, *Olea europaea* L. subsp. *cuspidata* (Wall. ex G. Don) Cif. (not planted) and *C. africana*. The most abundant tree species in homesteads were *F. thonningii, C. macrostachyus*, *C. africana*, *O. europaea* and *R. prinoides.* Tree species which

Table 1 Descriptive statistics of the variables that may affect tree planting propensity of smallholder farmers in northwest Ethiopia

Variable	Mean	SD
Age of household head (years)	45.75	13.91
Period of land ownership (years)	20.78	9.53
Family size (number of persons)	5.13	2.14
Farm size (ha)	1.10	0.86
Number of livestock units	2.28	2.33
Abundance of trees (no.)	98.21	149.36
Density of trees (stems per hectare, sph)	92.23	121.73
Species richness (number of species per land holding)	5.90	5.03
Species density (mean no. of species/ha)	7.34	7.59

Table 2 Mean tree abundance (SE) separated by village, gender and tree growing niches

Tree species	District		Gender		Growing niche			
	LB	GZ	Female	Male	Inside farm	Homestead	Boundary	Woodlot
Acacia decurrens	4.44 (10.40)	–	14.45 (8.65)	16.68 (5.47)	–	1.31 (0.08)		17.92 (92.91)
Cordia africana	0.98 (0.47)	0.58 (0.09)	0.41 (0.15)	0.73 (0.15)	1.03 (0.23)	1.41 (0.39)	0.17 (0.07)	–
Croton macrostachyus	0.39 (0.15)	0.95 (0.15)	0.43 (0.17)	0.97 (0.15)	1.35 (0.34)	1.57 (0.33)	0.47 (0.13)	–
Eucalyptus camaldulensis	44.34 (18.94)	11.97 (3.88)	14.45 (8.65)	18.68 (5.47)	0.09 (0.07)	0.08 (0.08)	1.57 (0.66)	69.47 (18.00)
Eucalyptus globulus	56.34 (34.39)	–	13.54 (45.98)	34.78 (45.56)	–	1.23 (4.35)	3.23 (2.49)	119.50 (163.00)
Euphorbia tirucalli	0.30 (0.23)	2.04 (0.50)	0.73 (0.48)	2.03 (0.52)	–	–	6.52 (1.57)	–
Ficus thonningii	1.62 (0.61)	0.79 (0.21)	0.33 (0.17)	1.12 (0.26)	0.30 (0.12)	2.14 (0.67)	1.31 (0.45)	–
Olea europaea	0.11 (0.08)	0.38 (0.07)	0.13 (0.06)	0.39 (0.07)	1.06 (0.21)	0.20 (0.07)	0.06 (0.04)	–
Rhaminus prinoides	1.14 (0.48)	4.50 (1.09)	1.41 (0.55)	4.66 (1.16)	13.82 (3.40)	1.08 (0.47)	0.70 (0.40)	–
Test statistic	t-value (district) = 24.71 (1.99)[a]		t-value (gender) = −12.48 (−1.11)		$F = 9.10^{b}$ Sig = 000[b]			

Dashes in the table refer to no observation

[a] Mean difference and t-values in parentheses for one sample *t* test

[b] ANOVA and the corresponding F-test and significance level

were found abundantly on boundary planting areas were *E. tirucalli*, *E. camaldulensis* and *F. thonningii*. Woodlots were composed mainly of *E. camaldulensis*, *E globulus* and *A. decurrens*. That the highest number of trees recorded was in woodlots was due to extremely high planting density of these species. Female-headed households preferred planting eucalypts on the boundary of farms and in homesteads.

The regression model explained 37 % of the variation observed among households in terms of total number of trees grown (F = 13.09, $P < 0.001$). When the dependent variable was adjusted for the size of land owned (i.e. planting density) and fitted for the same explanatory variables, the prediction power declined to 26.6 % (F = 8.34, $P < 0.001$). The number of livestock (in TLU), size of land owned and age of head of household were found to affect the dependent variable in both the initial and area-adjusted models. Family size was found to affect the dependent variable in the area-adjusted model (Table 3).

The model developed to predict the socio-economic factors responsible for the variation observed in the frequency of tree species predicted 48 % of the variation in the dependent variables (F = 19.80, $P < 0.001$). However, when the number of tree species was adjusted for farm size, the prediction power declined to 30.4 % (F = 9.87, $P < 0.001$). The number of livestock (in TLU), size of land owned, family size and age of head of household were found to affect the total number of tree species and tree species per hectare. The district dummy variable was significant in the area-adjusted model but not in the initial model (Table 4).

Mean tree abundance was significantly different ($P < 0.05$) between LK (64 trees) and GZ (119 trees) when the variability in landholding size among households was not taken into account. However, when the mean number of trees was adjusted for farm size, the difference became statistically non-significant (Table 5). The

Table 3 Estimated parameters and significance levels of variables affecting tree abundance with and without adjustment for land holding size

Variable	Model 1 (total number of trees)	Model 2 [density of trees (sph)]
District dummy	−37.95 (−1.57)	−0.25 (−0.48)
Gender of household head	−14.67 (−0.56)	3.58 (0.16)
Age of household head (years)	2.51 (2.29)*	4.08 (4.21)***
Period of land ownership (years)	−0.49 (−0.27)	0.64 (0.41)
Family size (number)	5.30 (0.98)	8.24 (1.72)*
Farm size (ha)	42.45 (2.51)**	−68.09 (−4.57)***
Livestock (TLUs)	27.44 (5.15)***	19.77 (4.20)***
Constant	−108 (−2.32)*	−116.51 (−2.82)**
Joint significance (F-test)	185,871.72 (13.09)***	92,334.73 (8.34)***
Adjusted R^2	0.37	0.27

Figures in parenthesis are corresponding t-values for the coefficient and number of asterisk indicates level of significance, where * $P < 0.01$, ** $P < 0.05$ and *** $P < 0.1$. sph is number of stems per hectare

Table 4 Estimated parameters and significance levels of variables affecting number of tree species with and without adjustment for landholding size

Variable	Model 1 (Total number of tree species)	Model 2 (Density of tree species (tsph))
District dummy	0.78 (1.06)	2.82 (2.18)*
Gender of household head	0 79 (0.99)	1.98 (1.43)
Age of household head (years)	0.10 (3.03)*	0.12 (2.08)*
Land ownership period (years)	−0.04 (−0.76)	−0.10 (−1.08)
Family size	0.34 (2.05)*	0.06 (0.22)
Farm size (hectares)	1.64 (3.19)**	−5.30 (−5.88)***
Livestock in TLU number	0.62 (3.83)***	1.11 (3.90)***
Constant	−3.91 (−2.74)**	3.64 (1.46)
Joint significance (F-test)	261.26 (19.80)***	399.28 (9.87)***
Adjusted R^2	0.48	0.30

Figures in parenthesis are corresponding t-values for the coefficient and the asterisk marks indicate their level of significance where * $P < 0.01$; ** $P < 0.05$; *** $P < 0.1$. tsph is number of tree species per hectare

independent *t* test for the mean difference in the count of tree stem numbers was not significantly different between female (58 trees) and male (112 trees) headed households. Nevertheless, there was a significant difference in the number of tree species maintained by male-headed and female-headed households (Table 5).

Trees on woodlots are mainly planted to be either sold as poles or used on-farm for charcoal. Trees on other tree growing niches are grown for five distinct uses, namely cattle fodder, fuelwood, medicine,[1] shade and construction materials. Some farmers mentioned that they are forced to plant trees because tree plantations in the neighbouring parcels depress crop productivity.

Discussion

The number of tree species and trees grown by farmers in the study area is low compared to that found in other studies by Mekonnen (2009), Gebreegziabher et al. (2010) and Duguma and Hager (2010). Duguma and Hager (2010) found that 27 tree species were grown by smallholder farmers in central highlands of Ethiopia. Mekonnen (2009) and Gebreegziabher et al. (2010) reported a higher density (of 150 trees per hectare) compared with the result from the present study in northern Ethiopia. The difference in the number of tree species may arise because the current study did not consider naturally-occurring native trees on the farm. In terms of

[1] It is common in the study area that various parts of plants (leaves, stem, bark, and roots) are used for healing ailments of humans and livestock.

Table 5 Test of equality of means of tree abundance (total number of trees) and number of tree species, by village and gender of head of the household

Variable	Village		Mean difference	Sex		Mean difference
	LK	GZ		Female	Male	
Number of trees	63.51 (98.43)	119.19 (170.14)	−55.68 (−2.12)**	58.49	111.70	−53.21 (−2.12)
Number of trees (tph)	85.83 (85.83)	96.10 (96.10)	−10.27 (−0.47)	71.99	99.104	−27.11 (−1.11)
Number of species	3.49 (3.49)	7.36 (5.27)	−3.87 (−5.34)**	3.24	6.81	−3.56 (−4.39)**
Number of species (sph)	5.81 (6.27)	8.26 (8.18)	−2.45 (−2.04)**	4.98	8.13	−3.15 (−2.47)**

The figures in parenthesis on the mean are the standard error (standard deviation of the mean)

The figures in parenthesis on the mean difference are t-values and the corresponding level of significance where ** $P < 0.05$

number of trees, it may be that fewer trees are planted by the farmers in the study area.

According to Warner (1997), the pattern of trees grown on farms and the drivers of this pattern can be examined in terms of smallholder farmer's livelihood strategies and of the dynamics of rural change. A pattern or a combination of patterns may exist in a given land-use system, depending on whether the farming system is extensive, protection against livestock is difficult, trees have a beneficial positive impact on neighbouring crops, or trees are cash crops. *F. thonningii, C. macrostachyus*, *C. africana* and *O. europaea* are planted because they have beneficial effects on the neighbouring crops (Poschen 1986; Gindaba et al. 2005; Teklay et al. 2006). *E. camaldulensis*, *E. globulus* and *A. Decurrens* are planted in compact blocks in woodlots because they are cash crops. *E. tirucalli*, *E. camaldulensis* and *F. Thonningii* are planted as live fences for protection against livestock which have free range grazing.

Farm boundaries and farms were the dominant tree planting niches that contributed to the highest proportion of tree planting by survey respondents. This is in agreement with a report by Duguma and Hager (2010) that boundaries are the favourite tree planting niches. The tendency to plant trees on farm boundaries may be the result of fragmentation of farmlands which will increase boundary areas and reaction to the changed tenure system (Deininger and Jin 2006; Gebreselassie 2006). Although there has been a debate on the equally possible trajectories of either Boserupian type of land-use which underlines intensification and resource conservation with increasing population and urbanization (Boserup 2005), or Malthusian resource degradation with increasing population, the results in this study suggest the increased number of planted trees with increasing fragmentation of farmlands which might have been caused by increased population.

Livestock ownership can be both a threat and an opportunity for tree growing. In the presence of free grazing and *de facto* open land access rights as is the case in the study area, livestock may be a threat to tree plantations. Nevertheless, livestock ownership can promote tree planting and conservation of tree species that have forage values. In the present study area, the mean TLU value was 2.3 per farm, and livestock ownership positively affected the number of trees planted by households. A one-unit increase in TLU increased the frequency of trees by 27 at $P < 0.001$ when the number of trees was not adjusted for farm size and by 20 trees at $P < 0.001$ when the number of trees was adjusted for farm size. These findings agree with finding reported for the Guraghe Highlands in Ethiopia by Ayele (2008). In contrast, Gebreegziabher et al. (2010) reported a decline in the number and diversity of trees planted with increasing number of livestock managed by households, in TLU units.

The size of farmland owned by the households affected tree planting behaviour positively. The present finding revealed that those farm households with larger farm size maintained more trees compared with those farm households that owned a relatively small land area. The impact was so large that as land area owned increased by 1 ha, the frequency of trees maintained per hectare by a household increased by 45 ($P < 0.001$). Ayele (2008) reported a positive and significant relationship between farm size and number of trees in the highlands of southern

Ethiopia, finding that an area increase of 1 ha increased the number of trees per household by 934. Positive effects of farm size on tree planting were reported in Ethiopia by Mekonnen (2009) and Gebreegziabher et al. (2010), as well as in the Philippines (by Emtage and Suh 2004) and Bangladesh (by Salam et al. 2000).

This investigation showed that households led by elderly people are likely to grow more trees than those headed by young people. For each one-year increase in age of the head of the household, the number of trees planted by the household was estimated to increase by 2.5 when number of trees was not adjusted for plot size and by 4 when the area adjustment was made. In contrast, period of land ownership was not significant in affecting number of tree and tree species. Similar reports of positive impacts of age and farming experience in favour of more tree planting has been reported by Gebreegziabher et al. (2010) for Ethiopia. In contrast, Ayele (2008) reported a negative relationship of landholder age with on-farm tree planting in Ethiopia. He argued that aged household heads will plant fewer trees when tree planting is less profitable than cropping and has a relatively high risk. He noted that experience and information accumulated through ages increased the the ability of households to estimate profitability of alternative land uses, estimation of anticipated natural hazards and risk of loss of land tenure. In other cases, older age may hinder tree planting simply because older farmers are less flexible and willing to engage in innovative farm technologies (as argued by Ayele 2008).

This study found no significant relationship between family size and number of trees grown by households, but it affected the number of tree species. Family size may affect household tree planting either by increasing the wood demand of the household or by increasing the availability of human labour for tree planting. In the study area, however, larger families were more likely to grow a diverse range of tree species than smaller families. The importance of family size in positively influencing tree planting on farms by increasing the availability of labour in Ethiopia has been discussed by Holden et al. (2003), Mekonnen (2009) and Gebreegziabher et al. (2010).

Independent sample *t* tests revealed significant differences in mean number of trees and number of tree species maintained by farmers, between LK and GZ districts. These differences in species composition may arise due to differences in management objectives in relation to the two tree genera, and ease of transporting the timber products to the road and market. Managed with very high planting density, eucalypts are mostly harvested when they attain a pole size, and for markets as far away as the Sudan. The poles are bulky to transport, which compels access to roads. On the other hand *R. prinoides* is grown mainly for its leaves, which are used for brewing local beverages. The leaves can be transported easily to markets by humans or draught animals. Therefore, those households located at GZ far from the road tend to specialize in planting and growing *R. prinoides*.

According to the Von Thünen theory, land is allocated to the use that gives the highest land rent. Land economic rent value can be affected by spatial location in relation to roads and markets. Both eucalypts and *R. prinoides* have a market at Gondar, but eucalypts have an additional market in the neighbouring country of Sudan. Households in the study area grow these two tree species disproportionally more than other tree species, supporting the basic land-use model of Von Thünen.

However, the potential threat may be that farms that are located close to the main road will be changed into monoculture plantations of eucalypts, where the land could otherwise have been used for food crop production. This threat may expand with increasing demand of eucalypt products in Ethiopia and neighbouring countries as well as rising urban wage rates and off-farm income opportunities. This will be a threat especially if there is no participatory and proper land-use planning that considers the supply and demand of food and wood.

There was no statistically significant difference in the total number of trees planted by female- and male-headed households. However, the difference in number of species grown was statistically significant. Although Hansen et al. (2005) reported increased tree planting as being associated with a high incidence of non-married women in Malawi, previous reports from Ethiopia by Ayele (2008), Mekonnen (2009), Mekonnen and Köhlin (2009) and Gebreegziabher et al. (2010) reveal tree planting by female-headed households to be much less likely than by male-headed households. In this study, the observed difference in the number of tree and tree species planted in relation to gender may be from the constrained selective behaviour of female-headed households. Female-headed households specialize in planting those tree species that increase the economic rent value of their land, legitimize their tenure security with the government or demarcate their property permanently from threat of border dispute from physically powerful neighbours.

In general, there is a growing trend in tree growing in the upper catchment of Lake Tana watershed, in north-western Ethiopia. Eucalypt and *A. decurrens* plantations are expanding in number and size on former grazing land and crop fields. The comparative advantage of tree growing needs to be examined in relation to food and animal feed shortage in the area. A generic extension package that encourage tree planting may not have a desirable outcome, in which case management-oriented outreach development plans and a policy of food security may need to be developed and implemented.

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