Factors Influencing Smallholder Farmers Adoption of Eucalyptus Woodlot in Wogera District, North Gondar Zone, Amhara Regional State of Ethiopia.

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Abstract

Eucalyptus is familiar specious in various weather conditions of the world. Eucalyptus woodlot planation in wogera district become increased since 1970. The study was to examine the determinant factors for the adoption of eucalyptus woodlots by smallholder farmers in Wogera district. Three stage sampling procedure was used to select 118 sample respondent farmers from three purposively selected Kebeles of the district. Household survey was used to collect quantitative data. Econometric model (binary logit model) was employed to analyze the quantitative data. Adoption of eucalyptus woodlot was affected negatively by family size and fertility of land, and positively affected by farm size, access to market, and farmers' perception towards eucalyptus woodlot production. It is concluded that adoption of eucalyptus woodlot plantation was affected mainly by socio-economic and institutional factors. Therefore, attention should be given to manage the identified factors and change smallholder farmer's attitude towards eucalyptus woodlot plantation.

Introduction

Eucalyptus has been grown in East Africa for over a century and people in the region have thus accumulated important local knowledge of its management. The area of eucalyptus plantations has now expanded greatly, so that this genus dominates many rural and urban landscapes often because it suits the limited resources of smallholder growers and generally yields more money than other tree crops (Zenebe *et al*., 2007). Increasing demand for fuel wood and construction material has also created dependable markets for eucalyptus products which have contributed to the steady expansion of its area in the region (Gessesse & Teklu, 2011).

The properties of fast growth and easy establishment in Ethiopia have made the eucalyptus a popular tree crop for over hundred years to meet demand for many products and services, and have created a strong local knowledge of the various species (Gessesse & Teklu, 2011). Eucalyptus woodlots have a potential to take poor farmers and urban dwellers out of the poverty trap. In tropical and subtropical countries, many farmers prefer to plant eucalyptus compared to other tree species and even to other cash crops. It is not a few strong qualities of eucalyptus that contributes to its popularity among smallholders but the fact that it possess many important and/or strong qualities that the smallholders appreciate (Hailemicael, 2012).

Eucalyptus provides multiple benefits like materials, fuel wood for cooking, it enhances food security by providing inputs into other food producing parts of the farm system, it generates income, and creates job opportunity for different age groups and particularly for women that could support of the livelihood of the communities (Birru *et al*., 2013; Selamyihun, 2004; Tegegne *et al*., 2017; Tsegaye, 2015; Zenebe *et al*., 2007). Hence, poor farmers respond to decreasing access to and declining agricultural productivity by increasing trees and agro-forestry activities (Tsegaye, 2015).

According to the information obtained from development agents and farmers in the study area, eucalyptus woodlot is the parcel of land which is devoted for Eucalyptus plantation, with a size of 0.1 hectare or conventionally named as "*Block*" which is 40m by 25m *and* above, The practical experience in Wogera district which is the study area showed that smallholder farmers have been using white eucalyptus (*Eucalyptus globules*) woodlot as an important cash source even by replacing their land from commonly grown staple food crops. It was also observed that in the study area there were many other farmers who were not planting eucalyptus woodlot even though it has contributions to household income. With this regard there was no any study made why some farmers are not using eucalyptus woodlot production for household income. Hence, this study was conducted to investigate the factors that influence the adoption of eucalyptus woodlot at smallholder levels with the attempt to fill the exiting knowledge gap.

Research Methodology

Description of the study area: The study was conducted in Wogera district of North Gondar Zone (figure 1), located 36 kms from Gondar town and 763 kms from Addis Ababa, elevated at an average altitude of 2,812m above sea level. It is found at between 37.36ºE and 12.46^{0}N longitude. The annual rainfall ranges between 1000 mm to 1200 mm, and the minimum and maximum mean temperature of the study area is 14°C and 33^{0}C, respectively. The study area was selected purposively because of its potential for eucalyptus production and farmers have rich experience of planting eucalyptus (*Eucalyptus globulus)* since the late 1970s.

The district has a total population of 268,833, of whom 137,057 are men and 131,776 women. Total area coverage of district is 182,126 ha. From the total area of land 46.32% (84,352 ha) is used for farm land, 11% (20,033 ha) is forest land, 22.7% (41,322.2 ha) is grazing land, 4.42% (8,049.9 ha) is used for construction and buildings and 12.85% (23,404.8 ha) institutions, and the remaining 2.73% (4,964 ha) is considered waste land. In addition, the dominant soil type of the area is Red, Brown and Black. (Unpublished woreda agricultural office report, 2016).

From the report, it was indicated that the topography of the area is 52% of flat, 23% mountainous, 14% valleys and the rest 11% are hills. The woreda agro ecological distribution includes 56% Dega (cold), 26% Woina Dega (moderate), 4% Wurch (frosty) and the rest 13% Kolla (hot). Livestock resources of the woreda were identified as cattle, sheep and goat, donkey, horse, mule, and poultry. Crops growing in the district are barley, Wheat, Bean, Chickpea, Pea, Maize, Sorghum, Teff, Lentil, Vetch, Onion and Potato.
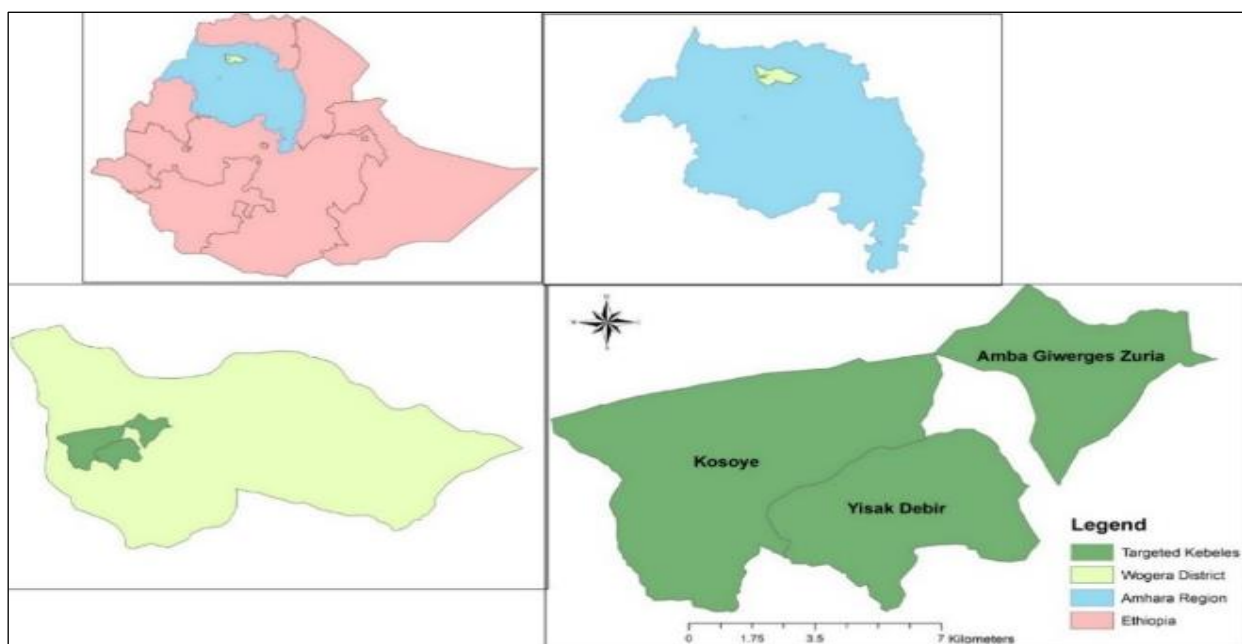

Figure 1. Map of the study area

Data collection methods: Data was collected mainly from rural households located in three Kebeles of Wogera district. Cross sectional survey was used by preparing structured interview schedule to collect quantitative data from farm households and pre-test was conducted under the supervision of the researchers and some adjustments were made to the questionnaire.

Sampling and sample size determination: The sample size was determined using the simplified formula provided by Yamane (1967) cited in Israel (2003) at 95% confidence level, degree of variability=0.5 and level of precision = 9% (0.09).

$$n = \frac{N}{1+N(e^2)}$$ .... (Equation 1)
$$n = 2686/(1 + 2686(0.09^2)$$
$$n = 118$$

Where n is the sample size, N is the population size (total household heads size), and e is level of precision.

In the sampling procedure, three-stage sampling techniques were employed to generate the required primary data. At the first stage, Wogera district was selected purposively and three kebeles with high coverage of eucalyptus woodlot were selected purposively. Next, farm households in the three kebele's were categorized into adopters and non-adopters. Then 118 household heads were selected using systematic random sampling technique. The selection was made using proportional probability to size from the two categories (80 from adopters and 38 from the non-adopters) and from the three kebeles (47 from Kosoye, 35 from Amba Giwergis Zuria and 36 from Yisak Debir kebele).

Method of data analysis: Binary logit regression analysis is applied to address the main objective of this study and answer to the question of this study. Adoption of eucalyptus woodlot production could not be the result of a single factor. Following the completion of data collection, data were coded and entered into Statistical Package for Social Science (SPSS) version 20-computer program for analysis.

The target of this study is to identify the factors that determine smallholder farmers' adoption of eucalyptus woodlot production. Hence, the response variable is dichotomous taking on two values (0 and 1); binary logistic regression was employed to examine the influence of explanatory variables on dependent variable (adoption of eucalyptus woodlot by smallholder farmers).

Demographic, institutional, socio-economic and psychological factors, which affect the adoption of eucalyptus woodlot was examined using binary logistic regression. The binary logistic function was used because it represents a close approximation to the cumulative normal distribution, fitted probabilities are between zero and one (Gujarati, 2004).

In logit model, the smallholder farmers who have eucalyptus woodlot were considered as "adopter", the variable takes the value 1. Otherwise, the smallholder farmers consider as "non-adopter", the variable takes as 0. According to Gujarati (2004), the functional form of the logit model is presented as follows:

$L_i = \ln(\frac{P_i}{1-P_i}) = Z_i = \beta_0+\beta_1x^1_+ \beta_2x^2+ \beta_3x^3+ \beta_4x^4 \dots \beta_nx^n$ .... (1)

Where; P_i = the probability adopting eucalyptus woodlot ranges from 0 to 1
L=the natural log of the odds ratio or logit
$Z_i = \beta_0+\beta_1x^1_+ \beta_2x^2+ \beta_3x^3+ \beta_4x^4 \dots \beta_nx^n$ .... (2)
β_0 = the intercept. It is the value of the log odd ratio, $\frac{P_i}{1-P_i}$ when X is zero.
$\beta = \beta_{1+} \beta_2+ \beta_3+ \beta_4 \dots \beta_n$ the slope, measures the change in L for a unit change in X;
Thus, if the stochastic disturbance term (Ui) is taken into consideration the logit model becomes
$L_i = \beta_0 +\beta_1 X_i +U_i$

Table 1. Explanatory variables and measurements

Variables, and Measurement	Expected sign
Age of household head (in year)	+
Sex of household head (1 is male, 0 otherwise)	+
Family size of the household (number)	+/-
Education level of household (0, cannot read and write; 1, can read and write; 2, attend 1-4	+

grads; 3, attend 5-8 grades and above)	
Family labor (adult equivalent)	+/-
Farm size of household (in hectare)	+
Number of livestock (TLU)	-
Fertility of land (0, fertile; 1, medium and 2, infertile)	-
Wealth status (0, poor; 1, medium and 3, rich)	+
Availability of road (1, yes; 0, otherwise)	+
Participation in training (1, yes; 0, otherwise)	+
Accesses of credit service (1, yes; 0, otherwise)	+
Access of market (1, yes; 0, otherwise)	+
Distant to the main road (in hectare)	-
Farmers perception towards eucalyptus woodlot production (1, the advantage of eucalyptus woodlot is greater than its disadvantage; 0, the advantage of eucalyptus woodlot is less than its disadvantage)	+

Results and Discussion

Factors influencing the adoption of eucalyptus woodlot by smallholder farmers

Many factors were hypothesized to influence the adoption of eucalyptus woodlot production in the study area. The selection of explanatory variables was done based on empirical evidences.

Prior to running the logistic regression model, both the continuous and discrete explanatory variables were checked for the existence of multi-collinearity problem. The problem arises when at least one of the independent variables is a linear combination of the others. The existence of multi-collinearity might cause the estimated regression coefficients to have the wrong signs and smaller t-ratios that might lead to wrong conclusions.

There are two measures that are often suggested to test the presence of multi-collinearity. These are: Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for dummy variables Gujarati, (2004). Based on the VIF and contingency coefficient results, the data were found to have no serious problem of multi-collinearity and therefore six continuous and nine discrete explanatory variables were retained in the model.

The various goodness of fit measures state that the model fits to the data well. The likelihood ratio test statistics exceed the chi-square critical values with 18 degree of freedom at less than 1%

probability levels indicating that the hypothesis that all the coefficients, except the intercept are equal to zero is rejected. The value of Pearson chi-square test shows the overall goodness of fit of the model at less than 1% probability level. In addition, the model explained about 82.2% of the total variation in the sample. Correctly, predicted figures for adopters were about 92.5%; while correctly predicted sample size for non-adopters were 60.5%. Thus, we can say that the model fits that the data well (Gujarati, 2004).

In the Logit model, a farmer who has eucalyptus woodlot was considered as "adopter", otherwise considered as "non-adopter". The outputs of binary logistic regression analysis indicates (table 2), five variables were found to be statistically significant with respect to adoption of eucalyptus woodlot by smallholder farmers. These are farm size, farmer's perception towards eucalyptus woodlot production and market access influenced positively whereas family size and fertility of land influenced negatively, whereas the rest explanatory variables were found to have no significant influence on the adoption of eucalyptus woodlot. The effect of the significant explanatory variables on production in study area is discussed below:

Family size: it was found that family size had influenced negatively and significantly, the adoption of eucalyptus woodlot by smallholder farmers at less than 10% significant level. The odds ratio of 0.586 for family size reveals that keeping the influence of all other factors constant, as the family size increases by a unit, the decision

of smallholder farmers to adopt eucalyptus woodlot will decreases by a factor of 0.586 in the study area.

Farm size: It was found that farm size had influenced positively and significantly, the probability of adopting eucalyptus woodlot by smallholder farmers at less than 5% significant level. The odds ratio of 4.454 for farm size indicate that keeping the influence of all other factors constant, the adoption of eucalyptus woodlot by smallholder farmers will increase by a factor of 4.454 as the farm size increases by one hectare.

Fertility of land owned by farmers: The result indicated that, the household's decision to adopt eucalyptus woodlot increase while the fertility of land goes to decrease and significant at less than 1% significant level. The odd ratio 7.045 for fertility of land owned by the farmers implies that smallholder farmers who have land with medium fertility are 7.045 times more likely to adopt eucalyptus woodlot compared to smallholder farmers with fertile land.

Access to market: The model result confirmed that the variable access to market had associated positively and significantly with the adoption of eucalyptus woodlot by smallholder farmers at less than 5% significance level. The result shows that the farmers who had an access of market for the inputs and outputs of eucalyptus woodlot production were 4.303 times more likely to adopt eucalyptus woodlot than the farmers who have not.

Farmer's perception towards eucalyptus woodlot production: It was found that the perception of farmers positively and significantly associated with the adoption of eucalyptus woodlot by smallholder farmers at less than 1% significance level. As the model result indicates (table 2), farmers who perceived the advantage of eucalyptus is more than its disadvantage were 12.219 times more likely to adopt eucalyptus woodlot than farmers who perceived the disadvantage of eucalyptus is greater than its advantage.

Table 2. Significant Binary logit model result on factors affecting the adoption of eucalyptus woodlots by smallholder farmers

Explanatory variables	B	S.E.	Sig. level	Odd Ratio
Family size	-.534	.299	.074*	.586
Farm size	1.494	.714	.036**	4.454
Fertility of land (based on farmers perception)	1.952	.633	.002***	7.045
Access to market	1.459	.727	.045**	4.303
Farmer's perception towards eucalyptus woodlot production	2.503	.820	.002***	12.219
Constant	-6.641	2.475	.007***	.001

-2 Log likelihood Ratio	93.437
Chi-square ($\chi2$)	17.356**
Correctly predicted overall sample	82.2
Correctly predicted adopters (%)	92.5
Correctly predicted non-adopters (%)	60.5
Sample size	118

Note: *, **, *** = Significant at 10%, 5% and 1% significant level, respectively.
Source: Computed from own survey data, (2017)

From the results of this study, family size of smallholder farmers were negatively and significantly affected the adoption of eucalyptus woodlot. The result implies that farmers with large family size are less likely to adopt eucalyptus woodlot than farmers who have small family size. The odds ratio of family size reveals that keeping the influence of all other factors constant, the decision of smallholder farmers to adopt eucalyptus woodlot will decreases by a

factor of 0.586 as the family size increases by one. This is due to that, smallholder farmers used their land for crop production instead of planting eucalyptus woodlot to feed their large family, and availability of sufficient household labour force in large families to engage in intensive crop production activities (Kebede, 2017). Mainly, the farmers who have high dependency ratio are less likely to plant eucalyptus than the farmers who have less (Setiye & Mulatu, 2016). However, the study directed by Dereje *et al.* (2012) indicate that the total family size had no significant effect for farmers decision to plant eucalyptus.

Farm size and adoption of eucalyptus woodlot by smallholder farmers was correlated positively and significantly. The odds ratio of farm size indicate that keeping the influence of all other factors constant, the adoption of eucalyptus woodlot by smallholder farmers will increase by a factor of 4.454 as the farm size increases by one hectare. The result infers that farmers with large farm size are more likely to adopt eucalyptus woodlot than the farmers who have small farm size in the study area. As observed in study area farm size is very important resource to invest in eucalyptus woodlot production, because farmers on their small land grow different crops, rearing diverse animals, and thereby likely to generate sufficient income, which could help them to produce or/and buy required food and non-food items. The result agrees with several studies (Abiyu *et al.*, 2012; Alemu *et al.*, 2010; Jenbere *et al*., 2012; Kabwe *et al.,* Bigsby, & Cullen, 2009; Kebede, 2017; Krause *et al*., 2006; Nsiah, 2010; Petro *et al*., 2015; Selamyihun, 2004; Setiye & Mulatu, 2016; Zenebe *et al.*, 2007; Zerihun & Gazahegn, 2010); availability of land is an essential factor in household tree planting and positively correlated with households' decision to plant and allocates land for eucalyptus woodlot.

The result indicated that, the household's decision to adopt eucalyptus woodlot increase while the fertility of land goes to decrease. The odd ratio of land implies that smallholder farmers who have land with medium fertility are 7.045 times more likely to adopt eucalyptus woodlot compared to smallholder farmers with fertile land. Because, in the study area, even though fertile lands are more productive to eucalyptus, they are devoted to crop production to produce the required amount of food

crops to feed families. Whereas, the land with medium fertility or infertile land[1] are not more productive for crop production but they give better product of eucalyptus. As a result, smallholder farmers produce eucalyptus woodlots on the land with less fertility. Analysis of the survey results confirm with findings of Nsiah (2010) reported that farmers use land with poor quality to establish their plantation while reserving productive lands for agricultural purposes. Likewise, Kebede (2017) and Tola (2010) have point out that farmers change their farm lands to eucalyptus woodlot plantation when the productivity of land start to decline since they cannot afford to invest agriculture inputs to improve the productivity of the land as well as when family food security is at risk. Further, Setiye & Mulatu (2016) have directed that availability of non-agricultural land, increases the farmers' propensity to adopt eucalyptus tree on their land.

Access to market had associated positively and significantly with the probability of adopting eucalyptus woodlot by smallholder farmers. The result shows that the farmers who had an access of market for the inputs and outputs of eucalyptus woodlot production were 4.303 times more likely to adopt eucalyptus woodlot than the farmers who have not. The farmers who have an access of market able to get the required input for eucalyptus woodlot production easily and they could sale the products at write time with reasonable price, which positively influence the decision of smallholder farmers to adopt eucalyptus woodlots on their land that enables them to improve their livelihood. The result congruence with the finding of Nsiah (2010), who deducted from his studies that availability of market for farm forest products increase farmers' decision to use land to plant trees.

Perception of farmers was positively and significantly associated with the probability of adopting eucalyptus woodlot by smallholder

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[1] In the study area, land fertility is categorized traditionally (based on farmer's perception).
1= fertile (black, red, and mix of red and black locally named as "*Serbola*" soil types, which are more productive land);
2= medium (sandy black and red soil types locally named as "*Foqifuaqa*", which are less productive lands for crop unlike eucalyptus; and
3= infertile (degraded, eroded and water logged lands, which are not giving crop production; used only for grazing purpose).

farmers. As the model result shows, farmers who perceived the eucalyptus woodlot advantage are greater than its disadvantage are 12.219 times more likely to adopt eucalyptus woodlot than farmers who perceived the disadvantage of eucalyptus is more. In connection with this result, Setiye & Mulatu, (2016), who conclude that farmers who perceived the risk of the eucalyptus tree planting is less likely making a decision in adopting of the eucalyptus tree than those who don't perceive as risky. Likewise, the result agrees with several findings in different parts of Ethiopia (Jenbere *et al*., 2012; Tilashwork Chanie, 2009; Zenebe e*t al*., 2007), who identified that the farmers who perceived the significance of eucalyptus is better than the risk of it are willing to plant and allocate their land to eucalyptus tree. Consequently, smallholder farmers keep on growing eucalyptus trees because of the relative short time required to produce wood biomass for fuel, construction and cash even though they perceived negative ecological impact of eucalyptus planting.

Conclusion

The adoption of eucalyptus (*Eucalyptus globulus*) in the form of woodlot by smallholder farmers has been increasing even by replacing their fertile lands to the tree production. The result confirmed that farm size, access to market and perception of farmers towards eucalyptus woodlot production were positively and significantly affected the adoption of eucalyptus woodlot by smallholder farmers. Whereas, family size and fertility of land (based on farmers perception) owned by the farmers were found to be affecting negatively. Therefore, the socio-economic characteristics and institutional factors can facilitate or hamper the adoption of eucalyptus woodlots by smallholder farmers. Hence, attention should be given to manage the identified factors and change farmer's attitude to optimize the positive value of eucalyptus and reduce its negative effects, contribute for enhancement of farmer's income.

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